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Exceptional Lifespans

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Chapter 1
Preface

James W. Vaupel

The advance of the frontier of survival is documented, verified, and brought to life in this monograph.

A dedicated international team has worked for two decades to gather data on supercentenarians, aged 110+, in 12 European countries, Japan, Quebec and the United States. For the last several years, additional information has been compiled on semi-supercentenarians, aged 105–109. The findings are stored in the International Database on Longevity (IDL), which was founded by Jean-Marie Robine and me, originally housed at INSERM, the French National Institute of Health, in Montpelier, France and now managed by the Max Planck Institute for Demographic Research in Rostock, Germany, in collaboration with the French Institute for Demographic Studies (INED). An updated version of this database will be released at the same time this book is published. The database is meticulously described in Chap. 2 by Jdanov, Shkolnikov and Gellers-Barkman, key researchers in the Laboratory of Demographic Data at the Max Planck Institute. France Meslé and Jacques Vallin at INED, as well as Jean-Marie Robine, at INED and INSERM, Bernard Jeune at the University of Southern Denmark, Michel Poulain at the Université catholique de Louvain and many of the authors of chapters in this book and its predecessor (Maier et al. 2010) helped develop the database.

In addition to the IDL data, carefully validated reports based on painstaking scholarship have been prepared on specific individuals with extraordinarily long lifespans. Some of these reports are presented in Chaps. 14, 15, 16, 17, 18, 19, 20, 21 and 22. Other reports were published in our 2010 monograph *Supercentenarians*. Chapter 14 provides references to additional case studies, including the book *Validation of Exceptional Longevity* (Jeune and Vaupel 1999). The exacting research

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to verify very long lives is impressive—and it is fascinating to read about extreme longlivers and how their lifespans were documented. The case studies in this monograph are the crown jewels of the laborious endeavors of the supercentenarian research team.

As briefly described in Chap. 14 and more fully discussed in Jeune and Vaupel (1999), most alleged supercentenarians were considerably younger than reported. The credulity of those who accept claims of very long lives is characteristic of the trust in naïve beliefs and acceptance of unproven claims that has obscured knowledge about the outposts of human life. Ignorant assertions based on shoddy research or canonical but questionable views are still being made about exceptional lifespans and about the trajectory of mortality at advanced ages. As Kestenbaum observes in Chap. 6, publications "that are clearly incorrect should serve as a reminder to the research community of the folly of using data for the extreme aged without questioning and evaluating them."

The 22 chapters in this monograph contribute substantial advances in verified facts about exceptional lifespans and in the application of analytical strategies to understand trends and patterns in the rare lifespans on the frontier of human existence.

This scrupulous, demanding research is important because it sheds light on "how long can we live?", a question of fundamental scientific, social and individual interest. The question can be posed "what is the maximum human lifespan?" This prejudges the answer because there may not be a limiting lifespan that is fixed over time. As knowledge advances, the maximum might also advance, perhaps gradually but without a definite limit. On the other hand, a biologically-determined maximum might constrain the lifespans of humans—and other species. As often asserted in the gerontological literature, every species may have its characteristic maximum, its species-specific lifespan.

"There is one and only one cause of death at older ages and that is old age and nothing can be done about old age." This dreary view is now discredited (Vaupel 2010) although it is still widely held. It is now known that the evolutionary theories of aging devised by Medawar, Williams, Hamilton and Kirkwood do not imply a maximum duration of life (Baudisch 2008; Baudisch and Vaupel 2010; Jones et al. 2014) although many biologists cling to the outdated dogma. It appears that the age-pattern of senescence, of growing old, is not fixed but is being postponed to higher ages as life expectancy increases (Oeppen and Vaupel 2002; Vaupel 2010; Colchero et al. 2016).

Still unanswered, however, is the fundamental question of whether human lifespans are approaching an intractable limit. If so, the advance of the frontier of survival documented in this monograph will slow and then cease. The pace of increase in life expectancy will decline and then stop.

A problematic report in *Nature* (Dong et al. 2016) asserts that the limit to lifespans has already been reached and is about 115 years, with cases of lifespans above this limit, as documented in Chaps. 14, 18, 19, 21 and 22 of this book, being random outliers. The statistical analysis underpinning the claim of a 115-year maximum is questionable (Van Santen 2016a, b; De Beer et al. 2017; Hughes and Hekimi 2017; Lenart and Vaupel 2017; Newman and Easteal 2017; Rootzén and Zholud 2017;

Rozing et al. 2017). Furthermore, the authors did not take into account the intricate nature of the IDL data they extracted from a 2007 compilation intended to supplement our 2010 volume on *Supercentenarians*. In Chap. 2 of this book, Jdanov, Shkolnikov and Gellers-Barkmann assiduously explain the complicated observational plans used for different countries in the database, some data pertaining to birth cohorts and other data to periods starting and ending at various years, some data left truncated, some data right truncated, some data right censored and some data interval censored.

In Chap. 3, Gampe shows how carefully and subtly the variegated IDL have to be handled. Her chapter follows up on a similar chapter in our earlier book (Gampe 2010) but now with data on 1219 verified supercentenarians, almost twice as many as available earlier. She confirms her earlier conclusion that the annual probability of death between ages 110 and 114 is constant and about 50% per year. The number of observations is too scanty to allow estimation of death rates after age 114. Differences in mortality between the sexes cannot be detected because males are too few in number. The risk of death in Japan might be somewhat lower that in Europe or the United States, but again the small number of observations precludes a firm conclusion.

Demographers use different measures of mortality, including the annual probability of death and the hazard of death or "force of mortality", which is usually close to the death rate estimated by dividing the number of deaths at some age by the number of people exposed to death at that age. Gampe presents most of her results in terms of the hazard of death. This value is the negative logarithm of 1 minus the probability of death. Hence, when Gampe reports a hazard of death of 0.7, this value implies a probability of death of 0.5.

Gampe's key finding—that the annual probability of death is about 50/50 after age 110—is important because if the plateau continues to hold after age 114, then the number of people reaching more advanced ages will increase as the number of people attaining age 110 increases. The mathematics of this are explained in Chap. 5 by Lenart, Aburto, Stockmarr and Vaupel. The finding is also important because it implies that the current longevity record—Jeanne Louise Calment's lifespan of 122.45 years—is not implausible and that it is also not implausible that her record, which was set in 1997, has not yet been broken. As shown in Chap. 5, these are implications of Gampe's 50/50 plateau.

The plateau is predicted by a theory of mortality in heterogeneous populations that postulates that individuals continue to grow weaker even after age 110, with the annual risk of death rising at perhaps about 14% per year (Vaupel 2010; Vaupel et al. 1979; Vaupel and Missov 2014; Missov and Vaupel 2015). The constant risk of death for the surviving population is the result of an equilibrium between two forces. Half the cohort dies, including many of its weaker members, leaving a more robust population of survivors. These survivors, however, grow a year older—and weaker. The plateau is reached when the death of the frail counterbalances the aging of the survivors.

Constant hazards of death after 110 are inconsistent with the claim by Dong, Millholland and Vijg (2016) that the maximum human lifespan is 115. If this were true, mortality should sharply rise at advanced ages, imposing a wall of death at age

115. Perhaps annual survival is constant from 110 to 114 and then steeply falls: this seems implausible but more analysis is needed to refute the conjecture. People have lived beyond 115, including those documented in Chapters 14, 18, 19, 21 and 22, so a wall of death at 115 would have to have a hole to let the outliers through. An upper bound on age-specific death rates at the highest ages could be estimated by careful study of how high the hazard of mortality after 114 could rise without precluding the validated super-supercentenarians, aged 115+. The mathematics developed in Chap. 5 indicates that the annual risk of death after age 114 cannot rise much above 50% unless Jeanne Louise Calment's rigorously documented lifespan of 122.45 is fraudulent.

In short, like many previous assertions about limits to human life expectancy and lifespans (Oeppen and Vaupel 2002), the claim that humans cannot live longer than 115 years adds more noise than knowledge to the study of longevity. Some more nuanced version of the claim might be correct: human lifespan records may not increase significantly. It seems more likely that lifespan records in specific countries and globally will be broken again and again as more people survive to become supercentenarians and super-supercentenarians (115+).

The Gavrilovs have achieved some notoriety by proclaiming that cohort death rates continue to rise exponentially even at the most advanced ages (e.g., Gavrilova et al. 2017). As documented by Villavicencio and Aburto in Chap. 4, the Gavrilovs reach this result by applying weak statistical methods to artfully selected data. Sophisticated tools have been developed to analyze censored data with age at death not observed for some individuals. Sophisticated tools have also been developed to analyze data on the lifespans of individuals, taking advantage of knowledge of exact dates of birth and death. The Gavrilovs, however, drop cohorts with censored data and group individuals by time periods of birth and death, greatly reducing the power of their analysis. In contrast, Gampe in Chap. 3 dissects the full individual-level information in the intricate IDL dataset by applying state-of-the-art statistical scalpels.

Individuals who have reached exceptional ages can be compared with cut and polished jewels—precious diamonds, rubies, emeralds, sapphires and opals, each unique with its own facets and tints. Exacting, state-of-the-art strategies should be deployed to extract the fullest information from knowledge about the rare humans on the marchlands of survival. Gampe does this in Chap. 3 and Villavicencio and Aburto in Chap. 4 indicate how the Gavrilovs could have done better. Lenart, Aburto, Stockmarr and Vaupel in Chap. 5 focus on Jeanne Louise Calment, the current longevity record holder: they debunk claims to the contrary by showing that (1) her lifespan is not implausible, (2) it is not surprising that her record still holds, and (3) her record might not be broken for decades.

Kestenbaum in Chap. 6 relates yet another sorry failure to treat longevity data with appropriate care and skepticism. In the United States annual estimates of the number of deaths by age for centenarians are distorted by unreported or unrecorded deaths and by age misstatement. Errors in reporting and recording and in age misreporting are even more severe with regard to the number of living centenarians. Hence death rates at advanced ages have to be estimated with care. Kestenbaum documents unacceptable estimates by the U.S. National Center for Health Statistics and outlines steps that can be taken to improve the estimates.

What are the causes of death at very old ages? Meslé and Vallin in Chap. 7 use data from France and Kaalby, Skytthe, Andersen-Ranberg and Jeune in Chap. 8 use data from Denmark to address this question. In Chap. 8, the question is posed: "As most centenarians suffer from multiple diseases, they are at high risk of dying—but what do they ultimately die of?" In both France and Denmark, cardio- and cerebrovascular diseases account for a third or so of deaths at high ages. Perhaps the most intriguing finding of both chapters is that with age cancer becomes a less important cause of death. In Denmark cancer was listed as the cause of death for only 3–4% of centenarians compared with 15% of those 85–99 years old; the decline with age in cancer as a cause of death was similarly dramatic in France.

Ill-defined or unspecified causes become increasingly important with age and are becoming more important over time, perhaps because of underdiagnosis of specific diseases. In France the cause of more than 40% of supercentenarian deaths was recorded as ill-defined or unspecified. Meslé and Vallin conclude that "daily care is more crucial to the survival of the oldest old than any conventional medical care or treatment. Supercentenarians tend to be so frail that any minor health event or brief lapse of attention on the part of caretakers can be lethal."

As Gampe documents in Chap. 3, the annual probability of death appears to be constant after age 110 for the IDL data analyzed as a whole. At what age is this plateau reached? To study this question, the IDL is expanding its coverage to semi-supercentenarians, aged 105–109. In four countries—Italy, France, Japan and the United States—numbers of observations are now sufficient to permit serviceable estimates.

An analysis of the Italian data by Barbi, Lagona, Marsili, Vaupel and Wachter was published in June 2018 in *Science*. The authors found a plateau starting at age 105 and extending to age 108, after which the data are too sparse to permit estimation. The plateau is at a level of about a 50% chance of death per year but with a modest decline in this level over successive cohorts. The theory of mortality in heterogeneous populations (Vaupel et al. 1979; Vaupel 2010; Missov and Vaupel 2015 and Vaupel and Missov 2014) predicts that death rates approach a plateau and get closer and closer to it with advancing age. As death rates decline prior to advanced old age, the plateau is approached at later ages. A reasonable hypothesis is that the plateau is not declining for successive Italian cohorts but that it is being reached at later ages. If so, estimates of the level of the plateau after age 105 based on the average level of mortality after 105 would be slight misestimates and somewhat lower for more recent cohorts.

In Chap. 9 of this monograph, Ouellette, Meslé, Vallin and Robine analyze the data at ages 105+ for France. They supplement Chap. 2 by providing further details about the nature and accuracy of the French data. They conclude that for French females "probabilities of death…appear to level off at 0.5 between ages 108 and 111.…After age 111, however, data become too scarce to assess the trend."

Mortality of centenarians and supercentenarians in Japan is the focus of Chap. 10, by Saito, Ishii and Robine. This chapter details the characteristics of the available data. Figure 2 shows the rise in the highest reported ages at death in Japan since 1963: for the longer-lived and more numerous females, the rise is roughly linear, with no indication that a limit at age 115 is being approached. Concerning the mortality plateau, the authors conclude that "for the cohorts born between 1894 and 1900, mortality seems to increase at least up to age 107 among males and up to age 111 among females." My reading of their Fig. 5b suggests that probabilities of death for females may reach a plateau starting at age 111 at a level of perhaps 55% per year. The data, however, are too sparse to be confident about this. In Chap. 3 Gampe applies her estimation strategy to the Japanese data and concludes that given the small number of observations it is not clear if and at what age a mortality plateau is reached but that if there is a plateau the annual probability of death might be about 45%.

The fourth country with a substantial number of observations after age 105 is the United States. Kestenbaum discusses the available data in Chap. 13. He concludes that the annual probability of death for men and women increases from age 105–109 "from something below 0.5 to something above 0.5." Gampe, in Chap. 3, examines the U.S. data above age 110. She finds a plateau at a 51.5% probability of death per year, with a standard error about 2%, with no significant difference between males and females or between earlier and later birth cohorts.

Mortality data for Quebec are of high quality and are available for several centuries. In Chap. 12, Beaudry-Godin, Bourbeau and Desjardins describe the increase in the number of centenarians in Quebec across cohorts born in 1871–1901. They document "remarkable progress realized in old age mortality" and show that the increase in the number of centenarians is largely due to progress in reducing death rates between ages 80 and 100. Their Fig. 5 shows that the trends for males and females in the highest ages at death since 1950 are linear with no sign of a looming limit. Figure 6 presents projections of future centenarian populations in Quebec: in their high scenario, which I favor, the number may increase from 1623 in 2015 to close to 100,000 in 2061.

Up until now, little reliable information has been available on people 100+, 105+ and 110+ in Poland. Kroczek, in Chap. 11, endeavors to "produce a list, as complete as possible, of validated Polish supercentarians." This is a major undertaking, which he clearly documents. He also presents preliminary data on those who reached age 105. And he provides information on the number of centenarians in Poland over time. In doing so, he explains how the complicated history of Poland makes research on exceptional lifespans difficult—but nonetheless possible.

The final chapters of this monograph focus on case studies of exceptional longevity. In Chap. 14, Jeune and Poulain provide an overview. These chapters are remarkable both for their human interest and their remarkable scholarship.

The authors of the chapters of this monograph and various co-researchers in 12 European countries, Japan, Canada and the United States have collaborated on research on exceptional lifespans for almost 20 years. We like each other and enjoyed meeting together to discuss various research issues and findings for a couple of days in:

- June 2000 in Rostock, Germany,
- June 2001 in Sophienberg/Rungsted, Denmark,
- May 2002 in Atlanta, Georgia,
- May 2003 in Montpellier, France,
- June 2004 in Tokyo, Japan,
- Oct. 2005 in Taormina, Italy,
- Sept. 2008 in Montreal, Quebec,
- Jan. 2011 in Madrid, Spain,
- May 2012 in Rome, Italy,
- Sept. 2014 in Paris, France,
- Sept. 2015 in Copenhagen, Denmark,
- June 2016 in Tallinn, Estonia and
- May 2017 in Rostock, Germany.

In 2010 the group produced a monograph called *Supercentenarians* that was edited by Maier, Gampe, Jeune, Robine and Vaupel. This second monograph summarizes our joint research since then. I helped edit the volume, but the bulk of the credit belongs to Heiner Maier at the Max Planck Institute for Demographic Research in Rostock, Germany and to Bernard Jeune at the University of Southern Denmark in Odense, Denmark. Others who have played especially important roles include Jean-Marie Robine from INSERM and INED in France, Jacques Vallin and France Mesle from INED, Vladimir Shkolnikov, Dmitri Jdanov and Sigrid Gellers-Barkmann from the Max Planck Institute, Graziella Caselli from Rome, Italy, and the other authors of the chapters of this monograph and the preceding one.

The history of the study of exceptional lifespans is a sorry saga of mutual-delusion societies, a desire for renown that trumps truthfulness and integrity, naïve credulity, self-serving fraud, egregious exaggeration, foolishly ignorant over-confidence, unquestioning adherence to questionable dogma, firm belief in what "clearly" must be true, trust in gut feelings, argumentation by metaphor, reliance on rhetoric rather than empirical analysis, use of unvalidated data, lack of understanding of the nature of the available data, and reliance on hatchets instead of scalpels to dissect the precious results of meticulous efforts to validate exceptional lifespans. The IDL data are not fodder to be shoveled into the feeding troughs of computers. Even if it does not close the debates, the careful, nuanced research in this monograph—building on what reliable research does exist, as cited in the references—sheds reliable new light on a topic shrouded in nonsense but fundamentally important—how long can we live?

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Part I
The International Database on Longevity

Chapter 2
The International Database on Longevity: Data Resource Profile

Dmitri A. Jdanov, Vladimir M. Shkolnikov, and Sigrid Gellers-Barkmann

2.1 Introduction

Extreme longevity has long been a topic of interest to the media and to the broader public. There are many legends of people who set longevity records, with tales of individuals who lived 200, 500, and even 969 years. Unfortunately, it is almost impossible to validate the ages of long-lived individuals until the twentieth century. In the second half of the twentieth century, the number of people in a collection of low-mortality countries who have reached age 100 has approximately doubled every decade (Jeune 2002). This trend continued in the first decade of the twenty-first century (HMD 2016), which suggests that the proportion of the long-lived will probably continue to increase in the future. The unprecedented growth in the number of centenarians and supercentenarians (those aged 110 and older) in recent decades provides us with a practical basis for investigating the extremes of human longevity. There is no consensus about the limits of longevity or about the form of the mortality hazard at extreme ages. The existing data suggest that the chances that a new Jeanne Calment – who died in 1997 at age 122 – will appear in the near future are quite low; however, the chances are clearly higher than zero. While the postponement of mortality has been reported in many studies (Vaupel 2010), the trajectories of longevity at ages above 105 or 110 are still disputed (Gampe 2010; Gavrilov and Gavrilova 2011; Robine and Vaupel 2001). There are radically different ideas and assumptions about the direction of future change in longevity, and about the

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potential limits to the human lifespan (de Beer et al. 2017; Dong et al. 2016; Oeppen and Vaupel 2002; Olshansky 2013). Having carefully collected and rigorously validated data might help us to confirm or reject these hypotheses.

The existing data sources on extreme human longevity can be placed into two categories. The first category consists of comprehensive data assembled by government agencies on deaths and population exposures for semi-supercentenarians (those aged 105–109) and supercentenarians. The second category consists of unofficial special lists and data collections of cases of extreme longevity compiled by researchers interested in the topic from sundry sources.

Even in countries with very good statistical systems, routine population statistics that cover individuals of very high ages are often problematic, as the proportion of erroneous cases increases sharply with age (Cairns et al. 2016; Jdanov et al. 2008). For example, according to U.S. vital statistics, there are numerous deaths at ages above 110, and even some above age 130 (HMD 2016), which clearly cannot be accurate (Rosenwaike and Stone 2003). The high-quality population registers of northern European countries are also far from perfect. For example, the proportion of foreign-born individuals in the 2014 Swedish population jumps from 6–8% at ages 90–94 to 23% at ages 105+, but there is no similar jump in the proportion of foreign-born among deaths, as the proportion of foreign-born individuals in the population who died after reaching age 90 is fairly stable across all age groups, at 5–7% (Glei et al. 2015). The surprisingly high proportion of foreign-born individuals alive at ages 105 and above suggests that age overstatement is occurring among people whose births were not registered in Sweden. A steep increase in the proportion of foreign-born individuals in the population denominator that does not coincide with a similar increase in the death numerator is a signal of problematic population estimates, and of a nominator-denominator bias at extremely old ages. In light of this growing problem, statistical offices have been forced to begin the open age interval at an age no higher than 100. The Human Mortality Database (HMD), the leading source of population and mortality data at the national level in the world, recommends the use of smoothed death rates at ages 95+ even for countries with high-quality statistics, such as the Western European countries (Wilmoth et al. 2007).

As we noted above, the second data category consists of lists of very old individuals compiled by researchers interested in extreme longevity. The Gerontology Research Group supercentenarian list (GRG 2015) is probably the best example of such a list. It consists of supercentenarians around the world who are known to the GRG and have met the GRG age-validation criteria. Such lists are open to several criticisms. First, what proportion of the target group is captured in the list is not known. Second, the list may be unrepresentative of the age distribution of the extreme aged. For example, newspapers may report on the oldest or the second-oldest person in a country, but not mention younger individuals of extreme ages. Because they are subject to this age-ascertainment bias, these lists cannot be used to measure mortality at extreme ages.

The desire to measure human mortality at extreme ages was the main motivation for the establishment of the International Database on Longevity (IDL) by an international collaborative research group (Maier et al. 2010). The IDL aims to provide highly reliable data on the ages of semi- and supercentenarians that are free of age ascertainment bias; and thus to ensure a solid basis for studying the mortality trajectories of extreme longevity. As the IDL obtains its candidates from the comprehensive records of government agencies, there is no dependency between the probability of being included and age. The candidates who meet strict validation criteria are ultimately included in the IDL. These criteria do, however, vary somewhat from country to country; for more about the validation processes, see Poulain (2010). Nevertheless, the IDL does not include exhaustive sets of validated supercentenarians and semi-supercentenarians for any country. Even if a complete list of individuals who survived to ages 105+ existed for a given country, it would be nearly impossible to find documents that would allow for the validation of the ages of all of the individuals on the list. Most importantly, the IDL guarantees that all of the data in the database are of high quality.

In most countries of the IDL, records of deaths at extreme ages are obtained from the vital registration system. Records of living persons are often more difficult to obtain, particularly for countries without a population register. In the validation process, records that do not meet the age threshold are rejected, and records for which no satisfactory determination cannot be made are annotated as such. Lists of validated semi- and supercentenarian cases may be somewhat biased compared to records on the general population due to the exclusion of two types of cases: (1) those with an incorrect age (age overstatement), and (2) those that could not be validated. For example, it is particularly difficult to validate the age of a person who was born abroad. While the number of validated cases is smaller than the number of candidate cases, if the data quality is good – i.e., if relatively few candidates are discarded – the patterns seen in the age-validated data will also be seen in the candidate data. For example, for France we can see that the numbers line up quite well for the cohorts born between 1883 and 1900 (Fig. 2.1). Only a few candidates in the cohorts born before 1883 could be age-validated because data with individual death records, which are needed for the validation process (records with, for example, name, year, and place of birth), are available in electronic form only from 1983

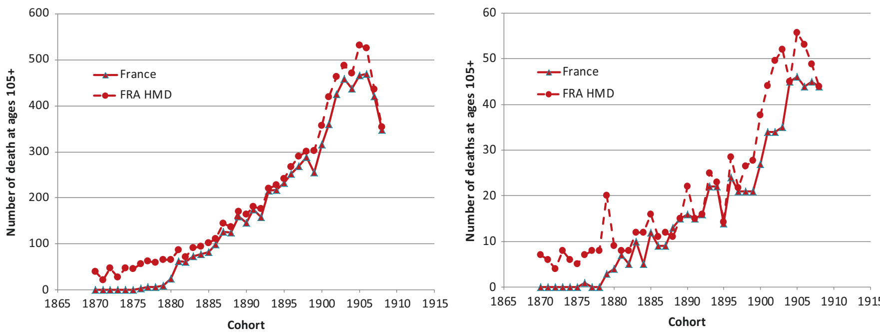

Fig. 2.1 Number of deaths at ages 105+ by cohort in France recorded in the HMD (FRA HMD) and in the IDL (France). Left panel – females, right panel – males

onward. For cohorts born after 1900, the numbers do not line up as well because the validation process has not been completed.

The first version of the IDL was launched in 2010 (Cournil et al. 2010) using the country data described in Maier et al. (2010). This chapter provides an overview of the updated and modified IDL. The new IDL includes all of the IDL-2010 data, as well as new data collected during two rounds of updates. The record content and the format of the new IDL differ from those in the IDL-2010, as we offer formalized descriptions of the metadata by applying a new set of variables.

Most importantly, the threshold age for the new IDL is 105, rather than the age of 110 used in the IDL-2010. Because it is so costly to validate the large number of candidates aged 105–109, for three countries, only a random sample of semi-supercentenarian candidates were put through the validation process. The United States provides only validated cases from a sample randomly drawn from the population, while France and England and Wales also provide full lists of known semi-supercentenarians and information about failures in the validation sample. In the second case, the probability of successful validation can be extrapolated based on the whole list. This approach is called sample validation.

Currently, the IDL includes data from 12 European countries, as well as from Canada, Japan, and the United States. The country-specific details of the validation process are given in the respective country-specific metadata files, which are an essential part of the dataset; and in (Maier et al. 2010). Additional details for some countries can be also found in the country chapters of this book. All of the data were provided either by individual researchers who collected the information from official data sources, or by national statistical agencies. The full list of contributors is given on the IDL website. The pooled IDL dataset was uniformly coded, harmonized, and carefully checked. The standards developed for data collection and presentation ensure the comparability of the present and future collections, and increase the cross-country coherence of the data.

In the next section of this chapter, we describe the main features of the data collection and verification procedures used in compiling the IDL. In the third section, we explain the structure and organization of the data, and describe the main data fields. In the fourth section, we provide a brief overview of the data available in each country. In the fifth section, we discuss the use of data from the IDL. Our concluding remarks are presented in the final section.

2.2 Data Collection

In the following, we describe the main features of the IDL data collection and validation procedures, which should be taken into account by researchers who intend to analyze these data.

2.2.1 Sampling Frames

The IDL deals with individual data sampled from the population. In practice, this means that the IDL collects individual trajectories in a certain age-period frame. The process of data collection eliminates any age ascertainment bias that might otherwise exist. The choice of specific procedures depends on the data availability.

Data might be collected using period or cross-sectional approach. The difference between the two approaches can be explained with the help of the Lexis diagram of Fig. 2.2. There, y0 and y3 denote the years of attainment of the threshold age of 110 for the first and the last cohorts, and y1 and y3 denote the first and the last years of period observation. The area consisting of A, B, C, and D in the Lexis diagram corresponds to the cohort approach: only the supercentenarians born between y0–110 and y3–110 are included. The age w is the age of extinction; i.e., the age of the oldest person alive in the population in the last year of observation y3. This oldest person reached age 110 in the year y2. The complete information can be obtained only for cohorts born between y0–110 and y2–110 (area A+B+C), while the data on supercentenarians born in the year y2–110 or later (area D) might be changed because there are candidates who are still alive. The area consisting of A, B, D, and E corresponds to the period approach; supercentenarians who died in C are excluded. Thus, the data for cohorts born before y1–110 are left-truncated: supercentenarians dying before y1 are excluded. The data representing the area D are still subject to change by future updates also based on a period approach.

As we mentioned above, for several countries, no information is available on individuals who are still alive, resulting in right-truncation. When such information is available, we still do not know the age at death of the then-living; we call this right-censoring. For Japan, the exact age at death cannot be determined, only the year of death and, respectively, the age range within which the death occurred; this we call interval-censoring.

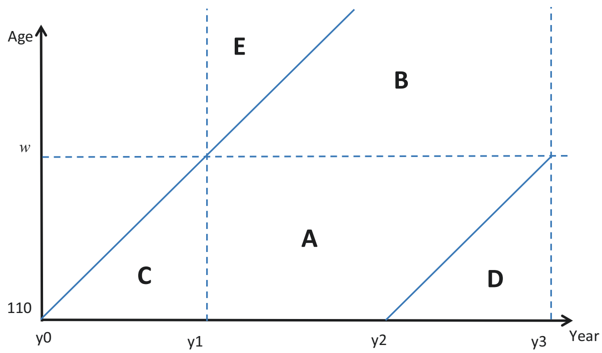

Fig. 2.2 Lexis diagram for data collection: area A+B+C+D – cohort approach; A+B+D+E – period approach; w is the age of extinction in the year y3

2.2.2 Validation Methods

Age validation procedures vary across countries depending on the sources of information that are available in each country. Birth or baptism records are available in some countries; while in others, the validation is performed by checking early census records. In the IDL-2010, the quality of the validation procedures used in the production of the country data was assigned to one of two categories: fully validated, which is the more reliable and desirable level of validation; and carefully checked, which is the less reliable and desirable level of validation. Cases in which the individual's early life documents were validated were classified as fully validated, while all of the other validated cases were classified as carefully checked. In the present version of the IDL, the quality of the validation procedures used is not noted, because in some situations it was difficult to establish the formal criteria needed to distinguish between the two levels of validation. Information about the documents used to validate age in each country is provided by the IDL in standardized country-specific metadata files.

In France and in England and Wales, there were large numbers of semi-supercentenarian candidates, which made the cost of validating all candidates prohibitive. Therefore, in these countries the validation of semi-supercentenarians was done on a sample basis (so-called sample validation). The idea of sample validation is very simple: instead of conducting an exhaustive validation of all candidates, only the candidates in a randomly selected sample are validated in order to estimate the age-specific probability of the successful validation of every candidate (i.e., the probability that the recorded age is correct). In particular, in France a random sample of 100 candidates was selected by choosing 20 records from each one-year age group. We used this non-proportional method of sampling because the value of the observations increases with age. Thus, in France and in England and Wales, the lists of semi-supercentenarians contain all of the known candidates, whereas the records selected for validation contain additional information about the result of the validation process.

The validated list of (semi-) supercentenarians for most countries consists exclusively of individuals who were born in that country. This is because foreign-born candidates often come from countries with poor records. Even when these individuals come from countries with good records, it is necessary to establish cooperation with the country of birth in order to perform an age validation.

2.3 Dataset Structure

The IDL data are classified by country. A country dataset contains as many as four data files: (1) a file of individuals who were alive at age 110 or older, if any; (2) a file of individuals who died at age 110 or older, if any; (3) a file of individuals who were alive at ages 105–109; and (4) a file of individuals who died at ages 105–109.

Each country dataset also includes a metadata file providing information about the data collection process and the validation method. When the exhaustive validation approach was used, the data files consist exclusively of validated records. Sample validated files include cases that have been validated, invalidated (selected for validation but found to be invalid), and not selected for validation.

Each record in the data files describes an individual. The names of the individuals are not provided to IDL users. The data fields can be grouped into the following types of information:

1. information about the date, country, and region of birth;
2. information about the date, country, and region of death;
3. information about the place of current residence and proof of being alive for those alive;
4. source of raw data, including information about the sampling frame;
5. method of validation (sample or exhaustive);
6. description of documents used for validation (birth certificate, census record, etc.)

A detailed description of the data fields and a list of the file names used are provided together with the data files.

2.4 Data Overview

Table 2.1 summarizes the information that the IDL currently has on supercentenarians. Fifteen countries contributed cases – in the case of Canada, for Quebec only. The IDL-2010 also had information for 15 countries, but we dropped Australia because of age-ascertainment bias in its data, and added Austria. New cases have been added for nine countries. The data are on a period basis, i.e. on the individuals who reached the threshold age during a period of years. The new IDL has records for 1304 validated supercentenarians. The large majority of the 138 living supercentenarians are from Japan, for reasons explained below; the other cases are of the supercentenarians who were alive at the time of the most recent investigation in the respective countries, which took place between 2000 and 2016, depending on the country. The first person in the IDL collection who attained age 110 was born in 1852 and died in 1962 in Quebec, while the last person in the collection was born in 1906 and reached age 110 in 2016.

The large number of living supercentenarians in Japan can be explained as follows. In Japan, the primary sources of supercentenarian data are annual government lists of centenarians alive on September 1, by age. Before 2006, these lists were complete; accordingly, an individual's death could be inferred by the first absence of his or her name from the annual lists. Since 2006, however, only those individuals who agreed to be included were listed (Saito 2010); accordingly, the absence of an individual from the list no longer necessarily implies that s/he died.

Table 2.1 IDL data on supercentenarians

Country	Updates	Data frame	Period	Cohorts	Dead	Alive	Year alive	Total SC
Austria	New country	Period, left truncation, right censoring	2005–2012	1895–1902	6	0	2014	6
Belgium	2	Period, left truncation, right censoring	1990–2015	1878–1904	21	2	2015	23
Canada (Quebec)	2	Period, left and right truncation	1962–2009	1852–1898	12	n/a	n/a	12
Denmark	2	Period, left truncation, right censoring	1996–2014	1884–1903	3	1	2014	4
England and Wales	2	Period, left and right truncation	1968–2014	1856–1904	129	n/a	n/a	129
Finland	1	Period, left truncation, right censoring	1989–2006	1878–1896	5	1	2008	6
France	2	Period, left and right truncation	1987–2014	1877–1904	167	n/a	n/a	167
Germany	1	Period, left truncation, right censoring	1994–2005	1883–1894	16	1	2005	17
Italy	2	Period, left truncation, right censoring	1973–2016	1863–1906	143	18	2016	161
Japan	2	Period, interval censoring (annual list of alive)	1963–2005	1846–1895	78	113	1968–2005	191
Norway	1	Period, left and right truncation	1987–2004	1875–1893	8	n/a	n/a	8
Spain	2	Period, left and right truncation	1989–2016	1878–1906	60	n/a	n/a	60
Sweden	1	Period, left truncation, right censoring	1986–2003	1874–1892	10	2	2008	12
Switzerland	1	Period, left and right truncation	1993–2000	1881–1890	4	n/a	n/a	4
USA	2	Period, left and right truncation	1980–2010	1867–1899	504	n/a	n/a	504
Total					1166	138		1304

Seven countries did not provide data on living supercentenarians because these data were unavailable due to data protection policies. Finally, all of the countries except France provided data based on the period approach.

Data on semi-supercentenarians were provided by 12 countries (Table 2.2), but not for Finland, Sweden, and Spain. Except for Germany and Switzerland, these

Table 2.2 IDL data on semi-supercentenarians

Country	Data frame	Period	Cohorts	Dead	Alive	Year alive	Type of validation	Total SSC
Austria	Period, left truncation, right censoring	2003–2014	1893–1909	261	44	2014	Exhaustive	305
Belgium	Period, left truncation, right censoring	1977–2015	1870–1910	784	61	2015	Exhaustive	845
Canada (Quebec)	Period, left and right truncation	1985–2009	1877–1904	321	n/a	n/a	Exhaustive	321
Denmark	Period, left truncation, right censoring	1970–2014	1863–1909	447	33	2015	Exhaustive	480
England and Wales	Period, left and right truncation	2000–2014	1890–1909	1027	n/a	n/a	Sample	1027
France	Period, left and right truncation	1978–2014	1870–1909	7467	n/a	n/a	Sample	7467
Germany	Period, left truncation, right censoring	1989–2005	1881–1898	928	25	2005	Exhaustive	953
Italy	Period, left truncation, right censoring	2009–2015	1899–1910	2336	1198	2016	Exhaustive	3534
Japan	Period, interval censoring (annual list of alive)	1995–2005	1886–1895	28	2836	1854–1898	Exhaustive	2864
Norway	Period, left and right truncation	1986–2006	1877–1899	220	n/a	n/a	Exhaustive	220
Switzerland	Period, left and right truncation	1971–2005	1864–1900	236	n/a	n/a	Exhaustive	236
USA[a]	Period, left and right truncation, sample	1979–2009	1871–1899	338	n/a	n/a	Exhaustive for sample	338
Total				14,393	4197			18,590

[a]For males ages 105–109 and females ages 108–109. Data for two randomly selected samples

data were collected after 2010. The current IDL includes 18,590 semi-supercentenarians. Most of the 4197 living semi-supercentenarians are from Japan, for the reason described earlier.

The lists of semi-supercentenarian cases were compiled in the same way as the corresponding lists of supercentenarians in all of the countries except England and Wales, France, and the U.S.

The first two countries used the sample validation approach; i.e., for England and Wales and France, all of the candidates appear on the list, but only a sample of cases randomly drawn from this list was validated. In England and Wales, 12% of the female deaths and 100% of the male deaths underwent a validation exercise. In France, where the pool of candidates came from a high-quality data source, a sample of 100 cases was chosen for validation, and 99 of these cases were validated. The last record could not be validated because the place of birth was missing, which meant that the municipality that could be approached to obtain a birth record was not known. All the U.S. semi-supercentenarian data in the IDL represent cases that were validated using the validation protocol that was also applied in validating supercentenarians (Kestenbaum and Ferguson, 2010); however, the list of candidates was limited to a sample representing only around 10% of the universe of candidates.

2.5 Using the IDL

Because its method of construction avoids the type of age-ascertainment bias that plagues other collections of records of the extreme aged, the IDL provides researchers with an opportunity for a careful analysis of extreme longevity. Whichever analysis approach is used – regardless of whether it is based on classic Bayesian theory or extreme-values theory or something else – the analyst needs to be aware of and account for the characteristics of the IDL collection. First, it is important to keep in mind that the IDL is a collection of validated individual cases. Although all of the country samples of (semi-) supercentenarian cases were randomly drawn, the cases that have been validated might be selective with respect to place and year of birth. Second, only certain countries and certain cohorts and time periods are represented. A related issue is that the number of supercentenarians in the IDL is fairly small. Additionally, because the number of contributing countries varies from one time period to another, comparisons over time of the oldest supercentenarian, or even of the average age of supercentenarians, can be misleading. Third, because some of the cohorts are not yet extinct, the complete set of mortality probabilities are not directly observed. Moreover, some countries do not even provide counts of their residents who are alive at extreme ages.

We believe, for example, that an analysis of IDL data performed recently by Dong et al. (2016) to support their controversial thesis that the limit to the human lifespan has already been reached is flawed. The authors tabulated combined data for England and Wales, France, Japan, and the United States from the IDL-2010 database to demonstrate, among other things, that the annual average age at death of supercentenarians did not increase from 1968 to 2006. Figure 2.3 shows these average supercentenarian ages at death along a dashed red line with open circles. Clearly, the observations from 1968 to 1980 are critical to their conclusion, as are the observations between 2000 and 2006.

But, as shown by the blue line in Fig. 2.3, the numbers of supercentenarian deaths before 1980 are tiny or nil: there were none in 1969, 1971, 1972, 1974, and 1975; only one in 1968, 1970, 1973, 1975, and 1977; and only three in 1978 and 1979. For the years 2000 to 2006, the lines with the solid triangles reflect the fact

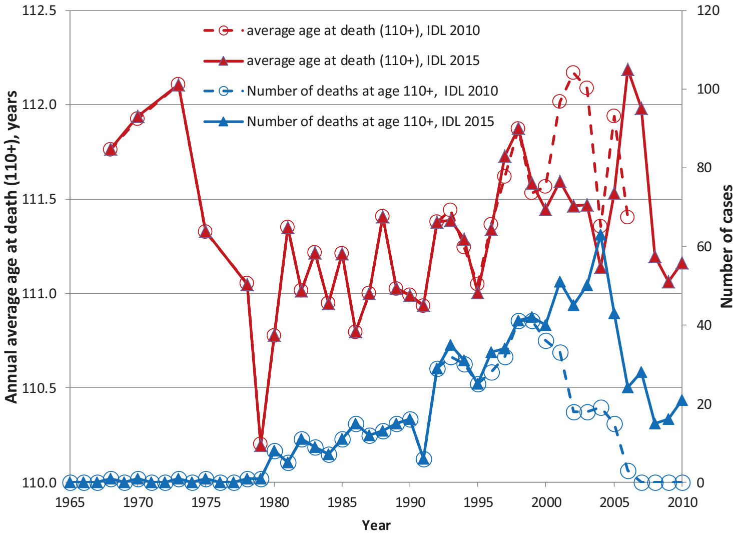

Fig. 2.3 Average age at death of individuals who died at ages 110+ (red lines), and the number of such supercentenarians (blue lines) according to the IDL-2010 (dashed lines with open circles) and the IDL-2015 (solid lines with triangles)

that the counts for those years in the earlier dataset used by Dong et al. were incomplete because some supercentenarian deaths had not yet occurred, and because some data had not yet been obtained and validated. Thus, the revised pattern is quite different. Indeed, over the periods with the most reliable data – roughly 1980–2007 for IDL-2015 and 1980–2003 for IDL-2010 – the average age at death was generally increasing.

2.6 Summary

The IDL, with its high-quality age-validated individual-level data on the ages of semi-supercentenarians and supercentenarians, and its goal of avoiding age-ascertainment bias, is a uniquely valuable source of information on extreme human longevity. Of course, like all data collections, the IDL has its limitations, and research using the IDL will be affected by those limitations. Among the main drawbacks of the IDL is that its coverage is limited to certain countries and times, and that the validation methodology is not uniform across countries.

Unfortunately, the recent changes in data protection rules and the general tendency toward limiting access to personal data, even for scientific research, are likely to make future updates of the IDL more and more problematic. Nonetheless, we are hopeful that the IDL will be expanded, despite the increasing strictures on access to personally identifiable information.

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Part II
Mortality and Longevity Studies

Chapter 3
Mortality of Supercentenarians: Estimates from the Updated IDL

Jutta Gampe

3.1 Introduction

Contributors to the IDL have made concerted efforts to collect data on individuals who survived to extreme ages that are free of age-ascertainment bias. The age of each of these individuals has been thoroughly validated. In their book on supercentenarians, Maier et al. (2010) described these efforts in detail, and the conclusions derived for human mortality beyond age 110 were presented in one of the chapters (Gampe 2010). The results were striking. Mortality was found to be flat after age 110, at a level corresponding to an annual probability of death of 50%. No differences between males and females could be detected, and no differences in levels of mortality were found between earlier and later birth cohorts.

Since then, the contributors to the IDL have continued their data collection and validation efforts. Consequently, the number of supercentenarians in the database has roughly doubled. The details of the IDL update and the specific data collection procedures are described in this volume (see Chap. 2). Here, the updated data are used to re-estimate the trajectory of human mortality beyond age 110.

3.2 Observation Schemes and Estimation Procedure

As survival to extreme ages is by definition rare, it is necessary to combine data from several countries to arrive at samples that are sufficiently large to allow us to make reliable inferences. The observation plans that are implemented depend on the available data in each country, and properly accounting for these sampling plans in the data analysis is crucial for generating unbiased results.

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Two main observation plans can be found in the IDL. For countries with accurate population registers, both the number of supercentenarians who have died before a specific target date and the number who are alive at this date can be determined, which leads to observed ages at death as well as right-censored (still alive) observations. The other prominent observation scheme provides the deaths of all supercentenarians that occurred between two specific (period) dates. The consequences of such a sampling plan have been discussed in Gampe (2010), and the key figure is reproduced here for easier reference; see Fig. 3.1.

If only events (deaths) that occurred between two time points, t_1 and t_2, are recorded, then individuals have to die ‘young enough’ – that is, before t_2 – to be included in the sample, while those who have been living ‘too long’ will not be seen in the data. As a consequence, we are not aware of individuals alive who are exposed to the risk of death during the sampling period, and this effect needs to be accounted for in the estimation procedure. This condition, whereby observations are included only if the event has occurred before the age when the individual would have left the sampling frame at time t_2, is called right-truncation. Incorporating this sampling condition in the analysis is essential for obtaining unbiased estimates. As the number of supercentenarians has been growing in recent years, ignoring right-truncation can have substantial effects. Adjusting observations for general censoring and truncation patterns has a long tradition. This practice was discussed in Dempster et al. (1977); and, for the model we use here, in Pagano et al. (1994).

Variations of these two main sampling plans have been implemented in some countries, the details of which were discussed in Chap. 2 (Jdanov et al., this volume).

The second choice that has to be made is regarding the specific distributional model that is assumed for the variable of interest; here, life spans after age 110. While global parametric models are parsimonious and efficient, they determine the tail behavior or the distribution, and, hence, the hazard trajectory in the limit. By contrast, flexible (quasi-)nonparametric models in the spirit of life table analysis allow for the investigation of the hazard without such global assumptions. However, the flexibility in these models comes at the price of much greater variability in the estimates.

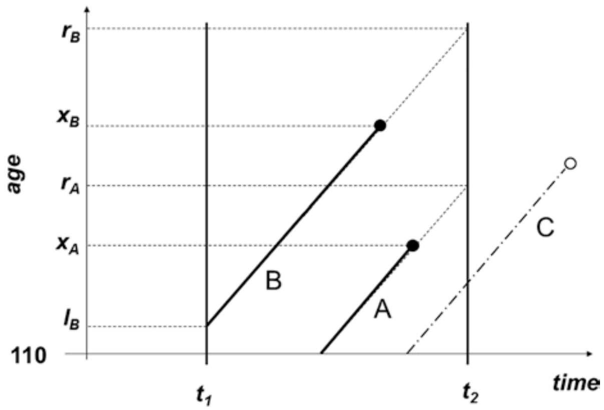

Fig. 3.1 Sampling frames, illustrating left- and right-truncation; from Gampe (2010)

The analysis strategy we pursue here is the same as the strategy used in Gampe (2010). The EM algorithm (Dempster et al. 1977) is employed to estimate a flexible model (Pagano et al. 1994) from the truncated and censored data. Standard errors for the estimates are not automatically provided by the EM algorithm, and several methods for estimating them have been suggested; see McLachlan and Krishnan (2008). Since the observed data information matrix (i.e., based on the incomplete data log-likelihood) can be derived analytically here without too much effort, this approach, which avoids numerical differentiation, was pursued. Standard errors for derived quantities, such as the survival function or the annual probabilities of death, are then determined by the delta method.[1]

3.3 Results

In the previous analysis of the IDL data, the data from all countries were combined to achieve a sufficiently large sample size. The United States contributed a large share of the data in this analysis (341 out of 637 individuals). Obtaining separate estimates for different geographical regions is desirable. The increased number of individuals in the updated IDL allows us to conduct separate analyses for the U.S. on the one hand and the European countries on the other. We have also chosen to analyze the data for Japan separately, even though the sample size for this country is relatively small. Table 3.1 summarizes the three subsamples.

We first consider the sample for the United States. The estimates of the survival function for the flexible model, based on intervals of single years of age, is shown in the left panel of Fig. 3.2, with 95% confidence intervals added. The right panel shows the corresponding annual probabilities of death (again, with 95% confidence intervals). Uncertainty for the annual probabilities of death increases quickly, and is large after age 113, at which point the data are too sparse to allow for an accurate

Table 3.1 Summary of three regions analyzed separately (top) and the contributions of different countries to the European sample (bottom)

Country	USA	Europe	Japan
Women	442	531	139
Men	44	42	21
Total	486	573	160

Country	FRA	ITA	BEL	ESP	EW	DEN	SWE	NOR	FIN	AUT	CHE	GER
Women	160	125	20	51	121	4	11	8	5	6	4	16
Men	5	11	3	9	7	0	1	2	1	0	0	3
Total	165	136	23	60	128	4	12	10	6	6	4	19

[1] Quadratic approximations to the log-likelihood can be problematic for estimates close to zero or one, leading to confidence intervals that extend beyond the unit interval for probabilities; alternative parametrization of the model via log-odds can mitigate this effect.

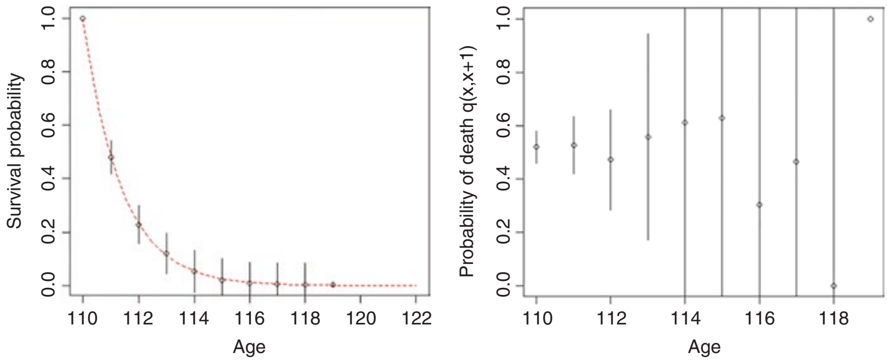

Fig. 3.2 Survival function (left) and the annual probability of death (right) for data from the U.S. Estimates for the flexible model are based on one-year intervals of age; the vertical bars give 95% confidence intervals. The red dashed line is the survival curve resulting from an exponential distribution, estimated by the maximum likelihood for the same data

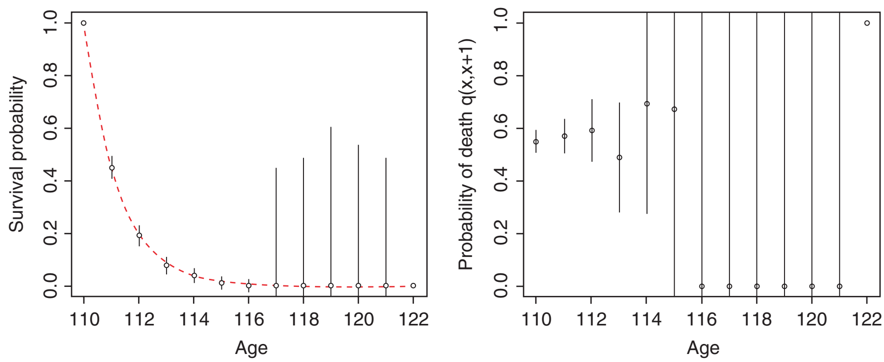

Fig. 3.3 Survival function (left) and the annual probability of death (right) for the combined data from European countries. Estimates for the flexible model are based on one-year intervals of age; the vertical bars give 95% confidence intervals. The red dashed line is the survival curve resulting from an exponential distribution, estimated by the maximum likelihood for the same data

assessment. The flexible model is restricted to the range defined by the maximal observed age at death (which is 119 for the U.S.).

The shape of the survival curve suggests an exponential model, implying a constant hazard; and the resulting estimate is added in Fig. 3.2, with the parameter λ estimated by the maximum likelihood from the same data. The two survival curves are in (surprisingly) close agreement.

The estimated value $\hat{\lambda} = 0.7238$ (s.e. 0.0343) corresponds to an annual probability of death $\hat{q} = 0.5151$.

The same analysis was repeated with the IDL data from the European countries; the results are displayed in Fig. 3.3. Again, the level of agreement between the flexible model and the exponential model is striking, and the estimated hazard parameter is $\hat{\lambda} = 0.7953$ (s.e. 0.0365). The estimated parameter is slightly higher, but is comparable to the estimate from the U.S. The corresponding estimated annual probability of death is $\hat{q} = 0.5486$.

The confidence intervals in Fig. 3.3 nicely illustrate the uncertainty implied by the right- truncated observations in the European data. The largest observation in the European data is for Jeanne Calment (at age 122), and the second largest observation is at age 116. Since there are no observed deaths in between these ages, the probability for these ages is practically zero. However, there is incomplete information on the possibly existing, but unobserved (because of right-truncation) supercentenarians who are still alive. This uncertainty about unobserved exposures is reflected in the stark increase in uncertainty for those ages.

Finally, the same analysis was performed for Japan. Although the sample is considerably smaller (160 individuals, 139 women, 21 men), Japan is of particular interest since it has been the record holder in life expectancy for many years. The results are presented in Fig. 3.4. The correspondence with the exponential distribution is less clear than it is for the U.S. and Europe, but if we estimate an exponential distribution, the estimated hazard is $\hat{\lambda} = 0.5891$ (s.e. 0.0481), which implies an annual probability of death $\hat{q} = 0.4452$.

Figure 3.5, left panel, summarizes the three estimates of $\hat{\lambda}$ for the U.S., Europe, and Japan. For Europe and the U.S., we estimated separate parameters for men and women; the resulting estimates of λ are given in Table 3.2. Although the point estimates are different, the uncertainty in the estimates (due to low numbers of male supercentenarians) does not allow us to reject the hypothesis that men and women have the same level of mortality; see also Fig. 3.5, right panel.

To investigate potential temporal trends in the level of mortality, both the European and the U.S. sample were split into early and late cohorts. The split was made so that the resulting subsets were of comparable size. Since the U.S. and the European data cover different birth cohort ranges, the split into early and late cohorts was done differently for the two samples. In the U.S. data, those individuals born

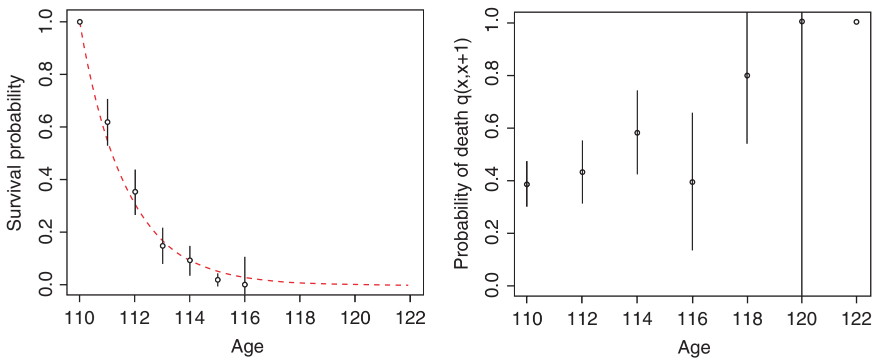

Fig. 3.4 Survival function (left) and the annual probability of death (right) for data from Japan. Estimates for the flexible model are based on one-year intervals of age; the vertical bars give 95% confidence intervals. The red dashed line is the survival curve resulting from an exponential distribution, estimated by the maximum likelihood for the same data

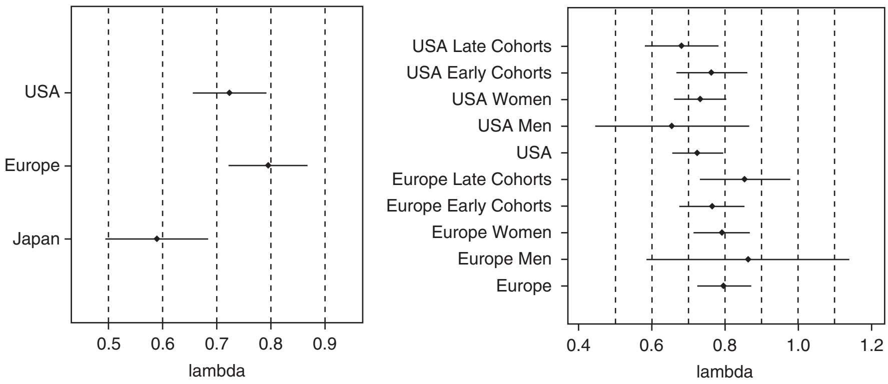

Fig. 3.5 Maximum likelihood estimates of the parameter λ assuming an exponential distribution for life spans after age 110. The horizontal bars give 95% confidence intervals. The details are summarized in Table 3.2

Table 3.2 Table of the maximum likelihood estimates of λ from different samples

Sample	MLE $\hat{\lambda}$	s.e.($\hat{\lambda}$)
Europe	0.7953	0.0365
Europe Men	0.8617	0.1387
Europe Women	0.7898	0.0379
Europe Early	0.7629	0.0448
Europe Late	0.8520	0.0619
U.S.	0.7238	0.0343
U.S. Men	0.6537	0.1049
U.S. Women	0.7313	0.0362
U.S. Early	0.7609	0.0480
U.S. Late	0.6805	0.0495

before 1887 (252 observations) were included in the early cohort, while those individuals born in 1887 or later (234 observations) were included in the later cohort.

In the European data, those individuals born before 1896 (293 observations) were included in the early cohort, while those individuals born in 1896 or later (280 observations) were included in the later cohort.

The resulting parameter estimates are summarized in Table 3.2, and are displayed in Fig. 3.5, right panel. For both regions, there is no evidence that the mortality levels of the early and the later birth cohorts differ.

3.4 Discussion

The updated version of the IDL allows for a re-analysis of the life span distribution after age 110, and hence the trajectory of human mortality beyond this age. The proper incorporation of censoring and truncation patterns is essential for the analysis. Estimates can be obtained via the EM algorithm for a flexible model that does not determine the global tail behavior of the distribution. The results of the model of constant mortality, implied by the exponential distribution, show strong agreement with the estimates obtained from the flexible model for both the European and the U.S. samples, in which the levels of mortality are found to be comparable.

Differences in mortality between the sexes cannot be detected in either sample due to the low numbers of male supercentenarians. A comparison of the mortality levels of earlier and later cohorts did not uncover significant differences in either the U.S. or the European dataset.

Thus, given these results, we confirm that the basic conclusions stated by Gampe (2010) still hold.

The picture for the data from Japan is less clear, as the mortality level for this dataset is lower, and the outcomes do not align as closely with the estimates of the exponential model. Because the sample size for Japan is much smaller, the conclusions are not as clear for this country as they are for Europe and the United States.

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Chapter 4
Does the Risk of Death Continue to Rise Among Supercentenarians?

Francisco Villavicencio and José Manuel Aburto

4.1 Introduction

Does the human force of mortality increase after age 110? A study by Gavrilova et al. (2017) published in the *2017 Living to 100 Monograph* suggests, in contrast to previous research, that this may effectively be the case. By fitting a Gompertz model to estimated central death rates for the oldest old, they aimed to prove that these rates continue to increase with age, and to challenge existing theory and empirical research indicating a deceleration of mortality at older ages and the emergence of a plateau (Gampe 2010; Robine and Vaupel 2001, 2002). Despite the efforts made by Gavrilova and colleagues to validate their hypothesis, we believe that their results are inconclusive for three reasons that we discuss in the following: (1) the data selection was arbitrary; (2) the statistical analysis was inappropriate; and (3) the

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presentation of the results is misleading and inadequate. The main flaw in this study is that the authors focused on the analysis of cohorts with no survivors beyond age 115, and systematically assumed that the probability of death at that age is 1. Furthermore, they do not mention any considerations about the uncertainty of the estimated central death rates.

We have carried out our analyses using the open-source statistical software R (R Core Team 2018). The results and the figures presented here are fully reproducible from the code and data available in the supplementary materials.

4.2 Selection of the Data

Gavrilova et al. (2017) analyzed data from two sources: the International Database on Longevity (IDL 2017) and the Gerontology Research Group Database on Supercentenarians (GRG 2017). The IDL contains all of the validated records of individuals aged 110 years and older – the so-called supercentenarians – from 15 countries, such that the inclusion of a person in the database does not depend on his or her age (Maier et al. 2010). The GRG aims to authenticate cases of the oldest humans in history, but its data may not be suitable for analyzing age patterns of mortality. For instance, the probability of being considered for inclusion in the GRG database increases with age, as older people get more attention in the media. Thus, individuals who died at ages 110 or 111 may be underrepresented in the GRG. Accordingly, our analysis of the work by Gavrilova and colleagues is restricted to the results they obtained with data from the IDL.

The data that were publicly available from the IDL as of 29 November 2017 were last updated on June 2010, and the last observed death dates from 2007 (IDL 2017). This dataset includes 672 supercentenarians born between 1852 and 1898. We have made these data available in the supplementary materials because they correspond to those used by Gavrilova et al. (2017). To avoid dealing with censored individuals, the only data Gavrilova and colleagues considered in their analyses were from cohorts born in 1894 or earlier, whom they believed to be extinct. It is our view, however, that this assumption is inaccurate, because one of the supercentenarians who were reported alive in the IDL from Germany was born in 1894. Thus, it does not appear to be the case that all of the cohorts in the database born in 1894 or earlier were extinct at the time of data collection. It is unclear how the authors dealt with this individual; that is, whether they assigned her a date of death extracted from another source, or simply excluded her from the study. In addition, their analytical strategy did not account for the presence of right-truncated individuals due to country-specific sample designs – which, as Gampe (2010) has pointed out, could affect mortality estimates.

These problems notwithstanding, let us assume for the sake of convenience that we are dealing exclusively with cohorts who are extinct. Gavrilova and colleagues went one step further and divided the data into cohorts born in 1852–1884 and cohorts born in 1884–1894, while focusing on the latter. They justify this decision by arguing that cohorts born in 1884–1894 “have the largest number of cases in IDL

(401) and hence are likely to be more complete" (Gavrilova et al. 2017, p. 4). However, this division of the data is arbitrary, and seems to hide a certain degree of intentionality, as the 400 dead supercentenarians from the IDL who were born in 1884–1894 (excluding the living individual from Germany) died between the ages of 110 and 115. If Gavrilova and colleagues had extended the analysis to the cohorts 1880–1894, they would have had to include 115 additional individuals, one of whom died at the age of 119. Moreover, if they had extended the interval to 1875–1894, they would have ended up with a total of 601 supercentenarians, among whom are three individuals who died at ages 117, 119, and 122, respectively (IDL 2017).

Selecting a subset of the data that only includes supercentenarians who died at age 115 or younger, and ignoring those individuals who survived beyond that age, is an example of selection bias. Such a bias may have a strong effect on the analysis, leading to incorrect results and compromising the validity of the conclusions.

4.3 Statistical Methods

Gavrilova et al. (2017) claim to have proved wrong that human mortality after age 110 is flat, a hypothesis they attribute to Gampe (2010). This is, however, a misinterpretation of Gampe's results, since in her conclusion she states that death rates are constant between the ages of 110 and 114 only, and that beyond age 114 the data become too sparse to make reliable statements (Gampe 2010). Moreover, they complain that "Gampe wrote her own program for hazard rate calculation, rather than using estimates provided by standard statistical packages, so it is difficult to test and reproduce her results" (Gavrilova et al. 2017, p. 15). We believe this criticism is unjustified for two main reasons. First, Gampe (2010) provides a complete formal mathematical description of her model, including details on the likelihood function and the different types of data (sampling frames of truncated and censored observations). This information can be used to implement the model with the preferred statistical software. Second – and perhaps more importantly – because built-in software packages are sometimes not flexible enough for the analysis of data with certain particularities, and it is essential in such situations to proceed with care. This is the case for the age-interval death rates computed by Gavrilova and colleagues using existing functions from a commercial statistical software package. Letting D_x denote the deaths within the age interval $[x, x + \Delta x]$, and N_x the number alive at the beginning of that interval, the corresponding central death rates are estimated as

$$M_x = \frac{1}{\Delta x} \frac{q_x}{1 - q_x / 2}, \tag{4.1}$$

where Δx is the length of the age interval and $q_x = D_x/N_x$ (Gavrilova et al. 2017, p. 4, although a slightly different notation is used here).

This method for assessing death rates provides a reasonable estimation for large samples, but turns out to be inappropriate in the analysis of the data on supercentenarians. First, the method implies that the probability of death in the last age is always $q_x = 1$, and the corresponding central death rate $M_x = 2$ when $\Delta x = 1$. This is wrong because the IDL reports validated individuals who lived up to age 122 (Jeanne L. Calment, 1875–1997), and these individuals are ignored by restricting the analysis to cohorts who died at age 115 or younger (1884–1894). While reaching higher ages may be unlikely, building a model that assumes that the probability of death at age 115 is 1 is equivalent to the assumption that no human being can survive beyond that age, which is false. In addition, as we will discuss in greater detail later, it is important to note that the estimated central death rates for the highest ages are not trustworthy due to the scarcity of data. For instance, only three individuals from the 1884–1894 birth cohorts reached age 115 (IDL 2017), and attempting to compute a rate with only three observations is highly questionable. Accepting the limitations of the data, Gampe (2010) concluded that her results are reliable for ages 110–114 only. Gavrilova et al. (2017), by contrast, did not mention any such considerations.

As a final remark, note that the IDL provides data on a daily time scale – meaning that it is possible to know how many days a supercentenarian lived after his or her last birthday – and it is worth using that information. Gavrilova and colleagues provide an estimation of central death rates for the 1884–1894 birth cohorts from the IDL in quarter-year age intervals (Gavrilova et al. 2017, Fig. 4), but most of their analysis focused on single-year estimates.

4.4 Analysis of the Results

When publishing a paper, providing replicable results is always good practice. When criticizing the replicability of someone else's work, it is a must. The results presented by Gavrilova et al. (2017) are confusing and misleading, and we have only been able to reproduce some of their findings after making additional guesses not detailed in their manuscript.

4.4.1 Estimates of the Gompertz Parameters

We begin by looking at Table 4.1, which reproduces Table 2 in Gavrilova et al. (2017). This table shows their estimates for the parameters of the Gompertz model, fitted to the central death rates of five subgroups of supercentenarians from the IDL: birth cohorts 1884–1894; cohorts 1884–1894 born in the USA; birth cohorts 1884–1894 with high-quality age validation; birth cohorts 1884–1894 measured in quarter-year age intervals; and cohorts born before 1885.

Table 4.1 Reproduction of Table 2 in Gavrilova et al. (2017): Parameters of the Gompertz model fitted to five subgroups of supercentenarians from the IDL (2017). Values between parentheses represent 95% confidence intervals

Subgroup	Slope parameter	Intercept parameter
Birth cohorts 1884–1894		
All	0.163	9.61×10^{-9}
	(0.047, 0.279)	$(-1.15 \times 10^{-7}, 1.34 \times 10^{-7})$
Born in the USA	0.204	9.76×10^{-11}
	(0.071, 0.337)	$(-1.35 \times 10^{-9}, 1.54 \times 10^{-9})$
All in group A (high quality data)	0.165	8.03×10^{-9}
	(0.043, 0.287)	$(-1.01 \times 10^{-7}, 1.17 \times 10^{-7})$
All, quarter-year age intervals	0.214	3.22×10^{-11}
	(0.073, 0.355)	$(-4.76 \times 10^{-10}, 5.40 \times 10^{-10})$
Older birth cohorts born before 1885		
All	0.018	0.095
	(−0.072, 0.108)	(−0.853, 1.043)

In Table 4.1, the Gompertz parameters are labelled "slope" and "intercept", respectively. Nevertheless, rather than providing estimates of the intercept parameter, Gavrilova et al. (2017) provide its exponential. The force of mortality (hazard rate or risk of death) of the Gompertz model is usually expressed as

$$\mu(x) = \mathrm{e}^{a+bx} = A\mathrm{e}^{bx}, \tag{4.2}$$

where x corresponds to age, and a, b, and A are parameters, with $A = \mathrm{e}^{a}$. In a natural logarithmic scale, the Gompertz force of mortality becomes a linear equation in which one intuitively identifies b as the slope and a as the intercept. However, Gavrilova et al. (2017) provide values of A instead of a. This is confusing, and has a strong effect on how we read their results. In the estimates of parameter A (right column in Table 4.1), the confidence intervals include negative values. We should therefore contemplate the possibility that $A < 0$. But following Eq. (4.2), if A is negative, so is the force of mortality, which contradicts the definition of death rate. While trying to reproduce their results, we have not been able to recover these same confidence intervals.

Following Eq. (4.1), Gavrilova et al. (2017) estimated central death rates for each of the five subgroups of supercentenarians described in Table 4.1. Next, they estimated parameters A and b by fitting the Gompertz model defined in Eq. (4.2) to each of these subgroups with a weighted non-linear regression. We have reproduced this procedure in R (R Core Team 2018) and using the same software as Gavrilova et al. (2017), obtaining identical results in both cases (the R code is available in the supplementary materials). Still, there is not an exact match between our estimates and theirs, as we recovered all five values for the slope parameter b (second column in Table 4.1), but only two out of five estimates of A (third column in Table 4.1). We can only attribute these differences to typos in their manuscript, since the remaining estimates coincide and we used the same methodology.

4.4.2 Graphical Display

We have also attempted to reproduce Figs. 1 to 5 in Gavrilova et al. (2017), five graphical representations of the estimated central death rates in a logarithmic scale for each of the five subgroups in Table 4.1. If we focus on the estimated Gompertz parameters for the 1884–1894 cohorts born in the USA (second row in Table 4.1), the following values are given: 0.204 for the slope, and 9.76×10^{-11} for the (exponential of the) intercept. We would expect these estimates to match the regression line of Fig. 2 in Gavrilova et al. (2017), but this is not the case. Clearly, the slope of that line is not 0.204, and the intercept is far from 9.76×10^{-11} (a value close to 0), which supports our claim that by "intercept parameter" they meant parameter A in Eq. (4.2). Through a process of trial and error, we found that most of the plots displayed by Gavrilova et al. (2017) are in logarithm base 10 rather than in the natural logarithm, which is not mentioned in the manuscript. The Gompertz model becomes a linear equation when applying both the natural logarithm and the logarithm in a different base. But in this second case, a reparameterization is required, which is why the natural logarithm is used more often.

Figure 4.1 below reproduces Fig. 2 in Gavrilova et al. (2017) by plotting the estimated central death rates in logarithm base 10. The data comprise 145 individuals born in the USA in 1884–1894 who died between the ages of 110 and 115 (IDL 2017). The central death rates, as well as the data used for their estimation, are shown in Table 4.2.

Line y_1 in Fig. 4.1 corresponds to the Gompertz parameters estimated by Gavrilova et al. (2017) as shown in Table 4.1, provided that $\ln(9.76 \times 10^{-11}) \approx -23.05$. Line y_3 are these same parameters transformed into logarithm base 10, whereas y_2 is a simple linear regression among the estimated central death rates in logarithm base 10. Surprisingly, we find that the line that best reproduces the original figure is y_2, which suggests that Gavrilova and colleagues first estimated the Gompertz parameters using a weighted non-linear regression ($b = 0.204$, $A = 9.76 \times 10^{-11}$); then transformed the estimated rates into logarithm base 10; and, finally, plotted the linear regression among these transformed rates while ignoring the previously estimated Gompertz parameters. Unfortunately, Gavrilova and colleagues do not provide any values for their estimated rates, nor the equations of the regression lines of the plots. The reader's analysis is limited to a visual inspection of their graphs. But if we are right in our assessment, which seems to be the most reasonable explanation, the approach they used to produce their plots is unorthodox and misleading.

We have also been able to reproduce Figs. 1, 3, 4, and 5 from Gavrilova et al. (2017) following the same procedure: first, we estimate the central death rates using Eq. (4.1); second, we plot the corresponding values in logarithm base 10; and finally,

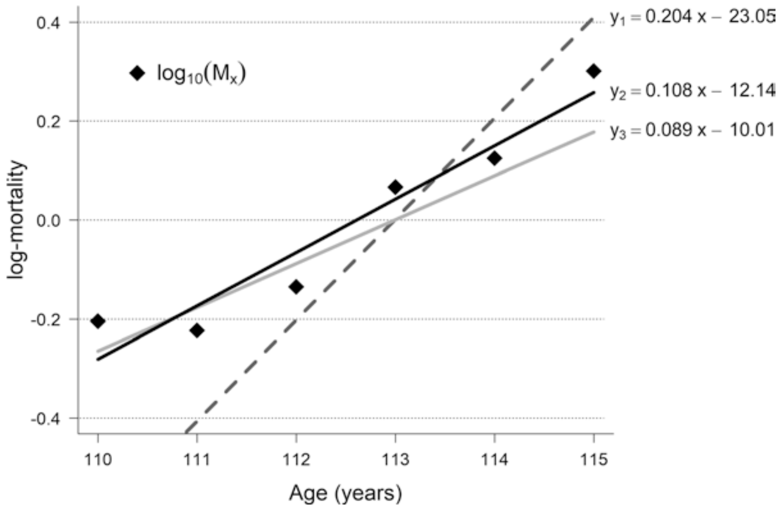

Fig. 4.1 Estimated central death rates in logarithm base 10 from Table 4.2 (as in Fig. 2 in Gavrilova et al. 2017). Supercentenarians from birth cohorts 1884–1894 born in the USA. Line y_1 corresponds to the Gompertz parameters estimated by Gavrilova et al. (2017) with a weighted non-linear regression (Table 4.1). Line y_3 are these same parameters transformed into logarithm base 10, whereas y_2 is a simple linear regression among the estimated central death rates in logarithm base 10, and is the line that best reproduces the original graph by Gavrilova and colleagues (Source: IDL 2017)

Table 4.2 Central death rates estimated using Eq. (4.1). Supercentenarians from birth cohorts 1884–1894 born in the USA (Source: IDL 2017)

x	110	111	112	113	114	115
N_x	145	76	41	19	5	1
D_x	69	35	22	14	4	1
q_x	0.4759	0.4605	0.5366	0.7368	0.8000	1.000
M_x	0.6244	0.5983	0.7333	1.1667	1.3333	2.0000
$\log_{10}(M_x)$	−0.2045	−0.2231	−0.1347	0.0669	0.1249	0.3010

we add the regression line among those transformed rates (the reader is referred to the R code in the supplementary materials to generate these figures). Furthermore, in their Figs. 1 to 3, 5, and 9, the central death rate of the highest age is always around 0.3. Not by accident, $\log_{10}(2) = 0.301$, which confirms our suspicion that they assumed the probability of death at age 115 to be 1 (except in Fig. 5, in which the highest age is 122), and estimated the corresponding central death rate at 2. It should also be noted that in their Figs. 4, 7, and 8, the death rate for the oldest age in logarithm base 10 is 0.903, which corresponds to a central death rate of 8. This astronomically high rate is an artifact of applying Eq. (4.1) with an interval of length $\Delta x = 0.25$ to account for the quarter-year age scale. The death rates of 8 for the last age groups in their Fig. 12 confirm this interpretation.

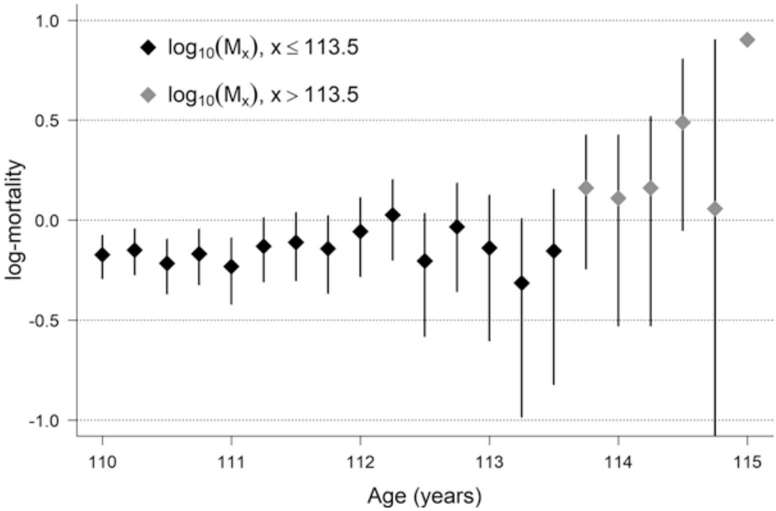

Fig. 4.2 Central death rates estimated using Eq. (4.1) in logarithm base 10, measured on a quarter-year age scale (as in Fig. 4 in Gavrilova et al. 2017). Supercentenarians from the 1884–1894 birth cohorts. Vertical lines represent 95% empirical confidence intervals obtained from data simulation. Note that the point at age 115 has a value of $\log_{10}(8) = 0.9031$. For $x = 114.75$ the confidence interval is $(-\infty, 0.9031]$, although the lower bound is not displayed in the graph (Source: IDL 2017)

4.4.3 Confidence Intervals of the Central Death Rates

Figure 4.2 below displays central death rate estimates for the 1884–1894 birth cohorts on a quarter-year age scale (as in Fig. 4 in Gavrilova et al. 2017). The vertical lines represent 95% confidence intervals, and illustrate how uncertain the point estimates of the central death rates for the oldest old are given the scarcity of data. Regrettably, Gavrilova and colleagues did not take this uncertainty into account when estimating the Gompertz parameters. On the contrary, they highlight that "[i]t is also interesting to note that at very old ages (114 to 115 years), hazard rates grow in fact more steeply than predicted by the Gompertz law" (Gavrilova et al. 2017, p. 6).

Due to the low number of observations at the oldest ages, the assumptions of the central limit theorem do not hold, and the standard methods used to compute confidence intervals are not valid. Hence, we carried out data simulation to extract empirical confidence intervals (additional details on the simulation process are provided in the Appendix, and the R code is available in the supplementary materials). For instance, we observe that the 95% empirical confidence interval for the probability of death at 114.75 is [0, 1]. Only one death was registered in this age category for the 1884–1894 birth cohorts (IDL 2017), which increases the level of uncertainty to the point where any probability of death is plausible. Following Eq. (4.1), the corresponding empirical confidence interval for the central death rate is [0, 8] (quarter-year age scale, $\Delta x = 0.25$), which leads to a 95% empirical confidence interval of $(-\infty, 0.9031]$ for the central death rate in logarithm base 10. On the other side of the spectrum, when it is (wrongly) assumed that the probability of death at age 115 is 1, there is no uncertainty about the death rate. For this reason, no confidence interval is shown in Fig. 4.2 for that age (see also Table 4.3 in the Appendix).

Figure 4.2 also distinguishes between estimates for ages up to 113.5 (black dots), and estimates for ages above 113.5 (grey dots). We are aware that this division is arbitrary, but we wanted to test whether excluding the death rates for the oldest ages could affect the Gompertz estimates, since only 26 individuals from the 1884–1894 birth cohorts lived beyond age 113.5 (IDL 2017). Furthermore, the estimates of the slope parameters are much too high for these cohorts (see Table 4.1), with values around 0.2 that allow for a steep increase in the force of mortality after age 110, and that are also driven by the (wrong) assumption that the probability of death at age 115 is 1. By fitting the Gompertz model to the central death rates for ages 110 to 113.5 with a weighted non-linear regression, we estimated a slope parameter $b = 0.063$, a value that is notably lower than the one obtained by Gavrilova et al. (2017) using the whole range of ages ($b = 0.214$, fourth row in Table 4.1). Most importantly, our estimate is not statistically significant, and has a p-value of 0.139. Thus, we cannot reject the hypothesis that mortality is flat between ages 110 and 113.5, even when using the same methodology and data, but excluding the oldest ages for being too sparse.

4.5 Conclusions

The results obtained by Gavrilova and colleagues in the analysis of data from the International Database on Longevity (IDL 2017) can be summarized as follows. Focusing on the 1884–1894 birth cohorts, from which no individuals survived beyond 115, they assigned a probability of death $q_x = 1$ to that age (Figs. 1 to 4 in their manuscript). Their corresponding estimates for the slope parameter of the Gompertz model were significantly different from 0 (see Table 4.1), which led them to claim that "hazard rate estimates […] continue to grow after age 110 years and follow the Gompertz law" (Gavrilova et al. 2017, p. 14). For older cohorts born before 1885, they assigned $q_x = 1$ to 122 – the highest observed age – instead of 115 (Fig. 5 in their manuscript), obtaining a slope parameter that is not significantly different from 0 (last row in Table 4.1), and concluding that the hypothesis of flat mortality could not be rejected in this case.

We argue that these results are a consequence of the data selection, since the division of the supercentenarians into two groups is arbitrary. This is especially relevant because, in combination with their statistical approach, it implies a change in the age to which the probability of death $q_x = 1$ is assigned. Moreover, Gavrilova et al. (2017) do not provide any measure of uncertainty for the estimated central death rates – which is imperative given the low number of observations at oldest ages – and the results and the plots they present are confusing and misleading. Overall, their work has too many inaccuracies for us to consider their conclusions reliable. Having been able to reproduce some of their graphs does not imply that the methodology used is adequate. We believe that a maximum likelihood approach including censored and truncated observations would have been more appropriate for estimating death rates.

In view of the above, does the risk of death continue to rise after age 110? The only conclusion we can reach for now is that Gavrilova and colleagues have not proved that to be the case. It has also been argued that late-life mortality deceleration and plateaus are observed mainly because of errors in the data (Gavrilov and Gavrilova 2019; Newman 2018). We hope that future research on the updated data from the IDL (see Chaps. 1 and 2 in this volume) will shed light on the mortality trajectories of supercentenarians.

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Appendix

This appendix describes the procedure designed to carry out the data simulation and compute the 95% empirical confidence intervals of the central death rates in logarithm base 10 displayed in Fig. 4.2. The basic idea was to simulate 10,000 times the lifetimes between ages 110 and 115 of 400 individuals who die according to some age-specific theoretical probabilities of death. By recording the observed empirical probabilities across all simulations, we were able to compute empirical confidence intervals for each age category.

Using data on supercentenarians from the 1884–1894 birth cohorts (IDL 2017), we obtained a set of theoretical probabilities of death $q_x = D_x/N_x$ for each age category, measured in a quarter-year age scale. D_x denotes the number of deaths, whereas N_x is the number of individuals at the beginning of each age interval (see Table 4.3). Next, we created a population of 400 individuals (the same size as the abovementioned cohorts from the IDL) who were exposed to these theoretical probabilities between ages 110 and 115. Within each age category, we assigned to all living individuals a random number between 0 and 1 drawn from a uniform distribution: those who get a value below the corresponding theoretical probability of death die; otherwise, they live and move to the next age category. This procedure enabled us to calculate an empirical probability of death for each age category, depending on the number of deaths and individuals at risk observed in each case. Due to randomness, these empirical probabilities were likely to differ from the theoretical probabilities in all age categories except for the last one, since the probability of death at age 115 was set at 1.

This procedure was repeated 10,000 times, obtaining 10,000 estimates of the probability of death for each age category. We then computed the corresponding central death rates following Eq. (4.1), and transformed them into logarithm base 10. Out of this set of estimates, we computed the 95% empirical confidence

Table 4.3 Central death rates estimated using Eq. (4.1) in logarithm base 10, measured in a quarter-year age scale. Empirical 95% confidence intervals are obtained from data simulation. Supercentenarians from the 1884–1894 birth cohorts (Source: IDL 2017)

x	N_x	D_x	q_x	M_x	$\log_{10}(M_x)$	95% CI
110	400	62	0.1550	0.6721	−0.1726	[−0.2919, −0.0696]
110.25	338	55	0.1627	0.7085	−0.1496	[−0.2772, −0.0453]
110.5	283	40	0.1413	0.6084	−0.2158	[− 0.3674, − 0.0952]
110.75	243	38	0.1564	0.6786	−0.1684	[− 0.3194, − 0.0407]
111	205	28	0.1366	0.5864	−0.2318	[− 0.4212, − 0.0913]
111.25	177	30	0.1695	0.7407	−0.1303	[− 0.3075, 0.0099]
111.5	147	26	0.1769	0.7761	−0.1101	[− 0.3010, 0.0411]
111.75	121	20	0.1653	0.7207	−0.1422	[− 0.3715, 0.0250]
112	101	20	0.1980	0.8791	−0.0560	[−0.2782, 0.1139]
112.25	81	19	0.2346	1.0629	0.0265	[− 0.2052, 0.2041]
112.5	62	9	0.1452	0.6261	−0.2034	[− 0.5883, 0.0339]
112.75	53	11	0.2075	0.9263	−0.0332	[− 0.3602, 0.1852]
113	42	7	0.1667	0.7273	−0.1383	[− 0.6066, 0.1249]
113.25	35	4	0.1143	0.4848	−0.3144	[− 0.9945, 0.0139]
113.5	31	5	0.1613	0.7018	−0.1538	[− 0.8212, 0.1549]
113.75	26	8	0.3077	1.4545	0.1627	[− 0.2326, 0.4260]
114	18	5	0.2778	1.2903	0.1107	[− 0.5283, 0.4260]
114.25	13	4	0.3077	1.4545	0.1627	[− 0.5283, 0.5051]
114.5	9	5	0.5556	3.0769	0.4881	[− 0.0512, 0.8062]
114.75	4	1	0.2500	1.1429	0.0580	(− ∞ , 0.9031]
115	3	3	1.0000	8.0000	0.9031	–

intervals of the death rates in logarithm base 10 for each age category. The results are shown in Table 4.3, and the R code to reproduce the data simulation is available in the supplementary materials.

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Chapter 5
The Human Longevity Record May Hold for Decades: Jeanne Calment's Extraordinary Record Is Not Evidence for an Upper Limit to Human Lifespan

Adam Lenart, José Manuel Aburto, Anders Stockmarr, and James W. Vaupel

Jeanne Louise Calment lived 122.45 years, longer than any other reliably documented person. She was born in Arles, France on 21 February 1875 and died there on 4 August 1997. Her date of death and that the person who died was indeed the person born 122.45 years earlier have been meticulously verified (Robine and Allard 1998, 1999). Her record seems remarkable because it is so high and because it has not yet been broken. This has been taken as evidence that human longevity is

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approaching a biological limit (Finch et al. 2014; Dong et al. 2016). Such a ceiling would have important implications for research policy since a ceiling implies that extension of human longevity requires unprecedented research breakthroughs that overcome the physiology of aging. Hence it is of interest to ask: (1) How likely is it that a person reached age 122.45? (2) How unlikely is it that this record has not yet been broken? (3) How soon might it be broken?

Here we exploit data on the number of supercentenarians (people who reach age 110). We used the data to estimate the probability distribution of the age of the record holder on 25 September 2017. To assess the probability that Calment's record would be broken by this date, we counted the number of supercentenarians alive when she died as well as the number of subsequent supercentenarians who could have reached the age of 122.45 by 25 September 2017. We forecast the time when a supercentenarian would reach an age greater than 122.45 by using observed data on supercentenarians and predicting their future numbers.

Three lists of supercentenarians are available. One is compiled by a research team working on the International Database on Longevity (IDL) (Maier et al. 2010). This list only includes supercentenarians in countries for which members of the research team have undertaken careful verification and for which exhaustive lists of supercentenarians are available. Two other lists, one compiled by Louis Epstein and colleagues and the other by Robert Douglas Young and colleagues at the Gerontology Research Group (GRG), include verified supercentenarians from any country (Young et al. 2009).

We used the GRG list to estimate how many people reached age 110 over time, because this list is more inclusive than the IDL list and appears to be more reliable than the Epstein list. We relied on the IDL list, however, for information on the age-pattern of mortality after age 110. The IDL list was created such that the probability of the inclusion of a person does not depend on the person's age; the list includes all age-validated supercentenarians in the populations studied. The inclusion criteria for the GRG and Epstein lists are not as strict as those of the IDL: some individuals might be accepted to the lists because of attracting public attention, perhaps via a newspaper article. The probability of attention tends to increase with age; for example, 115-year-olds are more likely to be included on the lists than a person who dies shortly after her or his 110th birthday.

Previous research on supercentenarians based on the IDL database (Gampe 2010) and subsequent research published in this book show that between ages 110 and 114 the annual probability of death is close to 50%. Data are too sparse after 114 to estimate risks of mortality reliably, but it may be reasonable to assume that the probability of dying reaches a plateau at a level of 0.5/year (Vaupel 2010; Missov and Vaupel 2015). GRG data are consistent with the probability of death levelling off at about 50%. Furthermore, if the probability of death per year is assumed to be constant after age 110, then the GRG data indicate that this probability is 0.491 with 95% confidence interval 0.474–0.508.

It is known that Jeanne Calment reached age 122.45 in 1997. Hence the likelihood of this is 100%. To estimate a probability for this record we have to put ourselves behind a veil of ignorance. One way to do so is as follows.

According to the Young list, 1049 people celebrated their 110th birthday more than 12.45 years before 25 September 2017. Assuming a 50% annual probability of death after age 110, the probability that one of them would have reached age 122.45 is 17.1% (see Box 5.1). Jeanne Calment's age at death is extraordinary but not impossibly so.

Now consider how extreme it is that Calment's record has not yet been broken. We know it has not been broken, so as above we have to put ourselves behind a veil of ignorance. An appealing way to do so is to estimate the probability, on the day of her death, that at least one supercentenarian would exceed her record before 25 September 2017. Her record could have been broken either by supercentenarians who were alive when she died on 4 August 1997 or by new supercentenarians who attained age 110 following her death but at least 12.45 years before 25 September 2017, permitting them to reach age 122.45 by this date.

Young's list shows that 67 supercentenarians were alive on the day of Calment's death. We now know the number of new supercentenarians afterwards but this was not known when Jeanne Calment died. The new group of supercentenarians needs to be estimated from the data potentially available on her day of death. Over the 10-year period preceding her demise, annual counts of newly recruited supercentenarians grew on average by 8.0% annually. Extending this trend line until 12.45 years before 25 September 2017 yields 742 new supercentenarians. If we combine analysis of the 67 supercentenarians whose exact ages were known with analysis of the 742 people who reached age 110 afterwards, we arrive at a probability of 20.4% that at least one of them would reach the age of 122.45 (see Box 5.1). This is an estimate of the chance that Calment's record would have been broken after 1997 but before 2017. It is not surprising that her record still holds.

It is reasonable to predict when Calment's record might be broken based on the available data, i.e., to make the prediction considering the fact that her record has not been broken by 25 September 2017.

The number of newly registered supercentenarians on the Young list dropped sharply after 2010, probably because of delays in registering and validating alleged new cases. On the list available on 25 September 2017, there were no 110 or 111-year-olds; only one person on the list at the end of 2010 was still alive, at age 117. Because the list available on 25 September 2017 is problematic, we decided not to use any of the information in it, including the information that there was one 117-year-old. Instead, we decided to base our estimates on data available for the period up until the end of 2010. It turns out that applying the 0.5 annual probability of survival to this 2010 list leads to the prediction that there would be one 117-year-old on 25 September 2017, which made us more comfortable about neglecting this information from the 25 September 2017 list. We used the GRG data to determine the number of people who celebrated their 110th birthdays over the period beginning on 25 September 2017 minus 12.45 years and ending on 31 December 2010; the number is 165. Then, using 77, the number of people who attained age 110 in 2010, as our base value, we estimated the number of new supercentenarians in subsequent years. We did so by using a continuous growth rate of 6.8%/year, which leads to annual growth by multiples of 1.07 (because exp(0.068) = 1.07). Hence we calculated the cumulative sum of 1.07 times 77 plus 1.07 squared times 77 plus.

Calment's record is likely to be broken when the probability of someone living longer than 122.45 exceeds 50%. To reach this level, we need to mix the estimated number of people attaining age 110 in the period prior to the end of 2010 (165 people) with 3713 new supercentenarians. The required number of new supercentenarians would not be reached until near the end of 2033. Then it would take an additional 12.45 years for one of them to break Calment's record, so about mid-year 2045, assuming the annual probability of death after age 110 remains at 0.5.

Is it plausible that Jeanne Calment might hold the longevity record from 23 May 1989, when she reached age 115.21 and broke the previous record, until 2045, some 56 years later? The Table shows how long previous records endured, for males as well as for females. Delina Filkins became the world's longest-lived woman in 1926 when she attained age 111.38; her record held until the end of 1980, over 54 years later. Among men, Gert Boomgaard died at age 110.37 in 1899; after his death his record lasted more than 67 years until 1966. Extreme-value theory is far from intuitive; jumps in maximum values are often surprising (De Haan and Ferreira 2007) (Table 5.1).

Jeanne Calment's exceptional lifespan provides evidence about another question. The force of mortality (hazard of death) increases approximately exponentially after age 50: the pattern is known as Gompertz' law. Strong evidence from various studies shows that the force of mortality levels off at advanced ages (Maier et al. 2010; Vaupel 2010). It has been claimed, however, that Gompertz law continues to hold up to the most advanced ages (Gavrilov and Gavrilova 2011). If the rate of increase in mortality after 110 is similar to the rate of increase at younger ages, then the age reached by Jeanne Calment is incompatible with this claim. Suppose the force of mortality continued to increase after age 110 at the rate of 10% per year observed at younger ages and suppose the increase at younger ages resulted in a probability of death at age 110 of 50%. Then, the probability an individual could survive to 122.45

Table 5.1 List of oldest females and males (up to 25 September 2017)

		Name	Age at death	Became oldest	Date of death	Years held record
Females	1	Margaret Ann Neve	110.85	?	1903-04-04	>21
	3	Delina Filkins	113.59	1926-03-21	1928-12-04	54.66
	4	Fannie Thomas	113.75	1980-11-15	1981-01-22	4.49
	5	Augusta Holtz	115.21	1985-05-14	1986-10-21	4.99
	6	Jeanne Calment	122.45	1990-05-12	1997-08-04	27.37
Males	1	Gert Adrians-Boomgaard	110.37	?	1899-02-03	>67
	2	John Turner	111.77	1966-10-29	1968-03-21	14.46
	3	Mathew Beard	114.61	1981-04-16	1985-02-16	16.03
	4	Christian Mortensen	115.69	1997-04-26	1998-04-25	15.67
	5	Jiroemon Kimura	116.15	2012-12-28	2013-06-12	4.74

Source: Young et al. (2009)

would be 0.00000008, three orders of magnitude less than then the 0.00018 chance if the force of mortality after 110 reached a plateau. The probability of a lifespan of 122.45 in our era would be minuscule. More generally, the survival of hundreds of individuals beyond age 110 is consistent with a marked slowing of death rates after age 100 and probably a plateau of mortality after age 110 or even earlier (as suggested in the chapters by Gampe and Villavicencio & Aburto in this book).

Jeanne Louise Calment is a truly exceptional person but not an impossible one. It is within the realm of possibility that someone could survive to age 122.45. (Newman and Easteal 2017) it is not surprising that her record stands. It is likely that her record will not be broken for decades. She should not be used to argue that human lifespans are approaching ultimate limits. Progress to date in increasing lifespans has been due to large reductions in death rates (Oeppen and Vaupel 2002); progress since 1950 has been due to the postponement of high levels of mortality to higher ages (Vaupel 2010). It is possible (albeit uncertain) that this long-term trend will continue: Jeanne Calment's enduring longevity record does not provide evidence to the contrary.

Box 5.1

Let p denote the probability that a person attaining age 110 reaches age 122.45. Then

$1-p$ is the chance the person will die before age 122.45. Assuming that the risk of death is 50%/year after age 110, the chance of reaching 110 is $0.5^{12.45}$, which is approximately 0.00018 or about 1 in 5595. The corresponding chance that a person who reaches 110 will not reach 122.45 is $1–0.5^{12.45}$ or about 99.982%.

If N people attain age 110, then the probability that all of them will die before age 122.45 is

$$\left(1-p\right)^{N}.$$

To calculate the probability that at least one person reaches age 122.45, this probability has to be subtracted from 1:

$$1-\left(1-p\right)^{N}.$$

Hence, the probability that at least one person out of N people will survive from 110 to at least 122.45 is

$$1-\left(1-0.5^{12.45}\right)^{N}$$

(continued)

Box 5.1 (continued)

which equals 17.1% if $N = 1049$.

If a person is age $x > 110$, the probability that this person would reach 122.45 is given by $0.5^{122.45-x}$. The chance that none of a group of n individuals with ages $x_1, x_2, \ldots, x_n$ would reach age 122.45 is given by:

$$\prod_{n}^{i=1}\left(1-0.5^{122.45-x_i}\right).$$

If a population is being analyzed that includes n people whose age is greater than 110 and N people whose age is exactly 110, then the probability that at least one of them will reach age 122.5 is:

$$1-\left(1-0.5^{12.45}\right)^N \cdot \prod_{n}^{i=1}\left(1-0.5^{122.45-x_i}\right).$$

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Chapter 6
Mortality of Centenarians in the United States

Bert Kestenbaum

6.1 Introduction

The recent government publication (Xu 2016) of death rates for the U.S. centenarian population – persons age 100 and over – that are clearly incorrect should serve as a reminder to the research community of the folly of using data for the extreme-aged without questioning and evaluating them. It could also serve as an impetus for demographers, actuaries, and others to whom the subject is important to determine which data are best for measuring the mortality of the extreme aged and whether there are creative ways to improve them. In this essay, after describing the incorrect recent estimates of the National Center for Health Statistics' (NCHS) Mortality Branch and how they came about, I present ways to make published Medicare data more useful for measuring the mortality of the very old.

6.2 The NCHS Estimate

In January 2016 the National Center for Health Statistics' Mortality Branch published Data Brief no. 233 on the subject of annual mortality rates of the centenarian population taken as a whole, over the 15-year period from 2000 to 2014. Data Brief no. 233 features the finding that for both males and females the death rate for centenarians taken as a whole increased substantially from the year 2000 – the beginning of the observation period – to the year 2008, then decreased substantially

The views expressed here are those of the author, and no endorsement of those views by the U.S. Security Administration should be inferred.

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through 2014, the end of the period. For females the increase was a significant 10%, from 385 per thousand in 2000 to 424 per thousand in 2008, and the decrease from 2008 to 2014 was a significant 14%. For males the increase to 2008 was a huge 41%, from 292 per thousand to 413 per thousand, and the decrease from 2008 was 20%, to 332 per thousand. It will be noted furthermore that in 2000 the male mortality rate for centenarians was about one-quarter less than the female rate – certainly very surprising. These rates are shown in Fig. 6.1.

How were the death rates for centenarians in Data Brief no. 233 computed? The numerators are counts of registered deaths at ages 100 and over (with no assessment of the accuracy of the reported ages). The denominators for the years 2000 through 2010 come from the Census Bureau's *intercensal* mid-year population estimates, and for the years after 2010 from *postcensal* estimates produced by the Bureau. These estimates are anchored by the counts of centenarians for April 1, 2000 and April 1, 2010 obtained in the decennial censuses of 50 thousand and 54 thousand, respectively – *even though the Bureau acknowledges that the decennial census significantly overcounts the centenarian population* (Meyer 2012). In particular, the Bureau itself speculated that the true number of centenarians on census day, 2000 is about one-third less than the official count of 50 thousand. It seems likely that the overcount was smaller in the 2010 decennial census, creating the illusion that the centenarian population grew little from the beginning of the decade to its end.

In fact, the Bureau's intercensal estimates of the size of the centenarian population for the 2000–2010 decade fall in the first half of the decade to 46 thousand and then turn around and rise. In sharp contrast, for the period after 2010 the Bureau's postcensal estimates imply an estimated average annual growth rate of about 10%!

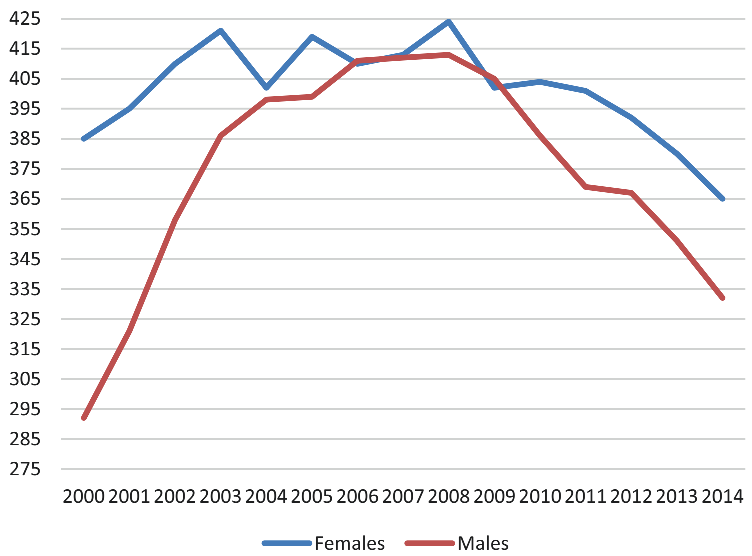

Fig. 6.1 Deaths per thousand, each year, 2000–2014, Data Brief No. 233

The Bureau's acknowledgement that the decennial census counts of the centenarian population are much too high appears only in the aforementioned special study it did on centenarians. Nowhere in the Bureau's intercensal population estimates publication – from which come the denominators for the NCHS' Data Brief no. 233 – is there a warning to users that the estimated number of centenarians in 2000 is much too high. When I asked "why not?", a Bureau staff person answered that the Bureau expects a certain degree of sophistication in its readership, to recognize that small estimates are subject to large relative errors. I did not pursue the matter further to argue that while 50 thousand may be a small number in an analysis of the total U.S. population, for readers interested in the oldest-old population 50 thousand is not a small number.

While the failure of the Census Bureau to alert its audience to shortcomings of the data might excuse others who use the data "as is", it doesn't excuse the National Center for Health Statistics' Mortality Statistics Branch, the nation's authority on population mortality. Indeed, this same organization declines to use Census Bureau population denominators beyond age 94 in the preparation of the U.S. Life Tables (Arias 2014).

It is abundantly clear that the rates computed in this manner, and the time series pattern which emerges, are casualties of the incorrect census estimates, and should never have been published. I urged NCHS executives to withdraw Data Brief no. 233, given that its primary finding is not correct and that any race-ethnicity detail and cause-of-death detail that the report provides cannot be relied on.

The NCHS was unwilling to do so. Instead, on July 28, 2016 – about 6 months after initial publication – the NCHS reissued the publication with the following addendum, which, I believe, fails to convey the gravity of the errors.

> "The death rates for centenarians shown in this report should be interpreted with caution. An overestimation of the centenarian population in the 2000 Census may have led to a slight underestimation of the death rates from 2000 to 2009 shown in this report. The rate of increase in the death rates for these years was also somewhat overestimated."

6.3 The Medicare Experience

Where then can one find good-quality national data on the mortality of the centenarian population in the United States, and are there creative approaches to increase the utility of these data? One possibility: *if* the reports of extreme age at death in death registration are of acceptable quality over a substantial period of years (and if net migration is negligible), the decedents can be grouped by year of birth, and an approach known as the "extinct cohort" method can be employed to compute from the death registration data alone the death probability at each age x, using as the denominator the number of deaths occurring at or after age x. However, it has not yet been demonstrated that extreme age reporting in death registration is of acceptable quality. Indeed, U.S. death probabilities at extreme ages for the 1900 birth cohort computed exactly in this manner for the Human Mortality Database project, and shown in Table 6.1, appear to be too large.

Table 6.1 q(x) for ages 95–109, males and females: various sources

Study	This study	SSA Actuary (2005)	NAAJ journal (2002)	NCHS	Human Mortality Database
Data	Medicare tabulations	Medicare tabulations	Medicare microdata	Medicare tabulations	NCHS deaths
Type of table	Cohort	Cohort (from period)	Period	Period	Cohort
Target population	Born 1893–1902	Born 1900	1990–1999 period	1999–2001 period	Born 1900
Males					
95	0.272	0.273	0.274	0.260	0.313
96	0.293	0.292	0.294	0.279	0.351
97	0.315	0.313	0.313	0.299	0.370
98	0.335	0.330	0.330	0.320	0.401
99	0.356	0.354	0.348	0.342	0.447
100	0.381	0.376	0.368	0.364	0.457
101	0.402	0.392	0.384	0.387	0.518
102	0.418	0.420	0.405	0.410	0.496
103	0.430	0.444	0.433	0.434	0.607
104	0.438	0.470	0.425	0.458	0.533
105	0.452	0.497	0.436	0.482	0.591
106	0.423	0.524	0.423	0.506	0.877
107	0.376	0.552	0.450	0.530	0.605
108	0.471	0.580	0.494	0.554	0.524
109	0.555	0.608	0.489	0.578	0.546
Females					
95	0.222	0.220	0.223	0.216	0.254
96	0.241	0.239	0.241	0.234	0.279
97	0.263	0.260	0.260	0.254	0.308
98	0.287	0.279	0.281	0.275	0.340
99	0.309	0.307	0.298	0.297	0.372
100	0.333	0.329	0.319	0.320	0.406
101	0.360	0.345	0.342	0.343	0.440
102	0.380	0.373	0.362	0.368	0.495
103	0.401	0.398	0.373	0.393	0.509
104	0.427	0.425	0.394	0.419	0.530
105	0.453	0.453	0.415	0.445	0.534
106	0.469	0.483	0.429	0.472	0.536
107	0.482	0.513	0.462	0.498	0.579
108	0.504	0.544	0.469	0.525	0.629
109	0.515	0.576	0.492	0.552	0.584

Another source of information for extreme-age mortality is the Medicare (national governmental health care program for the elderly and the disabled) experience, captured in the administrative records of both the Centers for Medicare and Medicaid Services (CMS) and the Social Security Administration (SSA). Because only a very small fraction of the very old does not participate in Medicare – probably less than 5%, the Medicare experience is a quite satisfactory representation of the U.S. experience. Enrollment and death data for the Medicare population are tabulated routinely and consistently each year by the Centers for Medicare and Medicare Services and provided to the Social Security Administration's Office of the Chief Actuary and the National Center for Health Statistics, both of whom use the Medicare experience in their preparation of life tables. However, both use the Medicare experience only through age 94 and close the life tables with mathematical models.[1] Published estimates of extreme-age mortality from the Social Security Administration's Office of the Chief Actuary (Bell and Miller 2005) and the National Center for Health Statistics Mortality Statistics Branch (Arias 2014), respectively, are shown in Table 6.1.

The quality of the Medicare data at extreme ages is affected by two problems. One is unique to the Medicare experience: the inclusion in the experience of "immortals" – deceased persons whose death was either not reported or not recorded. The other is the usual problem of age misstatement – intentional or unintentional – and misrecording. These problems have the greatest effect at the oldest ages, where there is not a predominance of accurate records. Both of these problems can be mitigated somewhat by excluding more error-prone records from the experience study. For this reason, both the SSA Actuary and the NCHS life-table program use tabulations of the Medicare experience from which are excluded records of persons who are not beneficiaries of the Social Security or Railroad Retirement programs, an exclusion of less than 5% of the total experience. I use these same tabulations in the new investigation reported on here.

I took a different approach in earlier studies on the mortality of the extreme-aged based on the Medicare experience, using person-level records of the Social Security Administration on participation in and termination by death from Medicare Part B – medical insurance (Kestenbaum 1992; Kestenbaum and Ferguson 2002). Unlike participation in Medicare Part A – hospital insurance, which generally is free of charge, participation in Part B requires the payment of monthly premiums to continue enrollment – either by the insured or by a third-party payor on behalf of the insured, such as a State government for its low-income population. If premium payments are discontinued, enrollment is terminated; hence there should be few immortals in the Medicare Part B experience.

This different approach with the Medicare experience – using person-level records in the SSA's master file – confers two advantages. One is that SSA

[1] Strictly speaking, this description applies to the (smoothed) *period* life tables produced by the SSA Actuary. The death probabilities in the *cohort* life tables produced by the SSA Actuary are taken directly from the period tables, which explains why their progression is not as smooth as the progression of the probabilities in the period table.

records – although more difficult to use – are slightly more accurate than CMS records. This is because updates such as death reports are generally received by SSA, which then shares the information with CMS; if on a particular day the transmission of information fails, the update (death) will be in SSA records but not CMS records.

More importantly, with the person-level approach it is possible to do some data cleansing. The Social Security Administration has other large person-based databases, indexed by social security number,[2] in which the record contains information on date of birth and/or date of death; the dates in the master file of Medicare enrollment can be compared with these other dates and adjusted for discrepancies. These other collections of data include the file of almost 1 billion applications and reapplications for a social security number, the file of nearly a half-billion earnings histories, and the file of 75 million applicants to the Supplemental Security Income (SSI) welfare program.

This approach, that is, tabulating the person-level experience in Medicare Part B as reflected in SSA records and after editing dates of birth and death by comparing with other SSA master files, was used to produce (ungraduated) estimates of male and female mortality prevailing during the decade of the 1990s by single year of age from age 85 to age 109 and for age 110+. The study was published in the North American Actuarial Journal (Kestenbaum and Ferguson 2002) and the published estimates, beginning with age 95, are reproduced in Table 6.1.

The implementation of this approach entails a significant investment of resources, and, furthermore, requires access to the Medicare microdata. In contrast, the new study reported here uses a series of the aforementioned tabulations of the Medicare experience of enrollees (Parts A and/or B) who are entitled to Social Security or Railroad Retirement benefits, routinely prepared by CMS and shared with the SSA Actuary and the National Center for Health Statistics. Our objective is to develop adjustments to these grouped data to enable the estimation of single-age mortality at ages beyond the ages they are currently used for, that is, at ages 95 and over.

The CMS tabulates the number of enrollees in the Medicare program alive on January 1st by gender and single year of age (last birthday), through age 110. Persons tabulated at any age, x, are on average age ($x + 1/2$) on January 1. The most recent counts I had are for January 1, 2013, and a historical series with data which are comparable from year to year goes back to January 1, 1988.

To address the problem of the "immortals", I combined the annual tabulations of the number of enrollees on January 1st, and rearranged the counts by year-of-birth cohort to follow the cohort until extinction.[3] Under the reasonable assumption that at extreme ages the net of entrants to and exits from the Medicare population is negligible, the decrease in the size of the cohort from one tabulated age, y, on

[2] The social security number is the nearly universal personal identifier used in the United States.

[3] It is perhaps worth noting the simple difference between this and the "extinct cohort" method mentioned earlier. Namely, in the "extinct cohort" method the researcher knows the number of deaths at each age up to extinction, from which he *constructs* the number of survivors to each age. Here I already know the number of survivors at each age.

January 1st of year y to the next tabulated age, $x + 1$, on January 1st of year $y + 1$ represents deaths occurring in calendar year y among persons with tabulated age x at the beginning of the calendar year; the mortality probability, $q(x)$, is easily obtained.

Few persons survive to age 110.5. Thus the count of persons at tabulated age 110 is the sum of a very small number of true "supercentenarians"[4] and a larger number of immortals. If we assume, for example (other assumptions will work, too), that the probability of mortality at (tabulated) age 109 is 0.5, then half of those who reached tabulated age 109 reach tabulated age 110, and the others counted at age 110 are the immortals. We then proceed to subtract the number of immortals from the tabulated numbers at age 110 and all the extreme ages.[5]

To address the problem of age misstatement and misrecording, I borrow and extrapolate results published by Rosenwaike and Stone in 2003 in the journal *Demography*. These were results from a record-check study of the accuracy of ages of 110 and over in the Medicare experience. The authors searched for these purported supercentenarians in the records of the decennial censuses of 1880 and 1900 (the records of the 1890 census were destroyed in a fire), using well-defined, replicable matching rules.

In the Rosenwaike-Stone study, when the search was successful the years of birth in the Medicare record and the early census record were identical 73% of the time. The Medicare year of birth was the earlier of the two in the large majority of the other 27% of the matched records. The average discrepancy – the census year of birth minus the Medicare year of birth – among discrepant cases was about 3 years.

If these results are to be extrapolated to extreme ages less than 110, assumptions must be made. It seems reasonable to assume that the fraction among persons with recorded age x in the Medicare experience whose recorded age is their true age, call it $r(x)$, increases as the size of the experience increases (and thus as the age decreases). I assume that $r(x)$ increases from 73% at age 110 by almost 2 percentage points per year of (decreasing) age until it reaches 100% at age 96. I also assume that the average size of the age error among persons whose recorded age in not their true age is an overstatement of 3 years, the same as in the Rosenwaike-Stone study.

Under these assumptions I estimate $q(x)$, the probability of mortality at age x, from the following approximate relationship, where q_{obs} denotes an <u>observed</u> probability:[6]

$$q_{obs}(x) = r(x) \cdot q(x) + (1 - r(x)) \cdot q_{obs}(x - 3).$$

[4] A supercentenarian is a person who has attained age 110.

[5] In theory it would be better to distribute the deaths of these immortals across all ages in proportion to the observed number of deaths at each age, but the additional precision which is obtained is surely trivial.

[6] The relationship would be exact with q(x − 3) in the equation, in place of $q_{obs}(x - 3)$. But, of course, q(x − 3) is not known.

For example, by our assumption the fraction of persons with recorded age 100 who are truly age 100, $r(100)$, is 0.93. The equation expresses the approximate relationship that the observed probability at age 100 equals 93% of the true probability at age 100 plus 7% of the observed probability at age 97.

A single year-of-birth cohort has too few survivors at extreme ages to generate reliable results. Accordingly, I combine the results for 10 adjacent birth cohorts, with years of birth from 1893 to 1902. The 1902 birth cohort is the latest cohort for which we have counts through tabulated age 110, since our latest data are for January 1st of 2013.

The results of this investigation are displayed in Table 6.1 and Figs. 6.2a and 6.2b, together with other estimates mentioned earlier: (1) from the Social Security Administration's Actuary and the NCHS' life tables, both extrapolations by mathematical modelling of the tabulated Medicare experience through age 94; (2) from my study in the North American Actuarial Journal based on edited person-level records of the Medicare Part B experience; and (3) in the Human Mortality Database, based on death records from the U.S. Vital Statistics system, synthesized by extinct-cohort methods. The ungraduated results from our new investigation are in the first column of data. While the pattern is somewhat erratic for males, the results for females, for whom there is overall three times the amount of experience that there is for males and about six times as much at the oldest ages, seem credible up through age 105 – a significant improvement over the performance of unedited tabulations. For females through age 105 the new mortality probabilities are higher than previous estimates except for the Human Mortality Database estimates.

We began with the peculiar findings in the NCHS' Data Brief no. 233 regarding the mortality rate in the centenarian population taken as a whole. Its main finding is

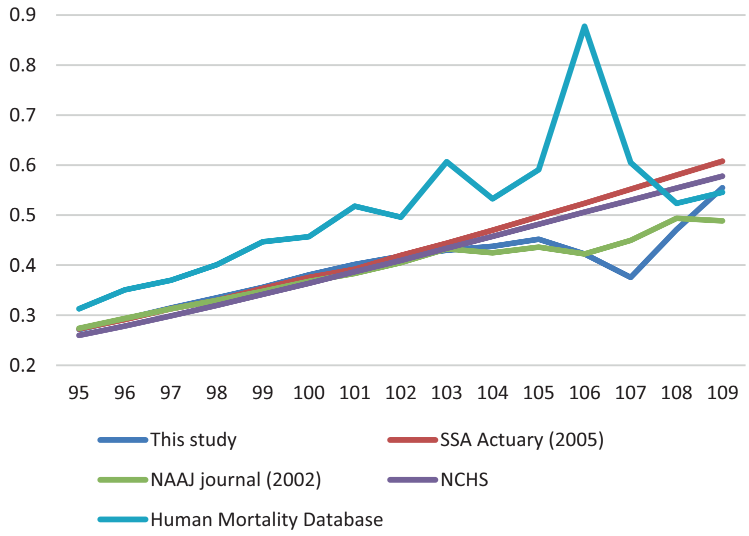

Fig. 6.2a q(x) for ages 95–109, males: various sources

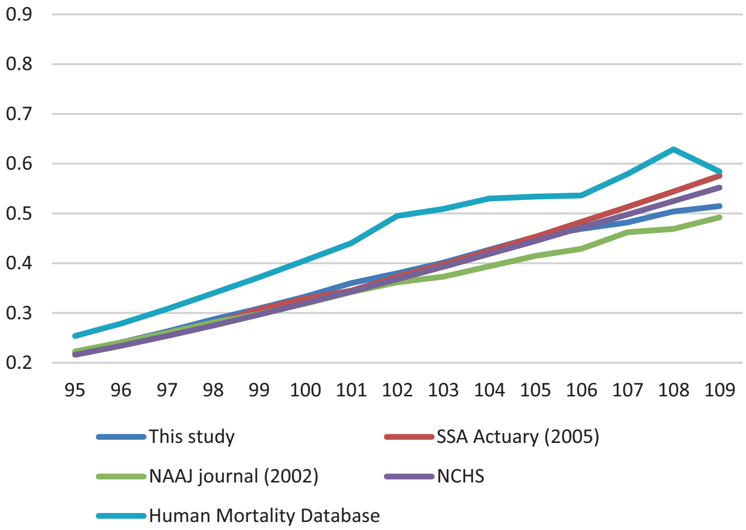

Fig. 6.2b q(x) for ages 95–109, females: various sources

Table 6.2 Overall probability of mortality of centenarians, by cohort and sex: edited Medicare tabulations

Birth cohort	Males	Females	Both sexes, combined
1893	.408	.366	.373
1894	.409	.365	.372
1895	.402	.365	.371
1896	.411	.373	.378
1897	.414	.374	.379
1898	.409	.377	.379
1899	.421	.379	.385
1900	.404	.384	.387
1901	.406	.383	.386
1902	.406	.380	.384

that the overall mortality rate among centenarians first increased significantly and then decreased significantly over the most recent 15-year period, particularly for males. It also found that mortality rates for centenarians were much smaller for males than for females for part of this period. In contrast to the NCHS findings, the mortality probabilities for the centenarian population taken as a whole in the edited Medicare data for ten birth cohorts from 1893 to 1902 – shown in Table 6.2 – (a) exhibit little variation from cohort to cohort[7] and (b) show a consistent mortality advantage for females over males.

[7] There *appears* to be a slight increase in mortality over time for females and both sexes, combined, but this might be due to a changing age distribution of the centenarian population.

6.4 In Conclusion

We have not yet reached the point where unedited numerators and denominators for death rates or probabilities are of satisfactory quality for measuring the mortality of the extreme aged. Ignoring this reality can lead to an estimation of extreme-age mortality which is unacceptable, as is the case for the NCHS' Data Brief no. 233. On the other hand, there are steps that can be taken to improve the quality of the underlying data, so that the threshold age at which a mathematical model replaces actual data and closes out the life table is pushed further out.

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Part III
Cause of Death Studies

Chapter 7
Causes of Death at Very Old Ages, Including for Supercentenarians

France Meslé and Jacques Vallin

The causes of death reported on the death certificates of the oldest old are generally seen as unreliable, and as thus providing little useful information on the process leading to death (Mathers et al. 2005). However, in advanced countries, a majority of the people who die each year are older and older. In France, for example, the share of all female deaths that occurred among the 85+ age group was 73% in 2016, up from 62% in 2000, 41% in 1975, and just 25% in 1950; and the proportion of all female deaths that occurred among the 90+ age group was 45% in 2016, up from 32% in 2000, 15% in 1975, and less than 7% in 1950.[1] For several decades, researchers have been calling for further investigation into the causes of death at old ages (Meslé 2006), and for efforts to identify groups of causes that characterize the oldest old population (Berzlanovich et al. 2005; Horiuchi 2006; Motta et al. 2010; Evans et al. 2014). Indeed, in many countries, increasingly detailed information on causes of death is being provided on medical certificates. At the same time, scholars are becoming more interested in studying not just the initial cause of death, but multiple causes of death, thereby taking all of the information reported on the certificate into account (Nam et al. 1994; Désesquelles et al. 2014a).

Looking at the case of France, it appears that additional information can now be derived from a precise examination of medical death records. In our analysis, we will seek to determine the initial causes of death by single year of age among individuals who died between the ages of 90 and 117 during the 2000–2014 period.[2] After briefly presenting the available data, we will investigate how the underlying

[1] To allow for a proper comparison, these proportions are computed on the basis of the life table deaths.

[2] For metropolitan France only; and thus excluding overseas territories (*Départements d'Outre-Mer, Territoires d'Outre-Mer*, and others) that account for about 2% of the total population.

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cause-of-death structure changed over the study period. We will then focus on deaths among supercentenarians (aged 110 or older). For these still rather exceptional cases, it is essential that we take benefit of all the information available on the death certificate (the so-called "multiple causes"), to attempt to identify the reasons why a particular underlying cause was chosen. Indeed, multiple causes are more and more considered in the literature as an important clue for understanding the full process of events leading to death even at very old age (Désesquelles et al. 2014b).

7.1 Available Data

The only source of data on causes of death in France is INSERM[3], the French Institute for Health and Medical Research. Since 1968, INSERM has been responsible for producing these cause-of-death statistics, having taken over this task from INSEE[4], the French National Institute for Statistics and Economic Surveys. For several decades, INSERM was simply coding the causes of death and passing this information on to INSEE, which performed the necessary computations and provided INSERM with the results that they then published. During this period, the data on total deaths by sex, age, and other demographic characteristics published by INSEE and the cause-of-death data published by INSERM were perfectly aligned. Unfortunately, this situation changed in 1998, when INSERM started producing results independently of INSEE. The total numbers published in the vital statistics (produced by INSEE) and the cause-of-death counts started to diverge. Fortunately, as the discrepancy between these figures is very small (less than 0.2% up to age 108), it should not affect the results of our study (Table 7.1).

However, the statistics for France published by both INSERM and INSEE continue to suffer from some degree of age inaccuracy at very old ages. This is the case in all countries, including those that maintain the most accurate vital statistics. Within the framework of an international group conducting research on supercentenarians (people aged 110 or older), great efforts were made to check the ages at death of the oldest old by matching their death and birth certificates (Maier et al. 2010). The results of this work are available in the International Database on Longevity (IDL) (Cournil et al. 2010). Thus, all deaths at ages 110 or older that occurred in France up to 2014 have been checked (Meslé et al. 2010). For our study on causes of death among the oldest old, we have chosen to use data starting in 2000, the year when the 10th revision of the International Classification of Diseases (ICD-10) was implemented, in order to avoid statistical disruptions resulting from classification changes. It is essential that we take into account the transition from the use of ICD-9 to the use of ICD-10, not only because the international classification changed, but also because when INSERM adopted ICD-10 it also adopted an

[3] *Institut national de la santé et de la recherche médicale*.

[4] *Institut national de la statistique et des enquêtes économiques*.

Table 7.1 Total numbers of deaths 2000–2014, by sex, age, and source (Metropolitan France only, excluding overseas territories)

	Males			Females		
	INSEE	INSERM	Relative difference (%)	INSEE	INSERM	Relative difference (%)
90	87,942	88,012	−0.1	163,663	163,830	−0.1
91	76,592	76,607	0.0	156,941	157,046	−0.1
92	64,023	64,016	0.0	145,320	145,463	−0.1
93	52,189	52,143	0.1	130,402	130,466	0.0
94	40,912	40,884	0.1	112,514	112,602	−0.1
95	31,550	31,522	0.1	96,026	96,129	−0.1
96	24,038	24,009	0.1	82,126	82,191	−0.1
97	18,146	18,137	0.0	67,470	67,549	−0.1
98	13,088	13,085	0.0	53,964	54,051	−0.2
99	8890	8879	0.1	41,190	41,221	−0.1
100	5744	5726	0.3	29,677	29,709	−0.1
101	3487	3474	0.4	20,493	20,533	−0.2
102	2047	2045	0.1	13,258	13,266	−0.1
103	1134	1131	0.3	8268	8272	0.0
104	585	580	0.9	4829	4828	0.0
105	310	307	1.0	2853	2852	0.0
106	151	153	−1.3	1543	1540	0.2
107	57	53	7.0	806	807	−0.1
108	47	47	0.0	403	404	−0.2
109	20	18	10.0	180	178	1.1
110	6	6	0.0	75	75	0.0
111	3	3	0.0	41	42	−2.4
112	1	1	0.0	17	17	0.0
113	0	0		5	6	−20.0
114	0	0		5	4	20.0
115	0	0		1	1	0.0
116	1	1	0.0	1	0	100.0
117	1	1	0.0	2	2	0.0
118	0	0		0	0	
119	0	0		1	0	100.0
120	0	0		0	0	
Total	430,964	430,840	0.0	1,132,074	1,133,084	−0.1

Source: Civil registration (INSEE); CépiDc (INSERM)

automated approach to coding causes of death. For our comparison of multiple causes with underlying causes of death, we believe that this change may have been even more consequential than the classification revision. The period under study (2000–2014) is also the period when the numbers of deaths at the oldest ages became large enough to be analysed.

7.2 An Overview of Causes of Death at Old Age in 2000–2014

Figure 7.1 shows how the distribution of deaths by nine large groups of causes changed with age at ages 90+ (Table 7.2).

Deaths are displayed by year of age up to the highest age attained (here, the highest age for both sexes is 117). However, it would be wrong to pay too much attention to the ages above 112. As we explain in more detail in section III, the numbers of deaths at ages 112+ were not only very small, they may contain errors because the ages listed in the INSERM data were not checked for accuracy. The most important here is to see how much the proportion of ill-defined or unspecified causes grows with age regularly. It rises from a bit less than 10% at age 90 to more than 40% after age 110.

Nevertheless, it is also very interesting to note that an underlying cause of death was identifiable even up to very old ages: i.e., for more than 65% of deaths up to ages 105–110, and for more than 55% of deaths at age 111. Another important finding is that the proportions of deaths from heart diseases, other circulatory diseases, and infectious and respiratory diseases were relatively stable across the age groups: i.e., at around 25%, 10%, and 10%, respectively. By contrast, the proportions of deaths from neoplasms, diabetes, and dementia/Alzheimer's were decreasing with age.

Figure 7.2 shows that no large differences can be observed between men and women, except that because of a number of deaths much lower among males than

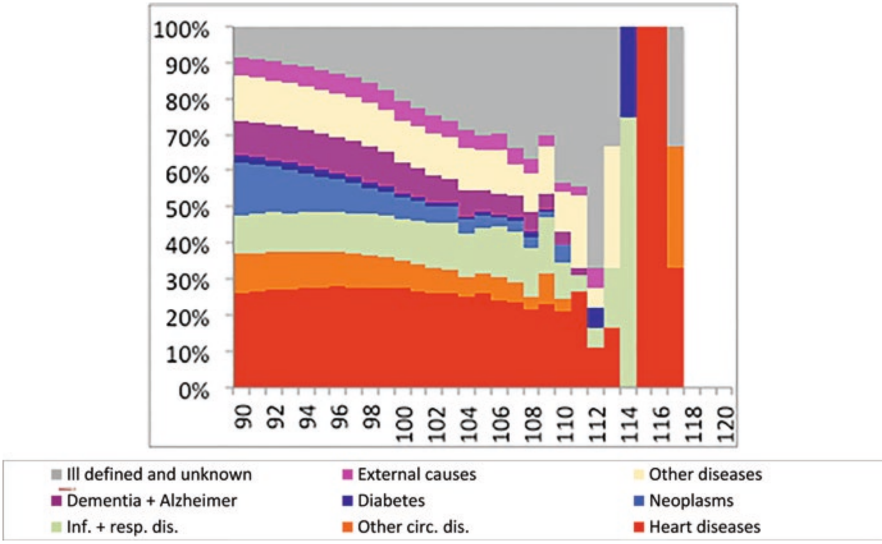


Fig. 7.1 Age-specific proportions (%) of deaths by group of causes (2000–2014): both sexes. (Source: files provided by CépiDc)

Table 7.2 Correspondence in ICD-10 of the groups and sub-groups of causes used

Group	Causes	ICD-10 code
1	Heart diseases	I00-I528
	Specified heart diseases	*I00-I459*
		I470-I499
		I510-I528
	Cardiac arrest, heart failure	*I460-I469*
		I500-I509
2	Other circulatory diseases	I600-I99
3	Infectious and respiratory diseases	A000-B99
		J00-J998
4	Neoplasms	C000-D489
5	Diabetes	E10-E149
6	Neuro-degenerative diseases	F000-F039
		G20-G269
		G300-G319
	Parkinson's disease, other extrapyramidal disorders, and Alzheimer's disease	*G20-G269*
		G300-G319
	Vascular and unspecified dementia	*F000-F039*
7	Other diseases	B500-E079
		E15-E90
		F04-G149
		G320-G457
		G460-H959
		K000-Q999
8	External causes	V010-Y98
9	Ill-defined and unknown causes	R000-R99
	Senility	*R54*
	Other ill-defined cause	*R000-R539*
		R55-R989
	Unknown cause	*R99*

among females at these very old ages the graph becomes erratic at an earlier stage among males than among females. It is also worth noting that while the share of deaths from cancer diminishes rapidly with age among both sexes, this share is much more pronounced among males than among females at age 90. Conversely, we find that infectious and respiratory diseases increase with age among males, but less so among females.

Indications that ill-defined information increases with age was not limited to the category of "ill-defined and unknown causes". In each large group of specified causes, it is known that some items are less precise than others. For these less specified causes, we also observe that the proportions increase with age. We see this pattern when, for example, we compare "specified heart diseases" with "cardiac arrest and heart failure" (Fig. 7.3), or "Alzheimer's disease" with "vascular and other dementias" (Fig. 7.4). However, in these cases as well we observe that the

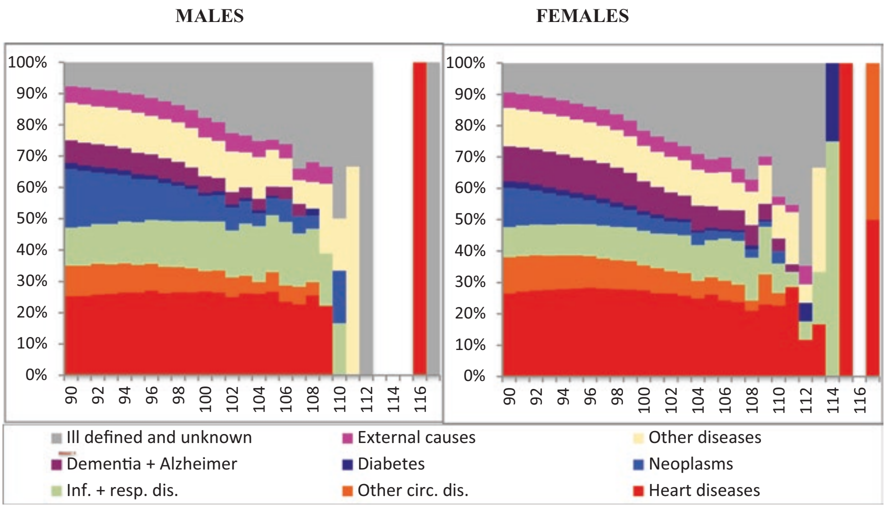


Fig. 7.2 Age-specific proportions (%) of deaths by sex and group of causes (2000–2014). (Source: files provided by CépiDc)

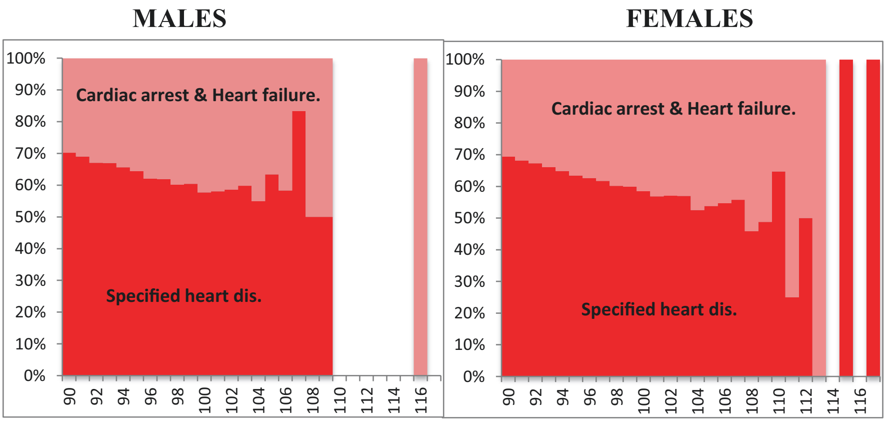


Fig. 7.3 Age-specific proportions (%) of deaths by group within heart diseases (2000–2014). (Source: files provided by CépiDc)

proportions of the most precise causes were never negligible. These results clearly suggest that exploring causes of death is worthwhile, even at very old ages.

Furthermore, if we join these unspecified sub-categories to the group of "ill-defined causes" (Fig. 7.5), we can see that although the total number of deaths in these categories increase considerably with age, the proportion of deaths from "specified diseases" remains important through the end of the significant data: among males, the proportion changes from 80% at age 90 to 50% at age 110; and among females, the decrease is even smaller, from 78% at age 90 to 53% at age 110.

It is also interesting to look at the distribution of the sub-categories of ill-defined causes: "senility", "other ill-defined causes", and "unknown cause" (Fig. 7.6).

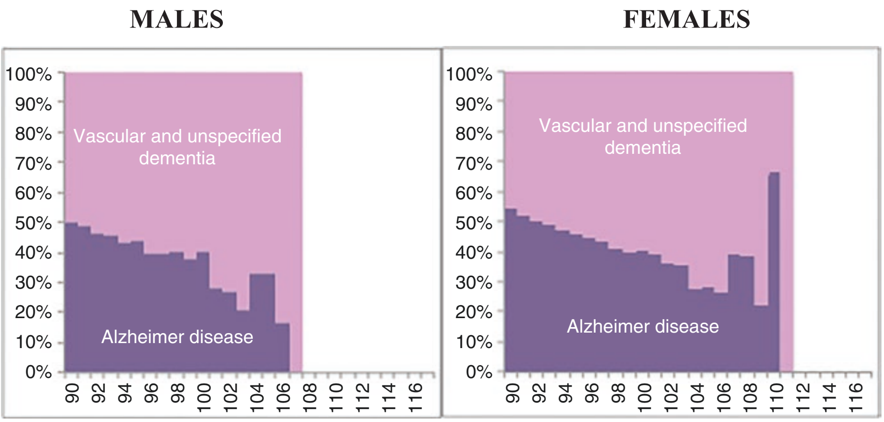


Fig. 7.4 Age-specific proportions (%) of deaths by group within dementias (2000–2014). (Source: files provided by CépiDc)

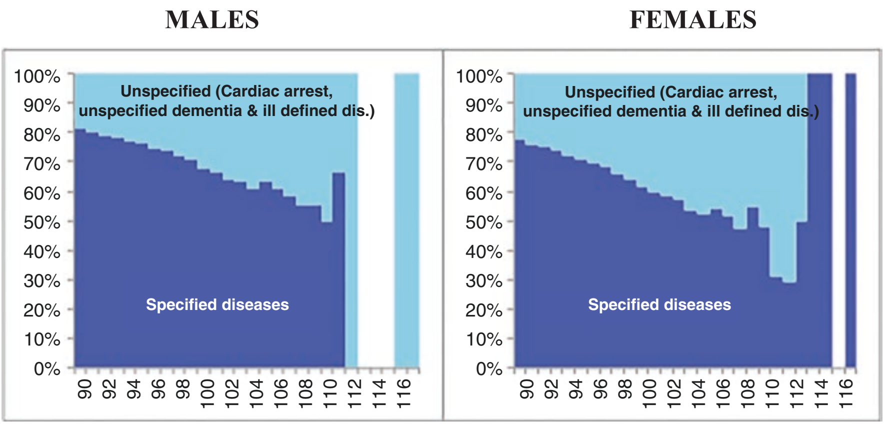


Fig. 7.5 Age-specific proportions (%) of deaths by specified vs unspecified causes (2000–2014). (Source: files provided by CépiDc)

While "other unspecified causes of death" decrease rapidly, "unknown cause" does not increase (it even decreases until around age 100). By contrast, "senility" increases. In this context, the question of whether "senility" can be seen as a real cause of death arises. We explore this issue further in the next section.

7.3 Supercentenarian Deaths by Cause Using Multiple Causes

While the statistics for deaths at very old ages cannot be considered fully reliable, we can look at individual cases to investigate whether the selected underlying cause is an accurate summary of all of the information reported on the cause-of-death certificate (Désesquelles et al. 2014a). For each death, we obtained from INSERM the complete

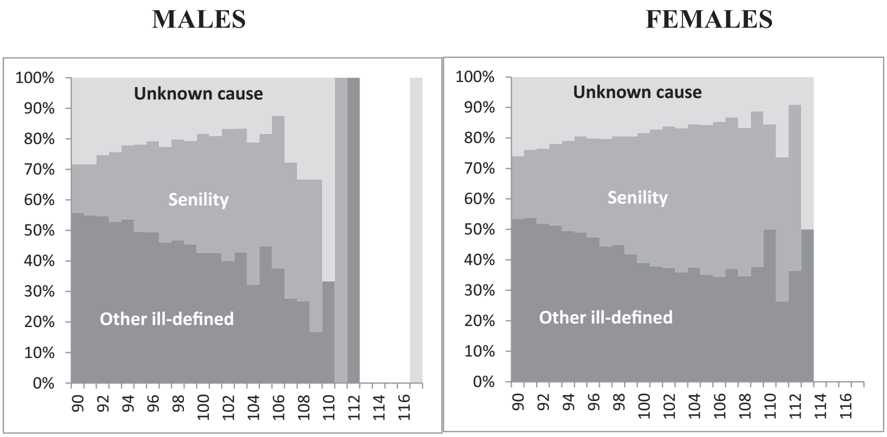


Fig. 7.6 Age-specific proportions (%) of deaths by group within ill-defined causes (2000–2014). (Source: files provided by CépiDc)

list of all of the original information written on the certificate by the medical doctor who reported the death, in its original wording. The form the doctor completed has two parts. In part I, each step of the lethal process has to be reported, from the most *immediate* cause to the *initial* one (several lines are provided for this information). In part II, the medical doctor can report any other condition or health event that may have contributed to the death, but did not cause it directly (*associated* causes).

Thus, for each case, the multiple causes can be compared to the selected underlying cause. It was our view that making such a comparison for all deaths of supercentenarians (aged 110+) would be quite informative. However, to ensure accurate results, we had to consider that even now, the reported ages in such exceptional cases must be proven. To ensure that we were dealing with true supercentenarians, we used the French part of the International Database on Longevity (IDL) to check the exact ages at death of the individuals listed in the INSERM file as supercentenarians. Out of a total of 160 cases of death at age 110+ listed in the INSERM file, 115 cases were validated[5], while the remaining 45 cases were not validated (either because the age was wrong or because matching the death with the birth certificate was impossible for various reasons).

After comparing the underlying and the multiple causes of death for each of these 115 true supercentenarians, we distinguished four possible degrees of knowledge about the cause of a supercentenarian death:

(A) a specific disease that caused the death was reported;
(B) a specific disease was reported, but the individual was in poor overall physical condition;

[5] In the framework of the international research group on supercentenarians, strict rules for age validation have been established. In particular, it is recommended that the death certificate be matched with an early piece of personal identification, which should ideally be the birth certificate. In France, the validation was strictly based on matching the death with the birth certificate. This process of validation was systematically done for all reported supercentenarians (aged 110 +).

(C) the individual's physical condition had deteriorated, but no precise cause of death was identified; or
(D) the individual was reported to have died of natural causes or old age.

In the following, we discuss some specific examples. For all these examples, a small frame gives:

– the sex and age of the deceased;
– the ICD-10 code of the underlying cause chosen and its title (in bold);
– all of the information written in French by the physician in part I of the certificate (in italics), and the translation of this information into English (in upright);
– and, if any, the information written in French by the physician in part II of the certificate (in italics) and the translation of this information into English (in upright).

(A) ***Examples in which "a specific disease caused the death"***

In Example 1, the underlying cause of death of a woman aged 113 is coded as an "*ulcer of oesophagus*", item K221 of the ICD-10. No precise information about the woman's condition is provided. The additional notes made by the medical doctor in part I of the certificate describe a logical progression from the appearance of a peptic ulcer of the oesophagus to the development of a digestive haemorrhage. The underlying cause that was reported (in bold here below) appears to be correct, and it is clear that this woman's death was attributable to a well-specified cause, without any mention of any symptom of an overall deterioration in her health.

Example 1. Woman, Aged 113: K221: Ulcer of Oesophagus
Information given on part I of the certificate:

– *hémorragie digestive* [digestive haemorrhage]
– *antécédents ulcère gastrique* [history of gastric ulcer]
– *ulcère peptique oesophagien* [peptic ulcer of the oesophagus]

Similarly, in Example 2, which refers to the death of a woman at age 110, the underlying cause was identified as "*acute myocardial infarction, unspecified*" (code I219 in ICD-10). This can be seen as a precise cause, even though the *AMI* is unspecified. The information provided on the certificate leaves no doubt about the underlying cause.

Example 2. Woman, Aged 110: I219: Acute Myocardial Infarction (AMI), Unspecified
Information given on part I of the certificate:

– *ischémie aiguë* [acute ischaemia]
– *embolie* [embolism]
– *TACFA* [tachyarrhythmia with atrial fibrillation]

(B) ***Examples of "a specific disease or injury with worsening overall physical health"***

In Example 3, the death of a woman aged 111 was attributed to "*exposure to unspecified factor causing other and unspecified injury*" (code X599, ICD-10). If the case were that of a younger adult, choosing this cause of death might have made sense. But because the case was that of a 111-year-old woman, selecting this cause may not have been appropriate, as her age and general physical deterioration could have been the cause of the fall itself. Even if the underlying cause chosen is correct according to the ICD rules of coding, it is clear that such rules are less pertinent at older than at younger ages. It is important to consider here that the worsening of the woman's overall physical condition likely played a non-negligible role in her death.

Example 3. Woman, Aged 111: X599: Exposure to Unspecified Factor Causing Other and Unspecified Injury
Information given on part I of the certificate:

– *arrêt cardio-respiratoire* [cardiorespiratory arrest]
– *altération état général* [general physical deterioration]
– *grabataire* [bedridden]
– *fracture du col du fémur* [fracture of neck of femur]
– *accident* [accident]

In Example 4 (a man aged 110), the choice of "*malignant neoplasm of prostate*" (code C61, ICD-10) as the underlying cause of death is even more striking. It is stipulated in the ICD rules that when only vague causes are mentioned in part I but if a precise cause is reported in part II, the precise cause should be chosen as the underlying cause of death. However, in the case of this 110-year-old man, it is unclear whether his prostate cancer was more responsible for his death than simply "old age". If his cancer had been sufficiently advanced to have caused his death, it is likely that the medical doctor would have mentioned the cancer in part I. For that reason, we put this case in category B.

Example 4. Man, Aged 110: C61: Malignant Neoplasm of Prostate
Information given on part I of the certificate:

– *défaillance cardio-respiratoire* [cardiorespiratory failure]
– *grand âge* [old age]

Information given on part II of the certificate

– *cancer de la prostate* [cancer of prostate]

(C) ***Examples of "the worsening of the individual's overall physical condition, without a specific disease"***

The third category brings together cases in which the worsening of the person's overall physical condition is the only known cause of death. In Example 5, the death of a woman aged 111 was attributed to *"unspecified protein-energy malnutrition"* (code E46, ICD-10), which could appear to be a precise cause. But all of the other information provided suggests that malnutrition was not the initial cause. It is clear that severe failures or disorders of the woman's fundamental functions were mainly responsible for her death. The "senescence" reported on the last line of part I might have also been selected. The most concise summary of the information provided is that the woman experienced a general deterioration in her health, and not a precise nutritional process.

Example 5. Woman, Aged 111: E46: Unspecified Protein-Energy Malnutrition
Information given on part I of the certificate:

- *dénutrition* [malnutrition]
- *grabatisation* [bedridden]
- *sénescence* [senescence]

Information given on part II of the certificate:

- *insuffisance rénale sévère* [severe renal failure]
- *troubles rythmiques cardiaques* [cardiac rhythm disorders]

Similarly, in Example 6, which concerns the death of a man aged 110, the selection of "*pulmonary oedema*" (J81, ICD-10) as the cause of death seems overly precise. The information provided on both part I (pulmonary congestion and cachexia) and part II (old age) is quite vague. It appears that actual underlying cause of death was old age, rather than any specific respiratory disease.

Example 6. Man, Aged 110: J81: Pulmonary Oedema
Information given on part I of the certificate:

- *encombrement pulmonaire* [pulmonary congestion]
- *cachexie* [cachexia]

Information given on part II of the certificate:

- *grand âge* [old age]

(D) ***Examples of "natural death"***

In the last two Examples (7 and 8), "*senility*" was obviously the only possible choice, as no information was provided that would suggest another cause. This cause could be an appropriate choice for very old people who died without suffering from any precise lethal disease. While it is possible that the medical doctor did not pay enough attention to the case, it is also possible that some very old people died simply because they had reached an age at which it is common to die of "natural causes". In such cases, "senility" should be recognised as a non-ill-defined cause of death, at least among those who die at very old ages. The challenge lies in ensuring that this cause is not selected simply out of laziness.

Example 7. Woman, Aged 111: R54: Senility
Information on part I of the certificate:

– *sénescence* [senescence];
– *mort naturelle pendant sommeil* [natural death while sleeping];

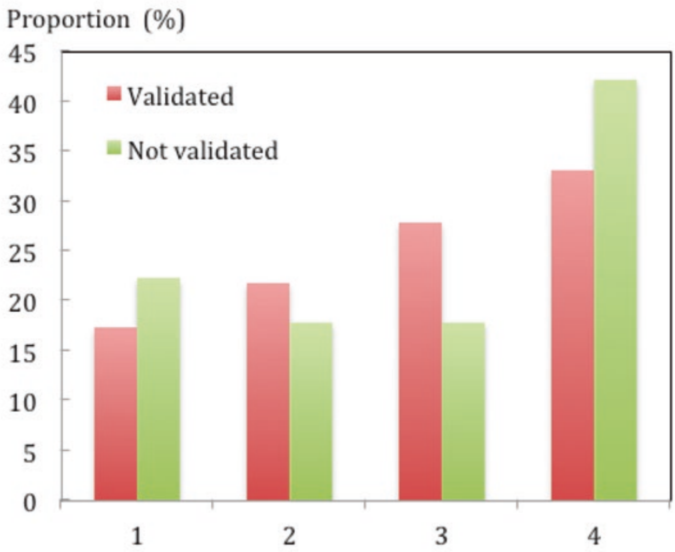
Example 8. Man, Aged 112: R54: Senility
Information on part I of the certificate:

– *sénilité* [senility]
– *arrêt cardio-respiratoire* [cardiorespiratory arrest]

All of the cases cited above are taken from our sample of 115 true supercentenarians. However, we systematically sorted all 160 cases in order to compare the cause-of-death precision of the validated and the non-validated cases. This was done to give us an idea of the bias that could result from the analysis of the crude INSERM data that lack the IDL reference.

Among the 115 deaths of age-validated supercentenarians for the 2000–2014 period, 20 could be attributed to precise underlying causes of death, with no suspicion that a mistake in identifying the main cause had been made (Table 7.2). Another 25 deaths could be attributed to precise underlying causes of death, but with an accompanying deterioration in the individual's overall physical condition, which suggests that the initial cause was not necessarily the one selected in the coding process. An additional 32 cases could be explicitly attributed to a worsening of the individual's overall physical condition without a precise cause. And, finally, 38 deaths could be attributed to various causes related to old age, without necessarily referring to senility explicitly. At these very old ages, it is not surprising that the first category was the smallest, while the sizes of the less precise categories grew with the degree of inaccuracy (Fig. 7.7).

The distribution of the 45 cases for which the age was not validated was quite different (Table 7.3 and Fig. 7.7). There were more deaths in the first category; i.e.,



1. *a specific disease that caused the death was reported;*
2. *a specific disease was reported, but the individual was in poor overall physical condition;*
3. *the individual's physical condition had deteriorated, but no precise cause of death was identified; or*
4. *the individual was reported to have died of natural causes or old age.*

Fig. 7.7 Distribution into four degrees of cause-of-death precision of supercentenarian deaths, ages validated and non-validated (2000–2014)

in the most precise category. This was as expected because many of these non-validated deaths occurred at relatively young ages, when diagnosing the cause of death tends to be easier. There were also more deaths in the last category; i.e., the category that included unknown causes of death. This was likely because we had less information about these people, including about their causes of death. Consequently, fewer of the non-validated than the validated cases were assigned to categories 2 and 3.

Despite these important differences between the validated and the non-validated cases, the bias that would result from including all of the INSERM cases in our analysis would not be dramatic. Since the non-validated cases made up less than 30% of all cases, the distribution of all cases would differ little from that of the validated cases only (Table 7.2).

Table 7.3 Summary of the types of causes of death at ages 110+

Type of cause	Number of deaths (*proportion*)		
	Age validated	Not age validated	Total
1. Precise cause of death	20 *(17%)*	10 *(22%)*	30 *(19%)*
2. Specific disease with a worsening of the overall physical condition	25 *(22%)*	8 *(18%)*	33 *(21%)*
3. Worsening of the overall physical condition without a precise cause	32 *(28%)*	8 *(18%)*	40 *(25%)*
4. "Natural death", "age", unknown, etc.	38 *(33%)*	19 *(42%)*	57 *(36%)*
Total	115 *(100%)*	45 *(100%)*	160 *(100%)*

7.4 Conclusion

Our analysis generated three main findings:

- Studying causes of death is worthwhile even among the oldest old. In a country like France, the cause-of-death pattern evolves regularly until around age 105. The share of deaths from circulatory diseases is quite stable over the age range, the share of deaths from cancers declines, and the share of deaths from respiratory/infectious diseases increases. The importance of ill-defined causes rises with age, partly due to a worsening of data quality. These insights open the door to an interesting discussion about the concept of cause of death at very old ages.
- Especially for deaths at very old ages, it is necessary to take into account multiple causes of death in assessing the quality of the medical information provided on the death certificate. It appears that the ICD rules for the selection of the underlying cause are not necessarily as convenient as for deaths at younger ages.
- While a minority of supercentenarian deaths can be attributed to a precise underlying cause, in most cases the death is attributed to an overall worsening of the person's physical condition, rather than to a precise underlying cause. This tends to be the case for two reasons:
  - the precise cause of death that is identified is not decisive (it led to death only because of a general deterioration in health); or
  - a general deterioration in health is the only cause that can be certified.
- It is possible that "senility" can be considered a real cause of death at very old ages. It becomes meaningful as an indicator because daily care may be more crucial to the survival of the oldest old than any conventional medical care or treatment (Fried et al. 2004; Motta et al. 2010). Supercentenarians tend to be so frail that any minor health event or brief lapse of attention on the part of their caregivers can be lethal.

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Chapter 8
Causes of Death Among 9000 Danish Centenarians and Semisuper-Centenarians in the 1970–2012 Period

Lasse Kaalby, Axel Skytthe, Karen Andersen-Ranberg, and Bernard Jeune

8.1 Introduction

The prevalence of morbidity and disability is very high among centenarians (Andersen-Ranberg et al. 2001a). As most centenarians suffer from several diseases (multi-morbidity) they are at high risk of dying – but what do they die of? This question has scarcely been examined. The few existing studies on causes of death (CoD) are often based on selected samples of centenarians.

According to the World Health Organization's recommendations, death certificates should always single out one "main cause of death," also known as the *underlying* CoD. This is the disease or injury that initiated the events leading to death, but not the *immediate* CoD. It is common among older people for co-existing chronic conditions to contribute to death, without being part of the sequential pathway from the underlying to the immediate CoD. These conditions are called *contributing* CoDs. All three types of CoD are listed on the death certificate form if they are known, but only the underlying CoD is registered as the main CoD.

The existing studies on CoD can be divided into two categories: autopsy studies and register studies.

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8.2 Autopsy Studies

The earliest studies were autopsy studies. Ishii and Sternby (1978a, b, c) published three articles based on the findings of 23 hospitalized Japanese centenarians. The most common underlying causes of death among this group were identified as cerebro- and cardiovascular disease (CVD) and pneumonia. All of these cases displayed signs of atherosclerosis, and myocardial fibrosis was present in 15 of the 23 centenarians. In six of the 23 centenarians, malignant neoplasms were found, although these appeared to be a contributing CoD rather than the underlying cause.

John and Koelmeyer (2001) is an autopsy study of cases from a forensic department in New Zealand of 319 nonagenarians and centenarians (with a mean age of 92) who were registered as having died suddenly between 1988 and 1998. Of the 319 deaths, 272 (85%) were from natural causes, while 47 (15%) were from unnatural causes. The most common causes of natural death were ischemic heart disease (23%), bronchopneumonia (12%), acute myocardial infarction (8%), cerebrovascular accidents (6%), ruptured aneurism (5%), and gastrointestinal disease (5%), including bleeding. CVD accounted for 50% of the deaths. However, cancer was listed as the underlying CoD in only six cases, and as a contributing cause of death in five additional cases. Among the subjects who died of unnatural causes, falls accounted for 35 of the 47 deaths, and suicides accounted for three deaths. Only 13 cases (5%) were “written off” as being attributable to “old age or senile debility.” The authors concluded “that elderly die of disease not of old age.”

Berzlanovich et al. (2005) also examined autopsy reports from a forensic department in Austria on 40 centenarians who died unexpectedly in Vienna between 1985 and 2002 (a total of 842 centenarians died in Vienna over this period). All of the deaths were from sudden natural causes, and occurred in private homes. The most common underlying CoD among these centenarians was CVD, which was found in 27 (68%) of the cases. Of these CVD deaths, 15 (38%) were from acute myocardial infarction, six (15%) were from acute cardiac failure, and six (15%) were from a rupture of an aortic aneurysm. Pneumonia was the underlying CoD in 10% of the cases, and gastrointestinal disease was the underlying CoD in 5% of the cases. Advanced neoplastic disease with widespread metastases was found in three of the cases. The autopsies also revealed that many of these centenarians had suffered from preexisting conditions that were not the underlying CoD, but that were probably contributory.

The most extensive study of autopsies of centenarians examined the autopsy reports on almost all of the centenarians who died in one Italian province over a certain period (Motta et al. 2010). These 140 autopsy reports were compared with autopsy reports on 96 younger old adults (aged 75–95). The study presented evidence on the frequency of various pathologies, but without clearly stating whether these pathologies were causes of death. Most of the pathologies of the circulatory system occurred more frequently among the centenarians than among the younger older people. The pathologies that occurred most frequently among the centenarians were ischemic cardiac diseases (37.8% versus 33.3%) and cerebral ischemia (23.4% versus 17.0%), followed by severe arteriosclerosis (18.4% versus 3.5%) and pulmonary embolism (11.3% versus 8.9%). In contrast, acute myocardial infarction occurred less frequently among the centenarians (5.9%) than among the younger older individuals (20.5%), and was only rarely identified as the underlying cause of death. Interestingly, cardiac amyloidosis was found among 11.3% of the centenarians, but among none among the younger older people. Respiratory pathologies were also very common among centenarians and higher than among the younger older people; especially chest infection (40.4% versus 24.8%), but also chronic obstructive pulmonary disease (8.4% versus 3.5%). However, the most remarkable finding was that the frequency of non-skin cancer was much lower among the centenarians than among the younger older people (16.3% versus 39.0%). Moreover, among those with cancer, the frequency of metastases was much lower among the centenarians than among the younger older individuals (26% versus 55%).

8.3 Register Studies

One of the earliest register studies on CoD among centenarians is included in a study on Finnish centenarians (Louhija 1995). Of the population of 92 deceased centenarians studied, 36% died from circulatory diseases, 34% died from diseases of the respiratory system, and 21% died from another CoD. Only 3% died from neoplasms.

A comprehensive register study of 35,867 deceased English centenarians examined the CoD and the place of death between 2001 and 2010. This study by Evans et al. (2014) found that the most common underlying CoD was pneumonia (17.7%), followed by cerebrovascular diseases (10%), ischemic heart disease (8.6%), and other circulatory diseases (9.8%). Cancer was cited as the underlying CoD in only 4.4% of these cases. A very large share of these deaths was attributed to “old age” (28.1%). This CoD was more common among deaths that occurred in a nursing home (34.2%), a residential home (35.9%), or the individual’s home (35.5%) than among deaths that occurred in a hospital (9.7%). The study compared the CoDs of the centenarians to the CoDs of individuals aged 80–99 years, and found that the centenarians died more frequently from pneumonia and “old age,” and less frequently from CVD and cancer.

A systematic review by Pavlidis et al. (2012) included 16 articles on cancer as the CoD among centenarians published over a time span of more than 80 years (1918–2002). The authors concluded that cancer was rarely an underlying CoD among centenarians, and that when it was reported as an underlying CoD, the immediate CoD was rarely due to the spread of tumors, but to cancer-related complications, such as bleeding from stomach cancer or pneumonia in patients with lung cancer. The authors stressed that the cases of cancer observed among centenarians were at a lower stage with fewer metastases than among younger old people.

In summary, the most common CoDs among centenarians appear to be circulatory and respiratory diseases. While “old age” was frequently mentioned as the only CoD in some studies, this cause was seldom cited in autopsy studies, and even less often in studies based on cases from forensic departments. Moreover, in autopsy studies cancer was not cited as a common CoD.

It is, however, difficult to evaluate whether centenarians – and especially semi-supercentenarians (aged 105–109) – die of one underlying clearly diagnosed disease or of a combination of equally important diseases (multi-morbidity), or whether a proportion of centenarians die of "old age" (i.e., of a breakdown of multiple systems of the body).

In this study, we examine the causes of death (CoD) of almost 9000 Danish centenarian deaths, including almost 500 semi-supercentenarians. We examine the relative frequencies of the CoDs and the age-, gender- and cause-specific mortality rates, and whether these rates have changed over the decades since 1970. We compare the CoDs of centenarians with the CoDs of people aged 85–99, and the CoDs of semi-supercentenarians with the CoDs of centenarians in the same periods.

8.4 Methods and Materials

8.4.1 Data Collection

The material includes all individuals who died in Denmark between 1970 and 2012 aged ≥100. For comparison, data have been extracted on people who died at ages 85–99 in the same period.

All of the data are from The Danish Register of Causes of Death (DRCD) and the Civil Registration System (CRS). The DRCD collects information on all deaths in Denmark. The registry, which contains data from 1970 onward, is managed by the Danish Health Data Authority (DHDA). The CoDs are classified using ICD − 8 in the 1970–1993 period, and using ICD-10 from 1994 onward (Table 8.1). To overcome the differences in coding schemes over time, the CoDs have been grouped into 49 categories by the DHDA (Sundhedsstyrelsen 2002). In addition, existing information on autopsies was obtained. After the law on autopsies was changed in 1990, there was a substantial decline in the number of ordinary autopsies performed in Denmark. As a result, the presented data are almost solely based on information given by the physicians who filled in the death certificates.

A total of 8573 centenarian deaths registered between 1970 and 2012 were obtained from the DRCD. In addition, 1019 centenarians were identified as alive and living in Denmark as of January 1, 2013, based on data obtained from the CRS registry in 2015. As there is a 3-year delay in the release of data by the DRCD, the last year that could be included for analyses of cause-specific mortality was 2012.

Aggregated data on 85–99-year-olds were collected from Statistics Denmark. Statistics on cause-specific mortality are available in 5-year age groups up to ages 80–84, but the statistics for higher ages are available only for the broader age group 85+. The collected data are based on the categorization of the 49 CoDs that is also used in the DRCD. By subtracting the number of deaths among centenarians from the number of deaths in the age group 85+, the number of deaths among the 85–99-year-olds in each of the 49 categories was calculated.

Table 8.1 Cause of death categorization using ICD-10 and ICD-8

Cause of Death	ICD-10	ICD-8
Ischemic heart disease	I20-I25	410-414
Cerebro-vascular disease	I60-I69	430-438
Other cardiovascular disease	I10-I15, I27, I30-I52, I28, I70- I79	400-404,420-429,440-448
Pneumonia	J13-J18	480-486
Other respiratory disease	J00-J06, J10-J11, J20-J22, J30- J47, J60-J99	460-474, 490-493,500-519
Cancer	C00-C34, C37-C97, D00-D09	140-199, 200-209
Digestive diseases	K00-K31, K70-K83, K35-67, K85- K93	520-577
Urinary & genital disease	N00-N08, N20-N23, N10-N19, N25-N99	580-629
Endocrine disorders	E00-E07, E10-E90	240-246, 250-279
Mental disease	F00-F99	290-315
Ill-defined conditions/ senility	R00-R99	780-796
Accidents	V01-V99, W00-X59, Y40-Y86, Y87.1-87.2	800-807, 810-823, 825-949
Other	A00-A09, A20-A99, B00-B90, B99,A15-19, D10-D48, D50-89, G00-G99, H00-H95, I00-I09, I26, I80-I99, O00-O99, L00-L99, M00-M99, Q20-Q28, Q00-Q18, Q30-Q99, P00-P86, X60-X84, Y87.0, X85-Y36	000-019, 210-239, 280-289, 320-398, 450- 458, 630-678, 680-738, 740-779, 950-999

8.4.2 Data Analysis

The data analysis of cause-specific mortality in this study is based on the 8573 deaths of centenarians from 1970 to 2012 extracted from the DRCD. Of the 8573 deaths, 14 had missing information about the CoD, which leaves 8559 deaths to be examined.

We have reduced the 49 categories to 13 groups of CoDs based on a combination of the relative frequencies (at least 1.5% of all deaths) and the absolute mortality rate in the last period of 2010–2012 (at least 10 deaths per 1000 person-years). The CoDs within the 49 categories that in relative and absolute numbers were below these thresholds have been grouped in the category "other causes of death." The classification is displayed in Table 8.1.

Since the data on cause-specific mortality among individuals aged 85 and older were only available in aggregated form, we were only able to calculate cause-specific mortality among 85–99-year-olds as a single age group. We were therefore unable to calculate standardized mortality rates.

Age-, gender-, and cause-specific mortality rates for centenarians were estimated based on individual data. In the comparison with the 85–99-year-olds, the aggregated data were used to estimate the cause-specific mortality rates.

The Danish certificate of death follows WHO's recommendations, and consists of two parts. In the first part, the physician provides a sequential list of conditions leading to the immediate CoD. The underlying CoD – i.e., the disease or injury that initiated the events leading to death – is listed last. In the second part of the certificate, the physician can report any other significant disease that contributed to the death (contributing CoD). In this study, we focus only on the underlying CoD.

8.5 Results

The number of centenarian deaths in Denmark has increased from 535 in 1970–1979 to 3165 in 2000–2009. A total of 8559 deaths were registered during 1970–2012 (see Table 8.2). The median age at death among Danish centenarians has increased to above 101 years due to a decrease in the proportion of deaths among 100- and 101-year-olds and an increase in deaths among those aged 102 or older. In particular, the proportion of centenarians who died at age 105 or older doubled over the study period (from 3.6% in the 1970s to 6.2% in 2010–2012). Furthermore, the gender distribution changed over time in favor of the female population: 82.9% of the centenarians who died in 2010–2012 were women, up from 68.6% in the 1970s.

Table 8.3 shows that in the last period (2010–2012), CVD – a category that includes ischemic heart diseases, cerebrovascular diseases, and other cardiovascular diseases – was listed as the underling CoD in about one-third of the deaths. However, this proportion has been declining substantially since the 1970s, when CVD was

Table 8.2 Age and gender of 8559 deceased Danish centenarians between 1970 and 2012

	1970–1979		1980–1989		1990–1999		2000–2009		2010–2012		Total
	n	Percent	n	Percent	n	Percent	n	Percent	n	Percent	N
					Gender						
Women	367	68.6	895	73.0	1713	77.8	2684	84.8	1186	82.9	6845
Men	168	31.4	331	27.0	489	22.2	481	15.2	245	17.1	1714
Age											
100	237	44.3	524	42.7	924	42.0	1259	39.8	577	40.3	3521
101	148	27.7	290	23.7	570	25.9	805	25.4	350	24.5	2163
102	69	12.9	193	15.7	341	15.5	484	15.3	215	15.0	1302
103	42	7.9	103	8.4	177	8.0	290	9.2	129	9.0	741
104	20	3.7	71	5.8	82	3.7	165	5.2	71	5.0	409
105+	19	3.6	45	3.7	108	4.9	162	5.1	89	6.2	423
Total	535	100	1226	100	2202	100	3165	100	1431	100	8559

Table 8.3 Cause of death in 8559 centenarians by period of time

	1970–1979		1980–1989		1990–1999		2000–2009		2010–2012		Total	
Cause of Death	n	Percent	n	Percent	n	Percent	n	Percent	n	Percent	N	Percent
Ischemic heart disease	210	39.3	395	32.2	512	23.3	509	16.1	165	11.5	1791	20.9
Cerebro-vascular disease	57	10.7	98	8.0	148	6.7	215	6.8	91	6.4	609	7.1
Other cardiovascular disease	104	19.4	231	18.8	403	18.3	512	16.2	214	15.0	1464	17.1
Pneumonia	49	9.2	128	10.4	183	8.3	294	9.3	125	8.7	779	9.1
Other respiratory disease	16	3.0	49	4.0	55	2.5	67	2.1	33	2.3	220	2.6
Cancer	16	3.0	49	4.0	62	2.8	105	3.3	57	4.0	289	3.4
Digestive disease	7	1.3	14	1.1	50	2.3	82	2.6	42	2.9	195	2.3
Urinary & genital disease	6	1.1	8	0.7	22	1.0	71	2.2	33	2.3	140	1.6
Endocrine disease	0	0.0	6	0.5	20	0.9	124	3.9	39	2.7	189	2.2
Mental disease	6	1.1	17	1.4	49	2.2	147	4.6	103	7.2	322	3.8
Ill-defined conditions/ senility	33	6.2	156	12.7	523	23.8	767	24.2	401	28.0	1880	22.0
Accidents	20	3.7	52	4.2	121	5.5	128	4.0	42	2.9	363	4.2
Other	11	2.1	23	1.9	54	2.5	144	4.6	86	6.0	318	3.7

identified as the underlying cause of death for more than two-thirds of centenarian deaths. This decline is mainly explained by a decline in the share of deaths from ischemic heart diseases, which declined by more than two-thirds. By contrast, the proportion of deaths in which cerebrovascular disease was identified as the underlying CoD decreased by only about one-third, while the shares of deaths from other types of CVD fell by one-quarter.

In contrast, the proportion of deaths for which pneumonia and other respiratory diseases was listed as the underlying CoD has been almost constant over time (at about 11–12%). The low proportions of deaths from cancer (about 3–4%) and from accidents (about 3–5%) were also constant, while the shares of deaths from most of the other minor groups of diseases increased. Deaths from mental diseases, including dementia, increased from about 1% to about 7%. Over the same period, deaths from ill-defined conditions/senility increased from about 6% to 28%, making this category the largest of the groups of underlying CoDs. In two-thirds of the deaths attributed to this group of causes, senility ("old age") was listed as the underlying CoD; and it is this subgroup in particular that has grown over time.

Table 8.4 shows that the proportions for most underlying CoDs were lower among the semi-supercentenarians (aged 105–109) than among the individuals aged 100–104, and that a very low proportion of deaths among the semi-supercentenarians was from cancer (about 2%). Shares of deaths from other respiratory diseases (including COPD) and accidents (including falls) were slightly higher among the semi-supercentenarians, and were especially high for ill-defined conditions/senility: one-third of deaths among the semi-supercentenarians were attributed to this cause, compared to less than one-fifth of deaths among the individuals aged 100–104. In particular, deaths attributed to the subgroup senility ("old age") increased sharply with age.

It is evident from Table 8.5, which shows the cause-specific mortality rates per 1000 person-years, that CVD was the leading underlying CoD in all periods, and especially in the 1970s and the 1980s. The absolute decline over time was substantial and steady for ischemic heart disease, with the share of deaths from this cause falling to almost one-quarter in 2010–2012 from very high levels in the 1970s (from 202.7 to 60.0 deaths per 1000 person-years). Over the same period, the decline in the share of deaths from cerebrovascular diseases and other cardiovascular diseases was much smaller.

Similarly, the mortality rate for pneumonia stayed constant at a relatively high level over the study period. Since the 1980s, the mortality rate for pneumonia was higher than the mortality rate for cerebrovascular diseases. The mortality rate for cancer stayed constant over this period, but at a relatively low level (less than half the rate for pneumonia). Except for accidents, the cause-specific mortality rates increased over the period for all other disease groups, especially for mental diseases, which increased sixfold; and for ill-defined conditions/senility, which increased fivefold. These increases resulted in a mortality rate in the 2000s of more than 10 per 1000 person-years for all of the defined groups of diseases.

It appears that centenarian women had a lower risk of dying from ischemic heart disease than centenarian men (see Table 8.6): the mortality rate for this cause was

Table 8.4 Cause of death in 8559 centenarians by age

	100		101		102		103		104		105+	
Cause of Death	n	Percent	n	Percent	n	Percent	n	Percent	n	Percent	n	Percent
Ischemic heart disease	775	22.0	432	20.0	262	20.1	167	22.5	81	19.8	74	17.5
Cerebro-vascular disease	247	7.0	169	7.8	89	6.8	55	7.4	24	5.9	25	5.9
Other cardiovascular disease	603	17.1	381	17.6	228	17.5	110	14.8	79	19.3	63	14.9
Pneumonia	326	9.3	190	8.8	129	9.9	66	8.9	31	7.6	37	8.8
Other respiratory disease	87	2.5	48	2.2	35	2.7	21	2.8	14	3.4	15	3.5
Cancer	128	3.6	76	3.5	40	3.1	19	2.6	17	4.2	9	2.1
Digestive disease	93	2.6	52	2.4	29	2.2	12	1.6	7	1.7	2	0.5
Urinary & genital disease	60	1.7	27	1.3	28	2.2	14	1.9	7	1.7	4	0.9
Endocrine disease	76	2.2	45	2.1	30	2.3	23	3.1	10	2.4	5	1.2
Mental disease	151	4.3	88	4.1	40	3.1	22	3.0	10	2.4	11	2.6
Ill-defined conditions/senility	678	19.3	487	22.5	303	23.3	176	23.8	100	24.4	136	32.2
Accidents	155	4.4	88	4.1	49	3.8	30	4.1	14	3.4	27	6.4
Other	142	4.0	80	3.7	40	3.1	26	3.5	15	3.7	15	3.5
Total	3521	100	2163	100	1302	100	741	100	409	100	423	100

Table 8.5 Cause-specific mortality rates per 1000 person-years (95% CI) by period

	1970–1979		1980–1989		1990–1999		2000–2009		2010–2012	
Cause of Death	MR	95% CI	MR	95% CI	MR	95% CI	MR	95% CI	MR	95% CI
Ischemic heart disease	203	177–232	179	156–190	125	115–136	80	73–87	60	52–70
Cerebro-vascular disease	55	43–72	43	35–52	36	31–42	34	30–39	33	27–41
Other cardiovascular disease	101	83–122	101	88–114	98	89–108	80	74–87	77	68–89
Pneumonia	48	36–63	56	47–66	45	39–52	47	42–52	47	40–56
Other respiratory disease	16	10–25	21	15–28	13	10–18	10	8–13	10	7–14
Cancer	16	10–25	21	16–28	15	12–19	16	14–20	21	16–27
Digestive disease	7	3–14	6	4–10	12	9–16	13	10–16	15	11–21
Urinary & genital disease	6	3–13	4	-8	5	3–8	11	9–14	12	9–16
Endocrine disease	0		3	1–6	5	3–6	19	16–23	14	10–19
Mental disease	6	3–13	7	5–12	12	9–16	23	20–27	37	31–45
Ill-defined conditions/ senility	32	23–45	68	58–79	128	117–139	120	112–129	146	132–161
Accidents	19	13–30	23	17–30	30	25–35	20	17–24	15	11–21
Other	11	6–19	10	7–15	13	10–17	22	19–26	31	25–39

Table 8.6 Cause of death and gender-specific mortality rates per 1000 person-years (95% CI)

	Women		Men	
Cause of Death	MR	95% CI	MR	95% CI
Ischemic heart disease	103	97–108	132	120–146
Cerebro-vascular disease	37	34–40	36	30–44
Other cardiovascular disease	88	83–93	89	78–100
Pneumonia	43	39–46	69	61–79
Other respiratory disease	11	9–13	21	16–27
Cancer	16	14–18	25	20–31
Digestive disease	12	10–14	12	8–16
Urinary & genital disease	8	6–9	12	9–17
Endocrine disease	12	10–14	11	8–15
Mental disease	21	19–23	13	10–18
Ill-defined conditions/senility	116	110–122	103	92–115
Accidents	21	19–24	26	20–32
Other	19	17–22	20	15–25

102.6 per 1000 person-years for women versus 132.2 per 1000 person-years for men. The mortality rate for pneumonia and other respiratory diseases as the underlying CoD was lower among women than among men (for pneumonia: 42.7 versus 69.2 per 1000 person-years). The same pattern can be observed for the mortality rate for cancer (15.8 versus 24.8 per 1000 person-years). On the other hand, the mortality rate for ill-defined conditions/senility as the main cause of death was a little higher among women than among men (115.8 versus 103.0 per 1000 person-years), and this pattern can also be seen for mental diseases (20.8 per versus 13.3 per 1000 person-years).

The proportion of individuals who died from ischemic heart disease was at the same level and decreased at the same rate over time among the centenarians as among the 85–99-year-olds (Fig. 8.1). Among both the 85–99-year-olds and the centenarians, ischemic heart disease was the leading CoD in the 1970s and the 1980s, but the share of deaths from this cause decreased from almost 40% to about 10% over the study period. However, the proportion of deaths from the group of cerebrovascular diseases was lower among the centenarians after the 1970s because the share decreased over time among the centenarians, but not among the 85–99-year-olds. The proportion of deaths from the group of other CVDs was a little higher for the centenarians in the most recent periods.

The proportion of deaths for which pneumonia was reported as the underlying CoD was higher among the centenarians than among the younger old people after the 1970s; over the study period, the share remained stable among the centenarians, but was halved among the younger old people (from about 10% to 5%). The share of deaths for which cancer was reported as the CoD was much lower among the centenarians (3–4%) than among the younger old people, for whom the share remained almost unchanged at around 15%. The share of deaths for which mental disease was the underlying CoD increased in both age groups over the period, but

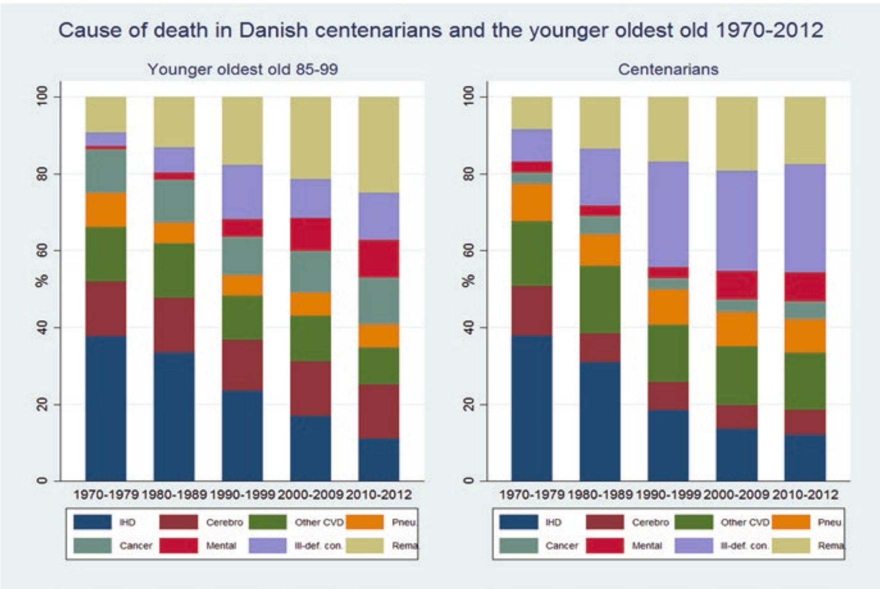

Fig. 8.1 Cause of death among Danish younger old people and centenarians 1970–2012

rose slightly more among the younger age group (to about 10%). However, the proportion of deaths from ill-defined conditions/senility was much higher among the centenarians: by the end of the study period, the share was three times higher among the centenarians than among the younger age group. In contrast, the proportions of deaths from the remaining groups of reported CoDs were higher among the younger old people than among the centenarians, and increased more over time.

8.6 Discussion

In 2010–2012, CVD was the underlying CoD in about one-third of all deaths among centenarians. This represents a significant decline from the 1970s, when CVD was the underlying cause for up to two-thirds of all deaths. The proportion of deaths for which pneumonia or another respiratory disease was the underlying CoD remained almost constant in the 1970–2012 period (at about 12%). The proportion of deaths for which cancer was the underlying CoD was low and remained constant at about 3–4%. Except for accidents, the shares of deaths assigned to other CoD groups increased substantially over time: a sevenfold increase was observed for deaths from mental disease, and an almost fivefold increase was observed for deaths from ill-defined conditions/senility (reaching 28% in the last period). The cause-specific mortality rates confirm these trends.

The mortality rates for ill-defined conditions/senility and mental disease were higher among women than among men. The proportions of deaths for which other CVDs, pneumonia, and ill-defined conditions/senility were reported as the underlying CoD were higher among the centenarians than among the 85–99-year-olds, but the proportions of deaths from other causes, especially cancer, were lower among the older than the younger age group. The proportions of deaths from most of the underlying CoD groups were lower among the semi-supercentenarians (aged 105–109) than among the 100–104-year-old centenarians. But over the study period, ill-defined conditions/senility accounted for one-third of the underlying CoDs among the semi-supercentenarians, but less than one-fifth of the underlying CoDs among the 100–104-year-old centenarians.

8.6.1 Cerebro- and Cardiovascular Diseases (CVD)

Our finding that the mortality rates and the proportions of deaths from CVD were high even in the latest period are consistent with the findings from previous studies (Berzlanovich et al. 2005; Motta et al. 2010). This was the case for ischemic heart disease in particular, as of the three CVD groups of causes of death, this group was the largest from 1970 to the 2000s. However, after 2000 the largest group of causes of death was other cardiovascular diseases, including arteriosclerosis, hypertension, peripheral artery disease, and other heart diseases such as heart valve diseases. For this group of underlying CoDs, both the relative proportion and the mortality rate decreased only moderately over time. The proportion of deaths for which cerebrovascular disease was the underlying CoD was smaller, and declined substantially over the period. We found that this group of causes accounted for 7% of deaths. Thus, our estimate is between previous estimates presented in Louhija (1995) (5%) and in Evans et al. (2014) (10%).

It is possible that the number of deaths due to CVD was underreported, as it has been shown that cardiovascular diseases are substantially underreported among living Danish centenarians (Andersen-Ranberg et al. 2013). As the proportion of the centenarians whose deaths were attributed to ill-defined conditions/senility is high in our study, especially for the most recent periods, a substantial number these deaths may have actually been caused by an undetected cardiovascular disease. A higher diagnostic threshold in very frail centenarians, as well as ageism, could explain such misreporting. It is therefore possible that CVD is still the cause of more than half of all centenarian deaths.

8.6.2 Pneumonia and Other Respiratory Diseases

The almost constant mortality rate for pneumonia over the 42-year study period is interesting, as the increasing number of centenarians might include more frail centenarians, and thus centenarians who are more susceptible to infections. The proportion of deaths from pneumonia (about one-tenth) in our study is consistent with the findings of other studies (Louhija 1995, Berzlanovich et al. 2005). In the relatively large autopsy study by Motta et al. (2010), the frequency of chest infection was shown to be much higher (40.4%). However, this was the frequency of all infection pathologies found in the lungs of the Italian centenarians during autopsies. It is likely that these infections represented the underlying CoD in only a fraction of these cases.

In the recent register study of centenarian deaths in England by Evans et al. (2014), the proportion of deaths from pneumonia was also found to be higher (17.7%). This result might be attributable to the fact that the share of the English centenarians studied who died in hospital was twice as high as the share of the Danish centenarians in our sample (27% versus 13%), and that pneumonia was more likely to have been listed as the underlying CoD among those who died in English hospitals.

Whether pneumonia actually was the underlying CoD in all of these cases can be discussed. It is possible that in some of these cases, pneumonia was the immediate, but not the underlying CoD. Nevertheless, if it is the only disease reported in the death certificate, it would be registered as the underlying cause. As we noted in our discussion of cardiovascular diseases, whether this disease is listed as the underlying CoD depends on the level ofknowledge the treating physicians have about the centenarian's health when they fill in the death certificate.

The group of other respiratory diseases that could be listed as the cause of death includes chronic obstructive pulmonary disease (COPD) and asthma. It is possible that a proportion of the deaths attributed to pneumonia may have actually been caused by an undiagnosed or unknown COPD.

8.6.3 Cancer

In our study, we found that the proportion of deaths in which cancer was listed as the underlying CoD was much lower among centenarians than among the 85–99-year-old group, and was even lower among the semi-supercentenarians (2.1%). Whether a death is caused by cancer depends of the severity of the cancer; i.e. the stage and the expansion of metastases. However, in the few existing autopsy studies on this age group, metastases were rarely observed in centenarians (Ishii and Sternby 1978c; Motta et al. 2010; Pavlidis et al. 2012). It is possible that other causes induced by the cancer – such as bleeding due to stomach cancer or pneumonia due to upper respiratory tract cancer – were reported as the main causes. In these cases, cancer may have been overlooked as the underlying CoD (Stanta et al. 1997).

8.6.4 Digestive, Urinary, and Endocrine Diseases

Although the shares of deaths attributable to these categories of disease are small (about 2% each), both the proportions of deaths from and the mortality rates for these three groups of CoDs more than doubled from the 1970s to the 2010–2012 period, when the mortality rate for each of these causes was higher than 10 per 1000 person-years. The endocrine disease group includes diabetes. This shift may have been the result of an increase in the numbers of older patients with diabetes who survived to very high ages. Moreover, an increase in the number of centenarians who were treating their arthritis by taking pain-relieving medicines such as NSAID, which may cause fatal gastro-intestinal bleeding (Wasteson et al. 2012), could explain the increase in the mortality rate for digestive diseases. In the few autopsy studies that included selected centenarian deaths, the proportion of deaths caused by urinary tract or genital diseases was found to be very low (less than 1%) among the nonagenerians and the centenarians in New Zealand, and to be zero among the centenarians who died at home in Austria (Berzlanovich et al. 2005).

8.6.5 Mental Diseases

This group of CoDs includes the ICD codes for dementia (F00-F03). The total proportion of deaths attributed to mental diseases is relatively low (about 4%), but the mortality rate for this group increased sixfold over the examined period. This shift reflects the increase in the number of older adults with dementia and the high prevalence of dementia among Danish centenarians – of about 50% (including mild dementia), according to the first study on Danish centenarians (Andersen-Ranberg et al. 2001b). However, this trend may also be partly due to the increased awareness and use of these diagnoses among physicians when completing the death certificate. Furthermore, it may have become more acceptable in recent years to report dementia as the underlying CoD instead of senility, fatigue, cachexia, or other ill-defined conditions/senility.

8.6.6 Ill-Defined Conditions/Senility

The group of ill-defined conditions/senility was probably listed as the underlying CoD when the physician who filled in the death certificate did not know the exact disease that caused the death. The proportion of registered deaths in which this CoD was listed increased dramatically over the study period, to more than one-quarter of the centenarian deaths and to more than one-third of the semi-supercentenarian deaths.

Evans et al. (2014) found that the proportion of deaths for which the CoD was listed as "old age" was high among centenarians in England (28.1%). This estimate is a little higher than our estimate for the share of deaths attributed to the group of "ill-defined conditions/senility" in the same period (24.2% in the 2000s). In Evans et al., the "old age" CoD group included the codes R53 (fatigue) and R54 (senility), while our CoD group of ill-defined conditions/senility included all R-codes (R0 to R99; i.e., including "lack of knowledge"). Although in our study the R54 code alone accounted for two-thirds of all the causes of deaths coded R0-R99, the share of deaths attributed to "old age" was found to be higher among English centenarians (28%) than among Danish centenarians in the most recent period. However, in both studies the proportion of deaths for which "old age" was listed as the CoD was very high; it was almost as high as the proportion of deaths from all three CVD groups in our study, and it was much higher than the proportion of deaths from all CVDs in Evans et al.

There are obviously some problems associated with using the ICD-10 codes of fatigue (R53), senility (R54), "lack of knowledge" (R99), and other R-codes. Among them are that physicians differ in their opinions about whether it is possible to die from old age. It can be argued that the physicians who reported one of these R-codes as the underlying CoD did so because they believe that ill-defined symptoms such as cachexia, fatigue, malaise, and senility are the result of degrading bodily functions and frailty. Like pneumonia, these symptoms might be seen as resulting from very old age. Supporting this point of view is the marked increase in the proportion of deaths attributed to this group of ill-defined conditions/senility with increasing age among the Danish centenarians.

This increase may be related to the Danish Health Department's recommendation at the end of the twentieth century that physicians avoid the use of "causa ignota" (unknown cause) when completing death certificates. The increasing tendency to report ill-defined symptoms as the CoD may be attributable to the inability to make a clear diagnosis due to a lack of knowledge, and to the tendency to underreport certain diseases, such as cardiovascular diseases and cancer. According to John and Koelmeyer (2001), autopsies of nonagenarians and centenarians showed that they died of diseases, and not of "old age." But this conclusion was based on sudden deaths. It may be the case that a substantial proportion of the Danish centenarians (maybe about one-fifth), and especially of the semi-supercentenarians (maybe about one-fourth), died of "old age" – i.e., a combination of several diseases and organ deficiencies – and not due to one single cause.

8.6.7 Differences Between Age Groups and Gender

Some differences between the centenarians who died at ages 100–104 and those who died at ages 105+ were identified. The proportions of deaths from cardiovascular diseases and from cancer were a little lower among the semi-supercentenarians than among the 100–104-year-old centenarians; while the proportions of deaths from accidents (falls), other respiratory diseases (including COPD), and ill-defined conditions/senility were higher among the semi-supercentenarians. The use of the R54 code ("old age," senility) in particular was substantially higher.

The comparison of the underlying CoDs reported for the centenarians and for the 85–99-year-olds showed that the differences between these age groups were substantial. These findings seem to confirm that serious forms of cancer were rarely reported as the underlying CoD among the centenarians, and that pneumonia and "old age" were important underlying CoDs among the Danish centenarians.

Male and female centenarians were shown to display different mortality patterns. The mortality rate observed among men indicates that men were more likely than women to have died from somatic diseases, while women were more likely than men to have died from mental diseases or ill-defined conditions/senility. Some of these gender differences could be attributable to the higher age structure of the centenarian women relative to that of the centenarian men. This gap could also be due in part to a higher detection rate of somatic diseases among men, especially of CVD. But since these differences were not large, it appears that having a very high age matters more than gender.

8.6.8 Strengths and Weaknesses of the Study

The strength of this study lies in the inclusion of the total number of registered deaths among centenarians in Denmark during a long period of more than 40 years. We have thereby avoided the selection of centenarian deaths, which was the basis for most of the previous studies, as reported in the introduction. Only the study for England by Evans et al. (2014) took a similar approach. Although this study included four times the number of centenarian deaths, it covered a shorter time period. Another strength of our study is that we were able to directly compare the centenarians with the 85–99-year-olds, and the semi-supercentenarians with the 100–104-year-olds.

However, when considering the findings of this study, it is important to take into account some possible barriers to ascertaining the cause of death. The shift in codes between the ICD-8 and the ICD-10 has been taken into consideration in the DRCD's classification of the CoD into 49 categories (see Table 8.1). One of the most reliable ways of clearly establishing the CoD is by performing an autopsy. However, in Denmark autopsies are performed on a very small proportion of the centenarians who die (less than 1% in the latest periods). Furthermore, as most of the Danish centenarians in our study did not die in a hospital (only about one-tenth died in a hospital), the death certificate would have been filled in by a general practitioner (GP) in the majority of these cases. This may help to explain the tendency to report ill-defined conditions/senility as the underlying CoD. As recent recommendations discourage physicians from listing an unknown CoD (code R99), the use of the ill-defined conditions/senility CoD may have increased among GPs.

In sum, we think that our findings regarding the distribution and the development over time of underlying CoDs among Danish centenarians approximately capture the real situation. However, we also think that the increasing tendency to report senility ("old age") as the underlying CoD is partly due to the under-diagnosis of diseases among centenarians, especially of heart diseases; and is partly due to an actual increase in the number of people dying from a combination of multi-morbidity and organ deficiencies that can be accurately described as "old age." In most cases, the underlying CoD listed was mainly based on the knowledge of the GPs who filled out the death certificate. It can be difficult for GPs to disentangle which disease initiated the events leading to death.

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Part IV
Country Reports

Chapter 9
Supercentenarians and Semi-supercentenarians in France

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9.1 Introduction

The number of centenarians has increased considerably in industrialized countries. In France, it rose from about 200 in 1954, to more than 1,000 in 1970, and to 3,500 by 1990 (Labat and Dekneudt 1989). It then exceeded 8,000 at the end of the twentieth century (Robert-Bobée 2006) and according to INSEE's recent estimates, it reached 21,000 in 2016 and this number could rise to as much as 270,000 by 2070 (Blanpain and Buisson 2016).

Given the high level of mortality at very old ages, most centenarians do not survive very long. However, the greater the increase of centenarians in number, then the more likely it is that some of them will live to be 110 and thus become so-called supercentenarians, simply because we expect to observe more extreme values in larger populations. Recently, we have indeed witnessed the emergence and the gradual expansion of a new age group that used to be limited to extremely rare and often dubious cases of exceptional longevity. The most famous validated case is the French female supercentenarian Jeanne Calment, who was born in 1875 and died in 1997 at the age of 122.4 years; to this day, she is the verified oldest person who has ever lived (Robine and Allard 1999). The study of this recent phenomenon is important for two main reasons: (1) the emergence of a new age group is interesting in its own right; (2) the growing size of this very old age group should make it possible to

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measure with greater accuracy the age-trajectory of mortality after the age of 100, and hence, to inform our expectations about how the mortality curve unfolds at very old ages. A slowdown in the increase of human death rates at these ages has been observed frequently in human populations (Horiuchi and Coale 1990; Manton 1992; Horiuchi and Wilmoth 1998; Lynch and Brown 2001; Gampe 2010). Moreover, this phenomenon of mortality deceleration is consistent with various theoretical explanations (Beard 1959; Vaupel et al. 1979; Wachter and Finch 1997; Wilmoth and Horiuchi 1999; Steinsaltz and Wachter 2006; Mueller et al. 2011). Nevertheless, its validity has recently been challenged by those who assert that the Gompertz model is appropriate even at the very oldest ages (Gavrilov and Gavrilova 2011; Brouard 2012; Gavrilova and Gavrilov 2015).

The question of the trajectory of mortality at very old ages was in fact the main driver in the development of an *International Database on Longevity* (IDL), gathering as many verified cases of supercentenarians as possible in countries where the quality of vital records allows it. France has been a contributor since the beginning of the IDL project. Prior to the project, "true" cases of French supercentenarians had been identified by trackers of exceptionally long-lived individuals but not exhaustively, and meanwhile, the quality of the reporting of age at death in France's official vital statistics system diminishes abruptly with advancing age among the oldest old (Meslé and Vallin 2002). It is true that the wide-ranging IPSEN survey on centenarians was conducted in the early 1990s (Allard 1991; Allard et al. 1996), but we must recognize that the follow-up of birth cohorts included in the sample provided no more than a very limited number of deaths above age 105.

A first important step was undertaken by the IDL project with the publication of a first volume on supercentenarians (Maier et al. 2010), giving an overview of country-specific analyses including France (Meslé et al. 2010) and international comparisons of the first IDL data sets. Nevertheless, the final objective was not entirely reached, because of the small numbers of survivors at the most extreme ages of the human lifespan. In brief, we were not far from being able to measure life expectancy at age 110, but not yet close to estimate how the actual shape of the mortality curve unfolds beyond 110. Another issue also became ever clearer: even if we are becoming capable of producing more and more precise mortality indicators above age 110, an important gap will remain between the reasonably accurate data on younger centenarians (let us say those aged 100–105 years) and the increasingly accurate data on older centenarians aged above 110 from the continuation of our systematic validation work on supercentenarians. Consequently, the IDL project members decided to expand its research agenda by including a special investigation on deaths occurring between ages 105 and 110, the so-called semi-supercentenarians.

The present chapter is the French contribution to this new endeavor. Our study covers the continuing quest for the identification and the validation of new cases of supercentenarians, which have emerged within the past 10 years, and the special investigation dedicated to producing accurate measurements of mortality among semi-supercentenarians.

Similarly to Meslé and colleagues' work published in the 2010 volume on supercentenarians, we mobilize three different sources of data here, each one grasping reality from a different angle and with varying degrees of accuracy and coverage: death counts from the official vital statistics system, nominative transcripts from the *Répertoire national d'identification des personnes physiques* (RNIPP), and a "public" list of individual supercentenarians. We will discuss the validity of these sources and how we can make the most of their respective strengths for the purpose of mortality measurements, with the help of age validation procedures and the extinct generation method to estimate populations at risk.

We will first focus on the RNIPP, which stands out as a crucial source of data for the identification of supercentenarian and semi-supercentenarian deaths in France (Sect. 9.2). We will then describe our age validation procedures for each of these two categories of old-age deaths (Sect. 9.3), and provide a comparison between the RNIPP records and "public" lists of individual supercentenarians (Sect. 9.4). The much-awaited analytical result of this research is presented in Sect. 9.5, where we will calculate mortality indicators using vital statistics and RNIPP data to compare them within selected appropriate births cohorts. Closing remarks are offered in Sect. 9.6.

9.2 The RNIPP Data

Three sources of data can be used to enumerate semi- and supercentenarians in France: (1) the vital statistics system operated by the French National Institute of Statistics and Economic Studies (*Institut national de la statistique et des études économiques*, or INSEE), (2) the National Directory for the Identification of Natural Persons (*Répertoire national d'identification des personnes physiques*, or RNIPP), also administered by INSEE, and (3) public lists of long-lived individuals compiled from personal archives, local media coverage, and to some extent the IPSEN survey. Among these, the RNIPP stands out as the most reliable source (Meslé et al. 2010).

In a nutshell, the RNIPP was created in 1945 and initially consisted of paper listings that were kept at INSEE's regional offices. In the early 1970s, the listings of persons born after 1890 in metropolitan France (1900 for French overseas *départements*) were computerized and centralized by INSEE. The RNIPP is considered exhaustive by INSEE for cohorts born 1890 (1900 for overseas *départements*) and beyond, but incomplete for earlier birth cohorts. It covers all persons born in France, as well as persons born abroad and living in France who have requested a social security number (*numéro d'identification personnel*). For further details on the RNIPP, see Meslé et al. (2010, p. 126-127).

Access to the RNIPP is limited because it gathers data at the individual level and it includes nominative information that is deemed confidential. In 2004, our research group was granted permission by the *Commission nationale de l'information et des libertés* (CNIL) to access transcripts of individual records of the RNIPP. That same year, INSEE provided us with an RNIPP extract, namely a nominative list of 3,272 persons who died in France between 1988 and 2002 and were born between 1883 and 1897[1]. For each individual, we were given the following information: first and last names[2], sex, date and place of birth, date and place of death, and age at death. The age validation results presented below for alleged semi-supercentenarians is based on this list.

For the remaining results, we use four newer extracts of the RNIPP that INSEE provided us following an agreement concluded between INSEE and the French National Institute for Demographic Studies (*Institut national d'études démographiques*, or INED) in May 2014. The agreement states that exactly 1 month after both parties signed the agreement, INSEE will first provide INED with an RNIPP extract of all individuals born in France (metropolitan France, overseas *départements*, as well as Saint Barthélemy, Saint-Martin, and Saint-Pierre et Miquelon), for which the difference between their alleged years of death and birth is at least 105, and with the longest-term perspective allowed by the RNIPP. Then, every calendar year starting in 2015, INSEE will be providing INED with the same type of RNIPP extract, but the lists will then be limited to persons who have died in the last 2 years according to the RNIPP. Since May 2014, we therefore received new files in June 2014 (10,305 cases, including the 3,272 cases already received in 2004), April 2015 (1,681 cases), March 2016 (1,851 cases), and April 2017 (2,037 cases). The individual nominative information given with each of these extracts are: first and last (and maiden for females) names of the deceased, sex, date and place of birth, date and place of death, and the number of the birth and death certificates (if available). In the present study, we use the lists of names resulting from these four RNIPP extracts, which are partly overlapping. If we keep a single occurrence for each individual, the RNIPP list then totals 12,751 cases. We also have to discard all cases where the death occurred before the 105th birthday, and that results in a new total of 9,138 alleged semi-supercentenarians and supercentenarians. Moreover, we decided to limit our work to individuals who were born and died in metropolitan France and four overseas *départements* (Guadeloupe, Guyane, Martinique, and Réunion)[3]. Our total RNIPP universe therefore sums up to 9,100 individuals (8,284 females and 816 males).

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[1] INSEE provided us with all cases where the difference between alleged years of death and birth was 105 or greater. The data set therefore included some deaths of individuals that passed away at age 104, namely those who had not yet celebrated their 105th anniversary that year.

[2] For married females, both married and maiden names are provided.

[3] Mayotte is excluded because it was too recently established as an overseas *département*. Other French overseas territories of various statuses were also excluded since the quality of their civil registration system was still questionable at the beginning of the twentieth century. It should be noted, however, that until they became overseas *collectivités* in 2007, the small islands of Saint Martin and Saint Barthélemy were included as parts of Guadeloupe, while Saint-Pierre et Miquelon is excluded altogether despite having been an overseas *département* until 1985. To make things clear, among French overseas territories only those currently coded 971 (Guadeloupe), 972 (Martinique), 973 (Guyane) and 974 (Réunion) are included, while those coded 975 to 988 are excluded.

9.3 Age Validation of Supercentenarians and Semi-supercentenarians

We used the following age at death validation protocol to determine whether the alleged supercentenarians and semi-supercentenarians lived as long as implied by the RNIPP. The first part consists in verifying the accuracy of the information relative to the person's birth, namely his/her exact date of birth (i.e., year, month, and day of birth). This is achieved by referring to the person's birth certificate, available at the town hall of his/her birthplace or at the *département*'s archives. The accuracy of the person's exact date of death (i.e., year, month, and day of death) is also subject to a thorough verification and for that purpose, we use the death certificate from the town hall of the person's death commune. Then we compute the person's verified age at death from his/her dates of birth and death indicated on the birth and death records.

In the validation results presented below, we consider that a person's age at death has been correctly recorded in the RNIPP if the difference with the verified age is either null, or less than 4 days when the discrepancy is due entirely to a birthdate error. The rationale for allowing such errors in the birthdate is that the maximum delay to report a birth is set to 3 days in France, which can create some confusion over the date of the birth and the date of its registration.

9.3.1 Supercentenarians

The RNIPP extracts yielded a total (both sexes) of 231 alleged supercentenarians that were born and died in French *départements* (except Mayotte), and their death was between 1988 and 2016[4]. As Table 9.1a shows, we were able to find the birth and death certificate for all of these individuals, and the dates of birth and death recorded in the RNIPP were correct for the vast majority of them (213 or 92%). Out of the 18 erroneous cases, 12 were cases of disappearance (explained below), five had errors on their year of death, and one had the wrong year of birth. The results for females only are provided in Table 9.1b, with even greater scores overall for correct dates of birth and death (205 out of 216 or 95%). Tables 9.2a and 9.2b list the type of errors that were found.

For cases of disappearances, the date of death recorded in the RNIPP actually corresponds to the date of judgement of the person gone missing (all dates are relatively recent, with the earliest at 2002, see Table 9.2b). This practice results in incorrect ages at death and we have no way of knowing the true ages at death of these

[4] For the sake of consistency with the age validation process of semi-supercentenarians presented in the next section, we limit our work on supercentenarians to those who died in 1988 or later. This results in a single exclusion: one case of a supercentenarian who died in 1987.

Table 9.1a Age validation results for alleged supercentenarians who died in France (French *départements* only, excluding Mayotte) between 1988 and 2016, both sexes[a]

Age at death (years)	Number of cases	Validation procedure: Birth and death certificates or other legal documents were found[b]		Dates of birth and death were validated	
		Number of cases	In%	Number of cases	In %
110	133	133	100.0	127	95.5
111	48	48	100.0	45	93.8
112	28	28	100.0	27	96.4
113	11	11	100.0	7	63.6
114	5	5	100.0	4	80.0
115	1	1	100.0	1	100.0
116	2	2	100.0	1	50.0
117	1	1	100.0	0	0.0
122	2	2	100.0	1	50.0
Total	231	231	100.0	213	92.2

[a]The alleged supercentenarians were supposedly born between 1875 and 1906 in French *départements* (excluding Mayotte)
[b]If the death certificate does not exist because the person has gone missing, then a legal document confirming the person's disappearance was found

Table 9.1b Age validation results for alleged supercentenarians who died in France (French *départements* only, excluding Mayotte) between 1988 and 2016, females[a]

Age at death (years)	Number of cases	Validation procedure: Birth and death certificates or other legal documents were found[b]		Dates of birth and death were validated	
		Number of cases	In %	Number of cases	In %
110	121	121	100.0	120	99,2
111	46	46	100.0	44	95.7
112	28	28	100.0	27	96.4
113	10	10	100.0	7	70.0
114	5	5	100.0	4	80.0
115	1	1	100.0	1	100.0
116	2	2	100.0	1	50.0
117	1	1	100.0	0	0.0
122	2	2	100.0	1	50.0
Total	216	216	100.0	205	94.9

[a]The alleged supercentenarians were supposedly born between 1875 and 1906 in French *départements* (excluding Mayotte)
[b]If the death certificate does not exist because the person has gone missing, then a legal document confirming the person's disappearance was found

Table 9.2a Six errors found on the dates of birth and death of alleged supercentenarians who died in France (French *départements* only, excluding Mayotte) between 1988 and 2016, both sexes

	True year of:		Errors on the year of:		Age at death:	
Sex	Birth	Death	Birth	Death	Alleged	True
M	1877	1966	Ok	1990	113	89
F	1878	1982	Ok	1992	113	103
F	1878	1982	Ok	1992	114	104
F	1879	1974	Ok	1992	113	95
F	1890	1975	Ok	2013	122	84
F	1891	1994	1881	Ok	113	103

Table 9.2b Twelve cases of disappearance for which the date of the court decision was registered as the date of death, among alleged supercentenarians who died in France (French *départements* only, excluding Mayotte) between 1988 and 2016, both sexes

	Year of:			Age at death:	
Sex	Birth	Disappearance	Court decision	Alleged	True
F	1890	1973	2002	111	Unknown
M	1892	1963	2002	110	Unknown
F	1892	1965	2008	116	Unknown
M	1895	1943	2006	110	Unknown
F	1895	1963	2007	111	Unknown
M	1897	1945	2007	110	Unknown
F	1898	1979	2011	112	Body found in 1980
F	1898	1995	2015	117	Unknown
M	1899	1947	2009	110	Unknown
F	1899	1989	2009	110	Unknown
M	1903	1993	2015	111	Unknown
M	1904	n.d.	2014	110	Unknown

individuals[5]. The sex distribution is half and half (i.e., 6 cases each). For all males except one, their alleged age was 110, while alleged ages ranged from 110 to 117 for females. With regards to the five erroneous cases due to incorrect years of death, all were females but one, and the errors artificially lengthened these person's lifespans (once by 38 years, once by 24 years, once by 18 years, and twice by 10 years). All of them actually died between 1966 and 1982 and errors are probably due to manual data entry errors. The person with an incorrect birth year (1891 rather than 1881) is a female and her verified age at death in 1994 is 103 instead of 113. This is also a typical data entry error.

Among the 213 "true" supercentenarians, 20 (9.4%) were born and died in an overseas *département*. Compared to the 3% share of the overseas population in the total French population, such a high proportion of supercentenarians looks very

[5]Taking in account the long delay to obtain a judgement after a disappearance, it is quite improbable to have supercentenarians among them.

suspicious. Indeed, levels of mortality in the past used to be much higher in overseas *départements* than in metropolitan France, and this should have produced the reverse result. It is very likely, however, that until these territories got the full status of *département* (1946) the functioning of the civil registration system and its use by administrative services were not perfect. A thorough scientific validation of age thus seems required in cases born or died in overseas *départements*, with a more in-depth check of the actual correspondence between their official death and birth certificates, complemented by intermediate individual proofs of life. In upcoming Sects. 9.4 and 9.5, we chose to exclude Guadeloupe, Guyane, Martinique, and Réunion, as we have already done for all other French overseas territories. Our analyses will therefore rely on 193 cases of validated supercentenarians (including 185 females).

9.3.2 Semi-supercentenarians

We now turn to the validation of alleged semi-supercentenarians that was conducted a few years ago using the 2004 RNIPP data extract. This was prior to the 2014 agreement between INED and INSEE (see Sect. 9.2) that resulted in the RNIPP data upon which the validation of alleged supercentenarians presented above rests. The validation period for alleged semi-supercentenarians is thus shorter and it covers years of death that range from 1988 to 2002. Out of the 3,272 persons included in the RNIPP data set at our disposal in 2004, all of whom had died in France between 1988 and 2002 and were born between 1883 and 1897, 2,031 had supposedly lived to ages 105–109, excluding those who died before their 105th birthday or after their 110th birthday, or were born outside French *départements*. Given the considerable size of this group, we had to limit the exhaustive check to the oldest individuals (alleged ages 107, 108, and 109), while half of cases at alleged age 106 and a third

Table 9.3a Age validation results for alleged semi-supercentenarians, cohorts supposedly born 1883–1897 and died 1988–2002 in France[a], both sexes

				Validation procedure			
		Sample		Birth and death certificates or other legal documents were found[b]		Dates of birth and death were validated	
Age at death (years)	Number of cases	Number of cases	Sampling fraction (%)	Number of cases	In %	Number of cases	In %
105	1,047	352	33.6	349	99.1	349	100.0
106	560	274	48.9	274	100.0	272	99.3
107	262	262	100.0	261	99.6	260	99.6
108	111	111	100.0	111	100.0	111	100.0
109	51	51	100.0	51	100.0	51	100.0
Total	2,031	1,050	51.7	1,046	99.6	1,043	99.7

[a]Metropolitan France and French overseas *départements* (excluding Mayotte)
[b]Excludes errors up to 3 days in the birthdate (8 cases)

of cases at alleged age 105 were checked. Table 9.3a shows the age-specific sampling fractions used for both sexes combined.

Among the 1,050 females and males in our sample, the birth and death certificates were found for nearly all of them (1,046 or 99.6%), and among the 1,046 checked cases the dates of birth and death recorded in the RNIPP were exact in 1,043 instances (99.7%). Only two of these three cases turned out to be false semi-supercentenarians. Indeed, the first one was allegedly born in 1884 and died in 1991 at age 106, but she was in fact born in 1894 and had thus died at true age 96. The second one had a 7-year error on her year of birth, which was supposedly 1891 but corrected to 1898, making her true age at death 100 in 1998, instead of 107. The last erroneous case is a woman born in 1895 for which we found a minor 10-day error on her date of death (she passed away on 8 Nov. 2001 instead of 29 Oct. 2001), but that left her age at death unchanged at 106. It should be noted that among these three erroneous cases, the one with a 10-year error on her year of birth was born and died outside metropolitan France, namely in Guadeloupe.

Table 9.3b displays the results limited to females (959 cases out of 1,050), which are highly similar to those presented in Table 9.3a for both sexes.

The high quality of RNIPP data was further confirmed by an additional age validation study of 100 cases (20 for each year of age from 105 to 109), randomly selected among the 10,305 cases from the 2014 RNIPP extract. No error was found either in the dates of birth or death among the 99 cases which could be validated (for the one remaining case, we were unable to find the birth and death certificates).

Nevertheless, it seems appropriate to apply the same conclusion as for supercentenarians and to exclude from this point forward all semi-supercentenarians born or died in overseas *départements*.

Table 9.3b Age validation results for alleged semi-supercentenarians, cohorts supposedly born 1883–1897 and died 1988–2002 in France[a], females

				Validation procedure			
		Sample		Birth and death certificates or other legal documents were found[b]		Dates of birth and death were validated	
Age at death (years)	Number of cases	Number of cases	Sampling fraction (%)	Number of cases	In %	Number of cases	In %
105	959	321	33.5	318	99.1	318	100.0
106	518	249	48.1	249	100.0	247	99.2
107	246	246	100.0	245	99.6	244	99.6
108	102	102	100.0	102	100.0	102	100.0
109	46	46	100.0	46	100.0	46	100.0
Total	1,871	964	51.5	960	99.6	957	99.7

[a]Metropolitan France and French overseas *départements* (excluding Mayotte)
[b]Excludes errors up to 3 days in the birthdate (8 cases)

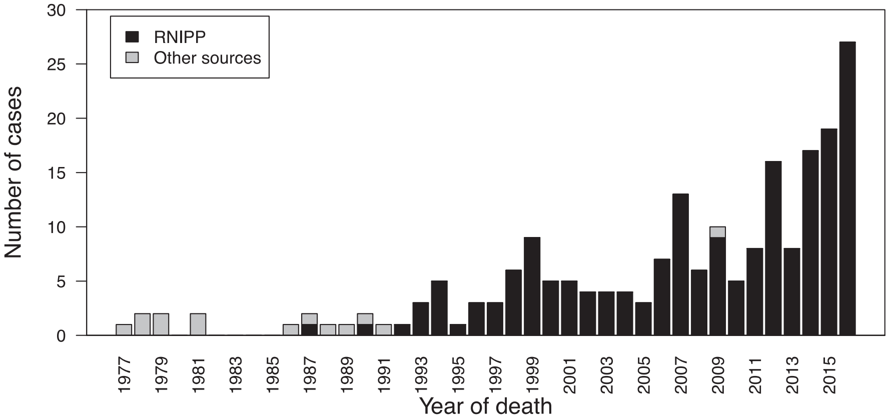

Fig. 9.1 Annual number of deaths of French supercentenarians included in the RNIPP and those that are known from other (public) sources but not found in the RNIPP, metropolitan France, 1977–2016, both sexes
Sources: RNIPP and https://fr.wikipedia.org/wiki/Liste_de_supercentenaires_français

9.4 RNIPP Data Comparison with Public Lists of French Supercentenarians

Besides official sources of information such as the RNIPP, that are subject to statistical confidentiality and for which permission by the CNIL must be obtained to grant data access, there are several public lists of individual supercentenarians in France. These public lists rely essentially on French communes' newsletters and information sites, local media coverage (e.g., press reports), research led by genealogical societies, and to a smaller extent the IPSEN survey. See, for instance, the Wikipedia list of French supercentenarians, available at https://fr.wikipedia.org/wiki/Liste_de_supercentenaires_français.

Previous work by Meslé et al. (2010) singles out the RNIPP data as the most reliable source for enumerating supercentenarians in France. Figure 9.1 shows that the RNIPP records identify a growing number of supercentenarians. A total of 14 cases are missing according to public sources, but most of these deaths of supercentenarians not reported in the RNIPP occurred quite a while ago. If we limit ourselves to years of death beyond 1991, missing cases from the 193 RNIPP records are reduced to a single occurrence, which took place in 2009.

9.5 Cohort Probabilities of Death and Death Rates at Older Ages

In the present section, we take advantage of the validation work described above to investigate patterns and trends in probabilities of death and death rates at very old ages in France. Our first set of calculations is based on data from the national vital statistics system, which is the most commonly available source of mortality data in France. As stated earlier, it suffers, however, from data quality problems at advanced ages. Here, we take these data as they are published, making no corrections whatsoever. In a second step, we compute probabilities of death and death rates using both raw and verified data from the RNIPP. Finally, we take advantage of these various probabilities of death series obtained from vital statistics and from the verified RNIPP data to derive and compare curves of life expectancy at ages 100 and above.

Before moving forward, it should be noted that probabilities of death and death rates are two different concepts. In particular, their age trajectories differ (Thatcher et al. 1998, Figs. 2.1 and 2.2) and failing to distinguish between the two concepts could lead to inaccurate claims about the shape of the mortality curve at very old ages (see Ouellette and Bourbeau (2014), pages 7–11 for more details). We compute one-year cohort probabilities of death and death rates series starting at ages 100 and 105 for vital statistics and RNIPP, respectively. By definition, the probability of dying in the age interval $[x, x + 1)$, written q_x, for a given cohort, corresponds to the number of deaths to the cohort between ages x and $x + 1$ divided by the size of the cohort at exact age x (i.e., at the beginning of the age interval). For probabilities of dying calculated from vital statistics data, the denominator was obtained using the method of extinct generations (Vincent 1951). In the absence of migration, the outcome is the same as counting the exact number of survivors at the beginning of each age interval from a data set consisting of individual records, as it was done with the RNIPP data.

With regard to death rates, death counts are divided by the population's exposure to the risk of death. For a given cohort, the death rate in the age interval $[x, x + 1)$, written m_x, is equal to the number of deaths to the cohort between exact ages x and $x + 1$ divided by the number of person-years lived by the cohort in the same age interval. The outcome is a number of events per person-year. For the RNIPP data, the number of person-years lived were directly counted by adding the contribution of each individual in each age interval, thereby taking full advantage of the information on the exact date of birth and date of death of the semi- and supercentenarians. Given that female deaths account for more than 90 percent of all deaths of semi- and supercentenarians recorded in the RNIPP data set, the results shown below in most figures are for females only.

9.5.1 Vital Statistics Data for Ages 100 and Above

Figure 9.2 displays one-year probabilities of death, q_x, starting from age $x = 100$ for female cohorts born between 1883 and 1901, as well as for an earlier group of female cohorts born during the period 1868–1882. All these cohorts are extinct today and the vital statistics data allow us to follow each one starting from age 100 onward. More specifically, the calculations are based on the vital statistics data received from INSEE, where death counts are aggregated by sex, year of birth, year

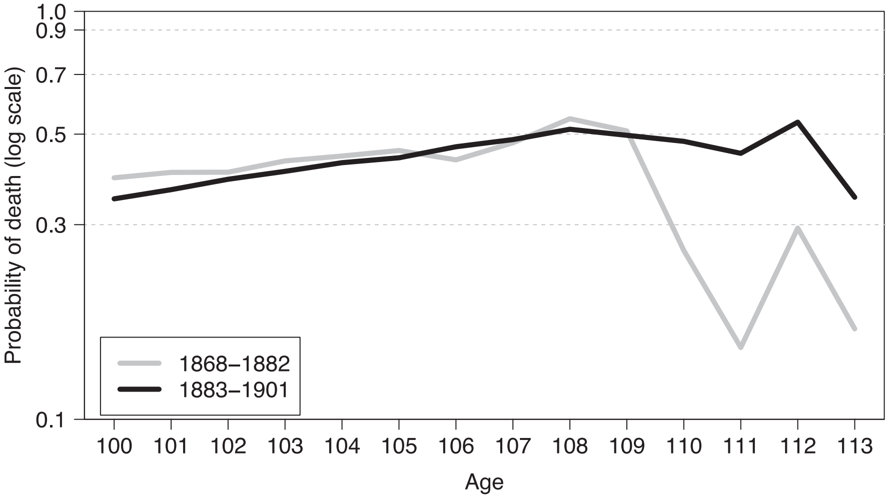

Fig. 9.2 Age-specific probabilities of death, q_x, for French female cohorts born 1868–1882 and 1883–1901 who died in metropolitan France
Note: The sizes of birth cohorts 1868–1882 and 1883–1901 at age 100 upon which the figure is based are $N = 10{,}829$ and $N = 45{,}684$, respectively
Source: Vital statistics

of death, and single years of age at death[6]. All deaths that occurred in metropolitan France are included here but we cannot distinguish between deaths of individuals born in France and deaths of individuals born abroad.

Figure 9.2 reveals that for the latest group of birth cohorts born between 1883 and 1901, the q_x series seems reasonable, both in terms of level and trend, up to about age 108. After age 108, the series starts to decline slightly and becomes irregular. For the q_x series for the earlier group of cohorts born between 1868 and 1882, however, the declining trend and fluctuations are much more pronounced beyond age 108. This goes to show that the quality of vital statistics data has greatly improved over time in France even if some part of this apparent progress is due to the increase in the number of survivors at age 100. At the most advanced ages, the q_x's used to be largely underestimated, most probably due to age exaggeration problems. The underestimation may persist to some lesser extent past the age of 108 for the latest set of birth cohorts, and the RNIPP can be used to provide us with better information on this matter.

[6] Vital statistics routinely published by INSEE include death counts by single years of age up to 104, followed by an open age group starting at 105. Every year, INSEE kindly provides us with a special tabulation distinguishing death counts by single years of age until the observed maximum age at death.

9.5.2 RNIPP Data for Ages 105 and Above

We used the RNIPP data to compute age-specific probabilities of death beyond age 105 among semi- and supercentenarians, all of whom were born and died in metropolitan French *départements*. We decided to focus on female cohorts born during the period 1883–1901[7]: 1901 is the most recent extinct birth cohort as of 31 December 2016 while individuals born in 1883 reached age 105 in 1988, which correspond to the first year where we can consider that death registration above age 105 is complete in the RNIPP, as suggested by Fig. 9.3.

First, we used the original RNIPP data as they were provided to us by INSEE, that is without applying any correction emerging from our age validation work presented in Sect. 9.3. The second set of calculations uses only verified RNIPP data for ages 110 and above, for which an exhaustive check has been done (Table 9.1b). For ages 105–109, the check was not exhaustive but it has been demonstrated that errors are quite negligible (Table 9.3b) and original RNIPP data were used. Note that correcting for age-at-death errors among alleged supercentenarians could lead to differences in q_x values beyond age x = 110, as well as prior to that age because of possible changes in the remaining size of the birth cohorts at the beginning of each age intervals serving as denominator for q_x.

The results are illustrated in Fig. 9.4, along with the vital statistics q_x series from age 100 for birth cohorts 1883–1901 (from Fig. 9.2). Caution is advised when contrasting the latter with the two RNIPP q_x series because it includes the foreign-born

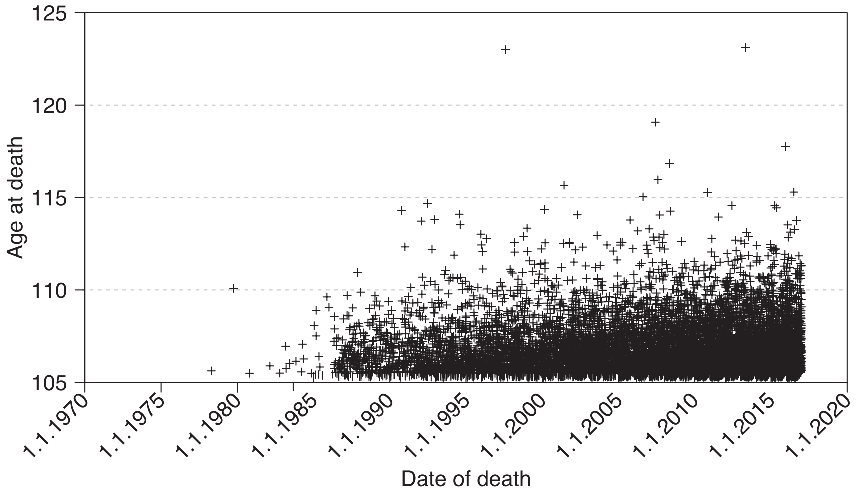

Fig. 9.3 Alleged age at death above age 105 by date of death in France
Source: RNIPP

[7]The group of birth cohorts 1883–1901 does not include the year 1875 during which Jeanne Calment was born.

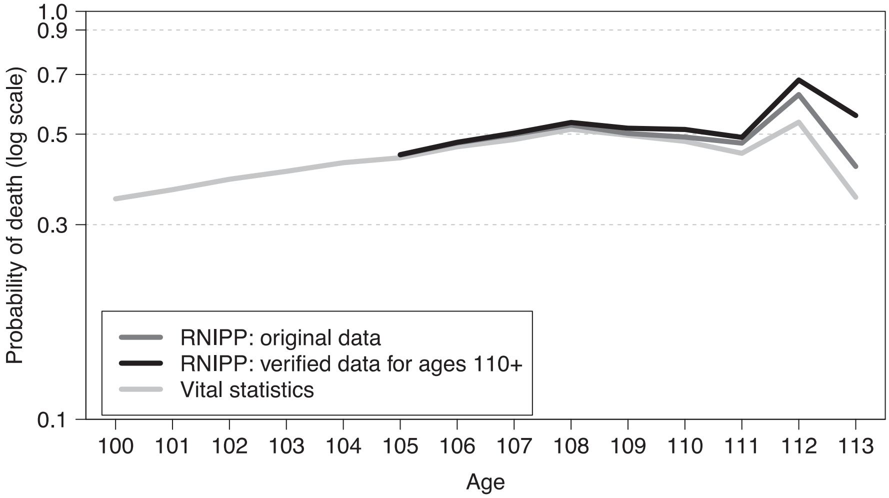

Fig. 9.4 Age-specific probabilities of death, q_x, calculated using two versions of the RNIPP data and the vital statistics data for French female cohorts born between 1883 and 1901 who died in metropolitan France
Note: The size of birth cohorts 1883–1901 at age 105 for the original and verified RNIPP data sets upon which the figure is based are $N = 3{,}492$ and $N = 3{,}485$, respectively. For vital statistics data, which includes deaths of individuals born abroad, the sizes are $N = 45{,}684$ at age 100 and $N = 3{,}959$ at age 105
Sources: RNIPP and vital statistics

female population, while the RNIPP data focuses exclusively on the native population. Despite this, the three curves practically overlap up to age 108, suggesting that the vital statistics is as reliable as RNIPP up to that age for cohorts born during the period 1883–1901. After age 108, however, the three curves start diverging. Probabilities of death derived from vital statistics data, which are known to be of poorer quality compared to the RNIPP data, show the lowest values and those calculated from the verified RNIPP data have the highest values. Such hierarchy between the curves was expected since age misstatement, especially when due to age overstatement, biases mortality estimates downwards at the most advanced ages (Preston et al. 1999). Probabilities of death beyond age 108 derived from the original set of RNIPP data fall between the two other curves, but they remain closer to the values obtained from verified RNIPP data.

So far in our analyses, we have focused solely on age-specific probabilities of death. Figure 9.5 presents these probabilities, together with age-specific death rates, m_x, according to the RNIPP verified data set[8]. As expected given the definition of q_x

[8] Recall that in the denominator of these death rates, the number of person-years lived were directly counted by adding the contribution of each individual. Calculations based on an aggregated version of the RNIPP data (by single years of age, death and birth) and resting on the assumption that deaths are distributed uniformly within each age interval leads to almost identical results (not shown here but available on request from nadine.ouellette@umontreal.ca)

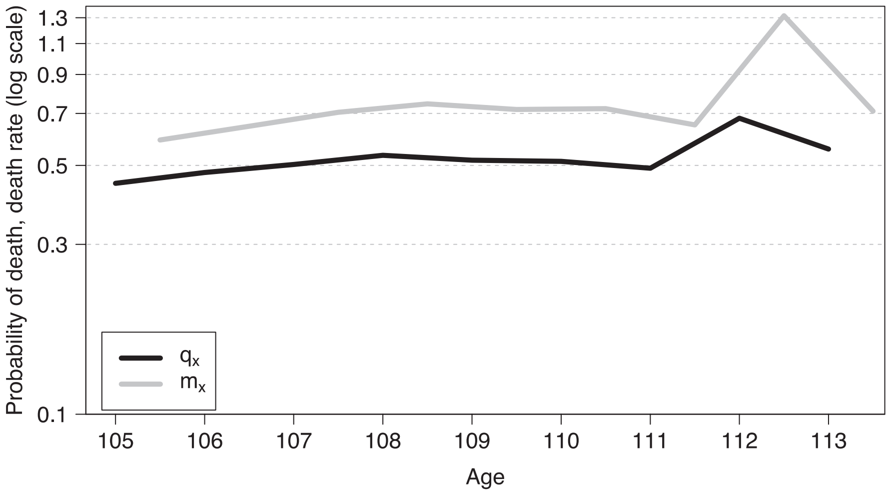

Fig. 9.5 Age-specific probabilities of death, q_x, and death rates, m_x, calculated using the verified RNIPP data for French female cohorts born between 1883 and 1901, metropolitan France
Note: The size of birth cohorts 1883–1901 at age 105 upon which the figure is based is $N = 3{,}485$
Source: RNIPP

and m_x, the figure shows clearly that the two series differ in terms of level, with lower q_x values at every age x compared to m_x values. The hierarchy comes indeed from the fact that in the absence of migration, the remaining size of birth cohorts at exact age x, serving as denominator in the calculation of q_x values, is greater (or equal) to the person-years lived in the given age interval, used in turn in the denominator of m_x values (see the details provided at the onset of Sect. 9.5). Although a definitive assessment of the age-trajectory of mortality falls beyond the scope of the present work because of the strongly decreasing number of survivors, the observed levels of mortality after age 105 displayed in Fig. 9.5 for French supercentenarians appear supportive of a force of mortality (or instantaneous death rate) at a constant level of 0.7 between age 108 and 111, corresponding to a 50% constant annual probability of death, suggested by previous scholars (Robine et al. 2005; Gampe 2010).

9.5.3 Life Expectancies After Age 100

We now use the q_x series discussed above to derive values of life expectancy at the oldest ages with standard life table techniques. For female cohorts born between 1883–1901, life expectancy at age 100 given by vital statistics is 1.57 years (Fig. 9.6). At age 105, when the verified RNIPP data becomes available, we obtain a barely higher value of female expectation of life from vital statistics (1.36 vs. 1.34 years). Afterwards, however, life expectancy values tend to diverge increasingly with age according to the two sources of data. At age 113, the vital statistics

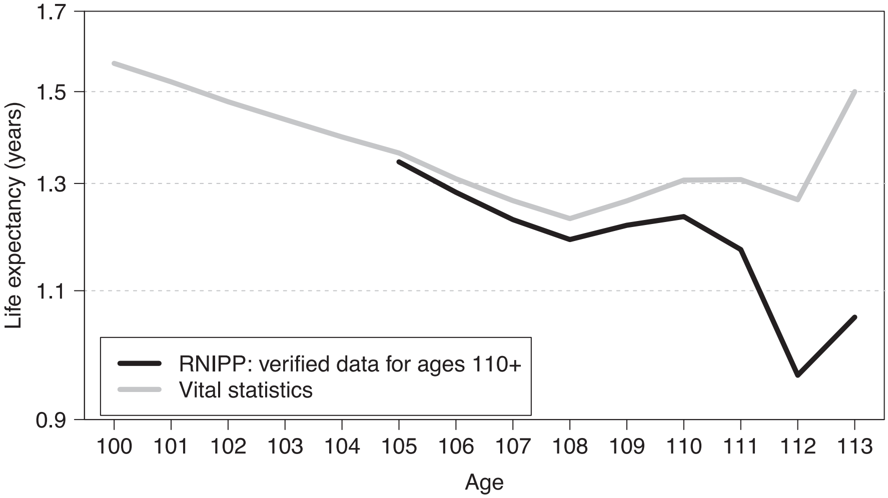

Fig. 9.6 Life expectancy by age above 100, according to vital statistics and according to verified RNIPP data for ages 110+ for French female cohorts born between 1883 and 1901 who died in metropolitan France
Note: The remaining size of birth cohorts 1883–1901 at age 105 for the verified RNIPP data upon which the figure is based is $N = 3{,}485$. For vital statistics data, which includes deaths of individuals born abroad, the sizes are $N = 45{,}684$ at age 100 and $N = 3{,}959$ at age 105
Sources: RNIPP and vital statistics

result appears to be quite exaggerated (1.50 years, compared to 1.23 if using verified RNIPP data), obviously due to the growing number of false cases of supercentenarians with age included in vital statistics. Perhaps more surprising is the sudden reversal of life expectancy values from vital statistics toward an unexpected increasing trend after age 108. The downward trend in the more trustworthy RNIPP life expectancy values also comes to a halt, but only temporarily between ages 108 and 110. Is this unexplainable bump at 109–111 years due to some undetected problem with the RNIPP data or is it attributable to random variation? The only way to know is to wait for additional years' worth of data. On the bright side, the vital statistics trend for life expectancy from age 100 to age 104 appears credible as it is in a perfect agreement with the life expectancy at 105, given by RNIPP data. Clearly, it would have been desirable to have the RNIPP data for ages 103 and 104 at hand. Such data could have been sufficient to demonstrate that vital statistics are probably reflecting the truth until these ages.

9.6 Conclusion

Although the evidence presented here illustrates the accuracy of mortality indicators given by vital statistics data for rather advanced ages (until around the age of 108 and 103–104 for probabilities of death and life expectancy calculations, respectively), these data cannot be used to assess the shape of the age-trajectory of mortality at the highest ages because they include growing shares of false supercentenarians or even semi-supercentenarians with advancing age. As for “public” lists of individual supercentenarians, they are inappropriate too because in addition to possible exhaustiveness concerns, there is a risk of selection bias due to the fact that data collected using press reports, notably, tend to favor extreme ages. On the other hand, thanks to their high quality, RNIPP data offer much firmer grounds to derive the level and age pattern of mortality at very old ages. The exhaustive validation of all deaths registered at the alleged ages of 110+ revealed that for cohorts born between 1883 and 1901 (all these cohorts are extinct today), errors are only few and easily explainable (either cases of disappearance when persons have gone missing or manual data entry errors), at least when dealing with individuals who were born and died in France. All corrections were effortless to make. Furthermore, for semi-supercentenarians, individual age at death validation conducted on a very large sample showed that errors are extremely rare, indicating that RNIPP data can be used without any verification until at least age 108. However, a first analysis of these RNIPP data indicates that the number of “verified” supercentenarians from overseas French *départements* is dubious. Most likely, in these territories, the age validation protocol would require more than the sole existence of a birth certificate corresponding to the death certificate. As for reported cases of exceptional longevity, these apparently more ordinary cases may actually require intermediate proofs of life between their birth and death. For this reason, we limited our mortality analyses to individuals that were born and died in metropolitan France.

Our study also reveals that while the quality of vital statistics remains quite deficient at very old ages, there has been a significant improvement over time. We see clearly the improvement when comparing curves of annual probabilities of death at ages 100 and above for two successive groups of birth cohorts (1868–1882 and 1883–1901). This finding provides hope that we will be able to get more and more accurate mortality trends at progressively older ages from a very accessible source of data in France. There is likely a long waiting time, however, for a conclusion about the shape of the mortality curve at very old age. Even the most accurate French data source today, namely the RNIPP, is not yet suitable to address this matter. But with the RNIPP, the ambition to reach a conclusion in a near future is not totally unrealistic, especially thanks to the rapidly-growing expected number of centenarians, semi-supercentenarians, and supercentenarians in coming decades. Furthermore, according to INSEE the RNIPP records are considered exhaustive only for cohorts born since 1890, meaning that the RNIPP covers all persons that died at age 110 since 2000 only, at age 111 since 2001 only, etc. Study of French supercentenarians has bright prospects in the next few years.

The probabilities of death calculated using RNIPP data for female birth cohorts born between 1883 and 1901 in Metropolitan France appear to level-off at 0.5 between ages 108 and 111, a finding in accordance with earlier studies (Robine et al. 2005; Gampe 2010). After age 111, however, data becomes too scarce to assess the trend. Also, we obtain a quite low life expectancy value of 1.2 years at age 108.

A practical conclusion is thus to recognize the usefulness of pursuing the gathering and validation of data in the following two directions: below age 105 to improve the link between the RNIPP and vital statistics mortality data series, and above age 110 to increase as much as possible the number of observations at the most advanced ages.

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Chapter 10
Centenarians and Supercentenarians in Japan

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10.1 Introduction

The number of centenarians in Japan, or people who have reached their 100th birthday, increased from 25,353 on October 1, 2005, to 61,763 on October 1, 2015. While the number of centenarians increased 146% over this 10-year period, over the same time period, the number of supercentenarians (people who have reached their 110th birthday) grew from 22 to 146 – a 563.6% increase. There are two main sources of data that can be used to study centenarians and supercentenarians who were alive during this period in Japan.

The census is one of them. Unfortunately, in the censuses published in 2005 and 2010, the number of people older than age 100 is presented by single year of age; while in the censuses published before 2000, we can only see the aggregate number of people above age 100. Moreover, the 2015 census provides information on the number of people aged 109 or younger by single year of age, and the number of people aged 110 or older as an aggregate. Therefore, not much research on centenarians and supercentenarians can be done using the published census data.

The centenarian list published by the Japanese Ministry of Health, Labour and Welfare (MHLW) is another source of data. Since early September of 1963, the MHLW has compiled data on the number of centenarians from the resident registry (Jumin Kihon Daicho) of local municipalities. On Respect of the Aged Day, the

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MHLW publishes a nominative list of centenarians to be celebrated for their longevity. Until 2001, the list was published on September 15. Since then, however, the list has been published on the third Monday of September. From 153 centenarians in 1963, the number of centenarians included on the list has increased successively to 532 in 1973, 1354 in 1983, 4802 in 1993, 20,561 in 2003, 54,397 in 2013, and 61,568 in 2015. Unfortunately, the MHLW stopped publishing the number of centenarians by single year of age in 2007. Currently, only the number of centenarians by sex is available from this source.

Both the census and the list of centenarians are based on information from the resident registry system, which was established in 1915. This system differs from the family register (KOSEKI, see below) in that it is based on residence and not on family origin. Until the early 2000s in Japan, the growth in the number of centenarians was documented (Robine and Saito 2003; Robine et al. 2003; Saito 2010), but early 2010s the actual number of centenarians was questioned. This uncertainty arose because the family register showed that there were more than 200,000 living centenarians, even though the most of these individuals had died, and the information on their deaths had not been reported (Saito et al. 2012). In recent years, the incidence of such errors has been reduced as the computerization of the two registration systems has facilitated data linkage.

As we described above, the extent to which demographic studies of centenarians and semi- and supercentenarians have used these data over the last 10 years is very limited. An alternative source of data for studying the demography of centenarians and semi- and supercentenarians is Japan's vital statistics. This source provides information on the number of deaths by sex, age at death, and year of birth from 1899 to the present. Here, we seek to update the demography of the population aged 100 and above in Japan primarily by drawing upon vital statistics data from January 1951 to December 2015.

Regardless of where the research is conducted, age validation is always a big issue for studies on very old adults. In introducing the Japanese registration systems and the sources of data used in this article, we first describe how age is recorded in statistics in Japan. We then briefly introduce the demography of the population in Japan aged 100 and above using census data. Finally, we describe the same population using data from Japan's vital statistics.

10.2 Data Sources: Important Key Dates

1872: On April 4, 1871, a new law established a family register system that went into effect on February 1, 1872. Known as the Jinshin-KOSEKI, this registration system was composed of one sheet per family containing information on all family members, including each person's age (in years and months) at the time of registration. Since this form of registration was established, newborns have been added to the family sheet with their age (expressed in months) at the time of registration.

Dates of birth have been recorded since 1881. Thus, in theory, all new centenarians in Japan since 1972 have been registered from birth through the family register system, introduced in 1872. Japanese data are therefore unlikely to suffer from the well-known phenomenon of age exaggeration.

1886: The Family Registration Law was revised with the introduction of a standardized form for each family, which included the registration of the dates of birth for all family members. Penalties were introduced for those who failed to report births or deaths within a specified period of time after these events occurred. The Jinshin-KOSEKI of 1872 was then revised through a transcription of all of the family information added between 1872 and 1886.

1898: Another revision of the Family Registration Law established the Japanese family system. With this revision, each family became a unit of registration. A new column was added to the registration form indicating the household head.

1899: Since this year, vital statistics by sex and single year of age have been available on an annual basis. The volume for the 1899 vital statistics was published in 1902. Following the revision of the Family Registration Law a year before, the bureau of statistics – which at that time was under the cabinet office of the government of Japan – started enumerating demographic events. Each demographic event was recorded on a piece of paper and sent from local municipalities to the central office for enumeration.

1914: The Resident Registry Law established another civil registration system based on current residence to help maintain the registration system. "As the volume of migration increased within Japan, the Family Registration System was inadequate for tracking migrants" (Saito 2010). The resident registry system went into effect in 1915. It contains information about the members of a given household, and is linked to the family register system. Details of the registration systems in Japan are available in Saito (2010).

1947: The 1947 revision of the family register system established each conjugal union as a unit of registration. Since that time, each KOSEKI is limited to two-generation families made up of parents and their unmarried children.

1951: Although vital statistics tabulation methods have changed over time, the number of deaths by sex, age at death, month of death, and year of birth has been continuously available since 1951. The same information is also available, albeit sporadically, for earlier years.

1963: Since 1963, the Ministry of Health and Welfare (now the Ministry of Health, Labour and Welfare) has been compiling a nominative list of people who would be age 100 or older by September 30 of each year. The purpose of the list, "Zenkoku Koureisha Meibo," is to celebrate centenarians on Respect of the Aged Day.

2007: In response to concerns about privacy and the size of the list, it was decided in 2007 that the list of living centenarians would no longer be publically available. Since then, only the total numbers of male and female centenarians have been released each year. According to the list for 2016, 8167 male and 57,525 female centenarians were living in one or another of Japan's municipalities in mid-September of that year.

Based on the history provided above, the following points are worth mentioning:

1. Age validation can only be done by using information from the family register in Japan. The family register was open to the public until 1976, but it has become highly restricted since then. Only family members of the target person of a study can request a copy of the relevant family register record.
2. As we mentioned above, newborns have been registered since February 1872, and the dates of birth have, in theory, been recorded since 1881. For age validation, we need to rely on records from the family register. This means that since February 1972, all Japanese people who reached age 100 should have been registered at birth in the family register; and that since 1981, the exact date of birth of all Japanese people who reached age 100 should have been recorded in the family register.
3. As explained by Saito (2010), the forms of the family register have been revised several times. The information for those who were registered at the time of the Jinshin-KOSEKI in 1872 has been transcribed several times. Even those who were born after the 1886 revision of the Family Registration Law have had their information in the family register transcribed a few times. This suggests that there may have been errors in the transcription of information from one form of family register to the next. However, as of today, there is no way of detecting mistakes in these transcriptions. It is, therefore, clear that we need to scrutinize the records in the family register of those who reached extremely high ages, as the cases presented in this book of Kimura and Okawa demonstrate.

10.3 The Number of Individuals in the Population Aged 100 and Above from the Censuses

Because we have very limited information on centenarians, we briefly present the number of surviving centenarians from the censuses conducted in 2005, 2010, and 2015. Looking at Table 10.1, we can see that over the 10-year period of 2005 and 2015, the total number of centenarians more than doubled from 25,353 to 61,763, while the number of semi-supercentenarians (people who reached age 105) also more than doubled from 1458 to 3770. Only 22 supercentenarians were alive in 2005, but that number had risen to 146 in 2015 – an almost seven-fold increase in 10 years. Considering that there were only 11 supercentenarians alive in 2000, and fewer than eight in most years prior to 1999 (based on the list of centenarians), the recent increase in the number of supercentenarians is quite surprising.

It is, however, important to keep in mind that the percent increase in the number of centenarians in almost all age groups between 2010 and 2015 is smaller than the percent increase between 2005 and 2010. We cannot predict whether the number of centenarians will continue to grow at the current pace. While the individuals who recently became centenarians were survivors of the Spanish Flu pandemic of 1918–1920, those who become centenarians after 2020 – and were thus born after 1920 – would not have been directly affected by the Spanish Flu. The parents of

Table 10.1 Total population and percent change in the number of individuals aged 100 and above by sex and 5-year age groups in 2005, 2010, and 2015

Age group	Sex	2005	2010	2015	%Increase 2005–2010	%Increase 2010–2015	%Increase 2005–2015
100	Males	3,760	5,851	8,383	55.6	43.3	123.0
	Females	21,593	38,031	53,380	76.1	40.4	147.2
	Total	25,353	43,882	61,763	73.1	40.7	143.6
100–104	Males	3,580	5,598	7,991	56.4	42.7	123.2
	Females	20,293	35,720	49,856	76.0	39.6	145.7
	Total	23,873	41,318	57,847	73.1	40.0	142.3
105–109	Males	178	250	383	40.4	53.2	115.2
	Females	1,280	2,236	3,387	74.7	51.5	164.6
	Total	1,458	2,486	3,770	70.5	51.6	158.6
110+	Males	2	3	9	50.0	200.0	350.0
	Females	20	75	137	275.0	82.7	585.0
	Total	22	78	146	254.5	87.2	563.6

these centenarians would, however, have been survivors of the 1918–1920 pandemic, which affected children and young adults in Japan (Ikeda et al. 2005; Richard et al. 2009). As Finch and Crimmins (2004) pointed out, "cohort levels of mortality during childhood are related to cohort mortality in old age." The effect of the Spanish Flu on the number of centenarians requires further study.

10.4 The Number of Centenarian Deaths in Japan Between January 1, 1951, and December 31, 2015

According to Japan's vital statistics, between January 1, 1951, and December 31, 2015, 260,220 Japanese died at age 100 or older, of whom 44,495 were males and 215,725 were females (82.9% of the total). These numbers include 592 people who died at age 110 or older, of whom 51 were males and 541 were females (91.4% of the total). This is the main dataset we will use to describe the demography of the population aged 100 or older in Japan between January 1951 and December 2015. The raw figures are displayed in Annex Table 10.5 by sex, single age from 100 to 120, and month of death.

Figures 10.1a and b provide a graphical view of this dataset. Figure 10.1a shows the age distribution of those who died between 1951 and 2015 by sex, while Fig. 10.1b shows the cumulative age distribution of the centenarians who died during the same period by sex. The latter figure displays the overall crude estimates of the mortality level above age 100 by sex and single year of age for those who died between 1951 and 2015. As we mentioned above, 215,725 females died at age 100 or older during the period. Therefore, 215,725 females reached the age of 100. Looking at Fig. 10.1b, we can see that out of this group of 100-year-olds, 36% (77,075/215,725) of females and 40% (17,983/44,495) of males died before reaching age 101. Mortality levels tended to increase after each successive

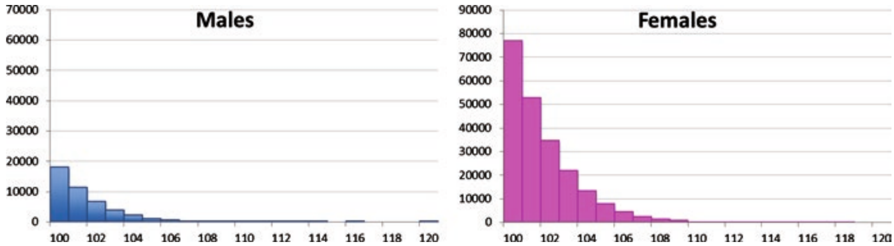

Fig. 10.1a Number of centenarian deaths in Japan between January 1, 1951, and December 31, 2015, by age at death and sex

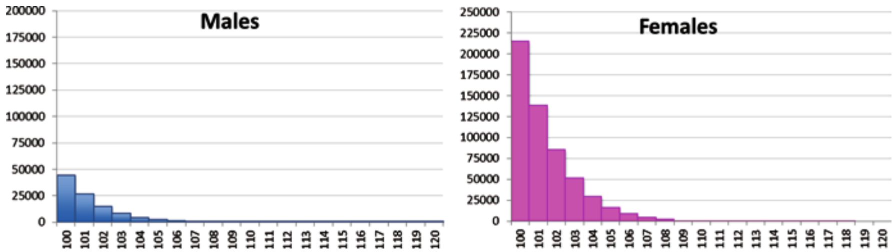

Fig. 10.1b Cumulative age distribution of centenarians who died in Japan between January 1, 1951, and December 31, 2015, by sex

birthday, reaching 59% for females between the 114th and the 115th birthday and 55% for males between the 107th and the 108th birthday. Only nine Japanese females died after reaching age 115. No more trends can be seen at higher ages. We observe that 229 Japanese males died after reaching age 108, and that a kind of mortality plateau is reached for four or five consecutive ages up to age 111/112. Only 10 males died after reaching age 112. No more trends can be seen at higher ages.

Our sample covers 65 calendar years, but in 1951, the number of those who died at age 100 or older was very low in Japan, and this number increased very slowly prior to the 1970s and even prior to the 1980s. Thus, Table 10.2 provides the raw number of centenarian deaths by sex and three age groups (100–104, 105–109, and 110+) for the period 1951–1975 and for the four 10-year periods 1976–1985, 1986–1995, 1996–2005, and 2006–2015.

Between 1951 and 1975, 3,331 deaths at age 100 or older were recorded in Japan, but the number of deaths recorded at age 110 or older for females may be too high, as suggested by the proportion represented by these deaths (0.4% of the total). All Japanese citizens who reached age 100 between 1951 and 1972 had been registered for the first time in 1872, when the family register system was introduced. At that time, the age of each person registered was expressed in years and months. In 1872, the ages of these future centenarians ranged from 1 year to about 25 years, leaving some room for mistakes in age reporting.

Table 10.2 Number of deaths at age 100 and above by broad age groups, period of time, and sex; Japan 1951–2015

	100–104	105–109	110+	Total	% 100–104	% 105–109	% 110+	% Total
1951–1975								
Females	2,472	96	11	2,579	95.9	3.7	0.4	100.0
Males	712	39	1	752	94.7	5.2	0.1	100.0
Sex-ratio	3.5	2.5	11.0	3.4	–	–	–	–
1976–1985								
Females	3,977	176	4	4,157	95.7	4.2	0.1	100.0
Males	1,033	41	1	1,075	96.1	3.8	0.1	100.0
Sex-ratio	3.8	43	4.0	3.9	–	–	–	–
1986–1995								
Females	11,838	612	23	12,473	94.9	4.9	0.2	100.0
Males	3,509	137	3	3,649	96.2	3.8	0.1	100.0
Sex-ratio	3.4	4.5	7.7	3.4	–	–	–	–
1996–2005								
Females	42,344	2,939	78	45,361	93.3	6.5	0.2	100.0
Males	10,552	522	14	11,088	95.2	4.7	0.1	100.0
Sex-ratio	4.0	5.6	5.6	4.1	–	–	–	–
2006–2015								
Females	1,38,658	12,072	425	1,51,155	91.7	8.0	0.3	100.0
Males	26,437	1,462	32	27,931	94.7	5.2	0.1	100.0
Sex-ratio	5.2	8.3	13.3	5.4	–	–	–	–
1951–2015								
Females	1,99,289	15,895	541	2,15,725	92.4	7.4	0.3	100.0
Males	42,243	2,201	51	44,495	94.9	4.9	0.1	100.0
Sex-ratio	4.7	7.2	10.6	4.8	–	–	–	–
Total	2,41,532	18,096	592	2,60,220	92.8	7.0	0.2	100.0

However, since 1963, all living centenarians have been enumerated each year by the Ministry of Health, Labour and Welfare through the compilation of the resident registry system of the Japanese municipalities. This administrative check may have indirectly improved the quality of age reporting at death. Thus, "extreme" cases of longevity, which were reported quite frequently between 1925 and 1955, almost disappeared after 1963 (Robine and Saito 2003; Saito 2010).

During the next decade, between 1976 and 1985, 5,232 deaths at age 100 or older were recorded in Japan. The births of almost all of these people should have been registered, with their current age at the time of the registration expressed in years and months. For those who died between 1951 and 1985, the information on their birth included in the KOSEKI may have been transcribed four times from one KOSEKI to another, with the last one being the KOSEKI of 1947, known as the current KOSEKI.

Between 1986 and 1995, 16,122 deaths at age 100 or older were recorded. Since 1986, most centenarians should have been registered according to the 1886 Family Registration Law, which standardized the registration form, including the registration of the date of birth for all family members. Since that time, the date of birth for each newborn should have been recorded at the time of birth within a specified period of time. For those who were registered for the first time after 1886, information on their birth may have been transcribed three times, from one family register to another.

During the next decade, between 1996 and 2005, 56,449 deaths at age 100 or older were recorded in Japan. In 1996–2005, the number of semi-supercentenarians who died was almost five times higher and the number of supercentenarians who died was 3.5 times higher than in the preceding decade. The centenarians who died in 1996–2005 had been born well after the family register was established in 1872 and standardized in 1886.

Over the last decade of our study period, between 2006 and 2015, 179,086 deaths at age 100 or older were recorded. Almost 50 supercentenarian deaths per year were reported in this period, compared to around nine per year in the previous decade. The birth information of those centenarians who died between 1996 and 2015 may have been transcribed at least twice, once from the third form of the family register, and again to the current form of the family register.

As Table 10.2 shows, the sex ratio and the distribution among the three age groups, 100–104, 105–109, and 110+, vary little from one period to the next. Over the whole study period, from 1951 to 2015, the sex ratio was 4.8 female deaths for each male death among centenarians; and the total distribution of the deaths among the three age groups was 92.8% in the age group 100–104, 7.2% in the age group 105–109, and 0.2% in the age group 110 + .

10.5 The Highest Reported Age at Death in Japan Between 1963 and 2015

Figure 10.2 displays the 10 highest reported ages at death (HRAD), for each sex, recorded in Japan between 1963 and 2015. Although this information is available from 1899 onward, we purposefully limited the series to the period covered by the centenarian list. We did so because, as we mentioned above, the centenarian list is based on the compilation of information from the resident registry system, and thus excludes incredible and unverifiable old cases. It appears, however, that most implausible age reports disappeared after 1963. On the male side, we note that a death was reported at age 120 in 1986. This is the well-known case of Shigechiyo Izumi, whose age seems to have been mistakenly reported. We also note that a death was reported at age 116 in 2013. This case, of a man named Jiroemon Kimura, has been thoroughly studied by Gondo et al. (2017), and appears to be rigorously documented. On the female side, we note that several deaths at very high ages have been reported, including one at age 118 in 1964, one at age 116 in 1970, and one at age 113 in 1976. These three old cases look like outliers. The first case, of a woman named Yasu Kobayashi, seems to be false. The second case, of a woman named Ito

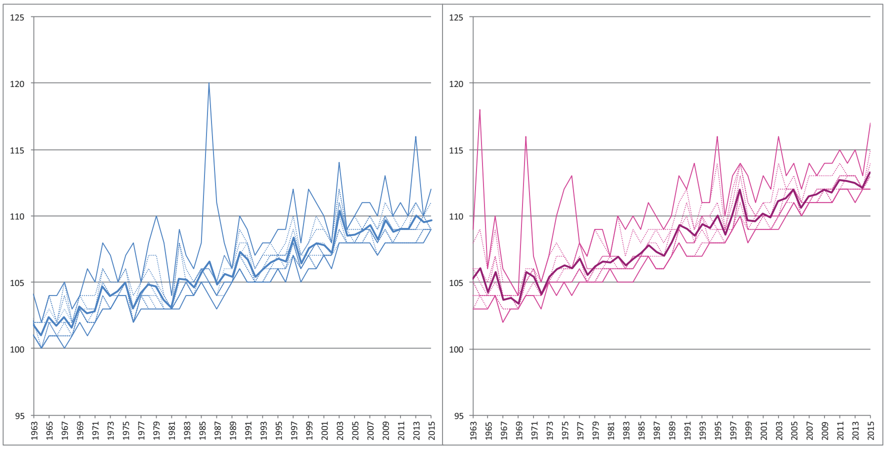

Fig. 10.2 The 10 highest reported ages at death (HRAD) and their mean in Japan since 1963, by sex
Note: The top solid line is the HRAD and the bottom solid line is the 10th HRAD. The bold line is the mean

Morimoto, has not been documented. But the third case, of a woman named Niwa Kawamoto,[1] may be true. The most recent cases of deaths reported at ages 114, 115, or even 116 have been examined by Saito (2010). The case of Hide Ohira, who reportedly died at the age of 114, seems to be true, but has not been documented with information from the KOSEKI (only press reports are available). The case of Tane Ikai, who was reported dead at the age of 116, has been verified (Inagaki et al. 1997). The spike in 2003 reflects the case of Kamato Hongo, who died at the age of 116. The case of Misao Okawa, who was reported dead at the age of 117 in 2015, seems to be true (see Chap. 21). Because these extreme cases are very rare and hard to verify, we prefer to focus on two alternative indicators of the highest reported ages at death (HRAD): the 10th HRAD and the mean of the first 10 HRADs. The two indicators provide similar information. Figure 10.2 shows the 10th HRAD and the mean of the 10 highest ages at death.

Looking at the 10th HRAD, we see that the figures increase from 101 in 1963 to 109 in 2015 for males, or by 8 years over 53 calendar years; and from 103 in 1963 to 112 in 2015 for women, or by 9 years over this period. When we examine the mean of the 10 HRADs, we find that the figures increase from 101.8 in 1963 to 109.7 in 2015 for males, or by 7.9 years over 53 calendar years; and from 105.3 in 1963 to 113.3 in 2013 for females, or by 8 years over the period (the bold lines on Fig. 10.2). On average, from 1963 to 2015, the 10th HRAD ages are 2.4 years higher for females than for males.

[1] She is listed by the Gerontological Research Group. See http://www.grg.org/Adams/OldestCentYear.HTM

10.6 Mortality Estimates by Using the Extinct Cohort Method

To provide another crude mortality estimate, we assembled the number of deaths by birth cohort. If we assume that the last member of a birth cohort died at a certain age – say, 115 – and that international migration above age 100 is negligible, we can reconstruct the centenarian cohort population between 100 and 115 years old by adding the number of deaths backward from 115 to 100. This is the same method we used for creating data for Fig. 10.1b above, but here we only create data by cohort. We grouped five cohorts to create data for mortality estimates by birth cohorts, starting with the 1874 cohort: i.e., 1874–1878, 1879–1883, 1884–1888, 1889–1893, and 1894–1898. In addition, we grouped two cohorts, 1899 and 1900, for the analysis.

Note that among the total of 260,220 deaths recorded at age 100 or older from 1951 to 2015 used in this study, only nine cases were reported to have died after the age of 115: five at the age of 116, one at the age of 117, two at the age of 118, and one at the age of 120. This last case, of Shigechiyo Izumi, is known to be misreported. As both cases of deaths at age 118 are old, (reported in 1951 and 1964), it is likely that they were also misreported, and are therefore excluded from our analysis. Our examination of the data by cohort is thus restricted to the cohorts who reached the age of 100 starting in 1974. The case of Misao Okawa, who reportedly died at the age of 117, may be true (see Chap. 21). This case should be added to our study as a survivor at her 117th birthday in order to eliminate any age censorship for the 1898 birth cohort. Among the five cases of individuals who reportedly died at age 116, two are old. These two cases, who were reported dead in 1951 and 1970, may be incorrect, but do not interfere with our cohort study. Another two of these cases are of individuals whose deaths at the age of 116 were reported more recently: one of a woman, Kamato Hongo, who died in 2003; and one of a man, Jiroemon Kimura, who died in 2013 (Gondo et al. 2017). Although Poulain (2010) investigated Hongo's case and questioned her reported age, we included her case here because there is currently no consensus about her age. The last case, of an individual named Tane Ikai who was reported dead at the age of 116 in 1995, has been verified (Inagaki et al. 1997). These three cases should be included in our study as survivors at their 116th birthdays to eliminate any age censorship in their respective birth cohorts: 1879 for Tane Ikai, 1887 for Kamato Hongo, and 1897 for Jiroemon Kimura. There may also be some missing cases of supercentenarians who belong to the studied cohorts and survived to 2015. We therefore looked carefully at the public lists of Japanese supercentenarians who died in 2016 or 2017 at the age of 116 or older, as well as at the list of Japanese supercentenarians who were known to be alive on August 5, 2017.[2] Of these living supercentenarians, two are older than 115 years old: Chiyo Miyako (116 years old on August, 5, 2017; see Chap. 21) and Nabi Tajima (117 years old on August, 5, 2017). Chiyo Miyako was born in 1901, and therefore is not part of the present cohort study; but Nabi Tajima was born in 1900, and should be added to our study as having survived to her 117th birthday in August 2017.

[2] https://en.wikipedia.org/wiki/List_of_Japanese_supercentenarians, accessed on August fifth 2015.

Table 10.3 Reconstruction of the population from age 117 to age 100 by the extinct cohort method for the cohorts 1874 to 1900, by sex and by group of five cohorts, except for the last two cohorts 1899 and 1900

	Males							Females						
Cohorts	1874–1878	1879–1883	1884–1888	1889–1893	1894–1898	1899–1900	1874–1900	1874–1878	1879–1883	1884–1888	1889–1893	1894–1898	1899–1900	1874–1900
Age														
100	363	670	1,270	2,252	4,170	2,261	10,986	1,648	2,513	4,413	8,079	16,036	9,858	42,547
101	207	392	803	1,406	2,676	1,476	6,960	975	1,596	2,921	5,376	11,047	7,091	29,006
102	121	247	464	852	1,657	944	4,285	597	987	1,864	3,446	7,487	4,869	19,250
103	66	153	268	495	977	572	2,531	345	597	1,153	2,230	5,014	3,293	12,632
104	31	87	139	294	592	336	1,479	191	351	662	1,403	3,242	2,133	7,982
105	20	49	75	164	334	206	848	121	197	381	855	2,084	1,357	4,995
106	8	29	44	86	199	100	466	64	122	210	495	1,284	836	3,011
107	5	15	26	42	108	52	248	34	74	120	274	774	521	1,797
108	4	8	13	25	59	22	131	16	41	66	152	433	297	1,005
109	1	3	7	13	30	13	67	12	30	39	83	252	167	583
110	1	1	4	8	11	7	32	6	17	21	49	130	92	315
111	1	0	3	5	5	1	15	4	10	15	26	69	47	171
112	0	0	2	3	2	0	7	3	3	11	15	29	22	83
113	0	0	0	1	2	0	3	2	2	8	5	15	9	41
114	0	0	0	1	1	0	2	1	2	4	3	7	2	19
115	0	0	0	0	1	0	1	0	1	1	0	3	2	7
116	0	0	0	0	1	0	1	0	1	1	0	1	1	4
117	0	0	0	0	0	0	0	0	0	0	0	1	1	2

By adding these five cases to their respective cohorts, we reconstructed cohort populations from age 100 to age 117, as shown in Table 10.3. Of these five added cases, four were female and one was male. To the best of our knowledge, our information on the Japanese centenarians belonging to the 1874–1900 birth cohorts is complete. Only two of these individuals reached the age of 117, one of whom was still alive on August 5, 2015. We used this information to study empirically the mortality trajectories in Japan above the age of 100.

In total, this part of our study comprises 53,533 centenarians – 42,547 females and 10,986 males – belonging to the cohorts born in 1874–1900. For each group of birth cohorts, the number of survivors was followed from the age of 100 to extinction at age 117, without any age censorship, except for two females who survived to age 117. The survival curves are plotted on Fig. 10.3, with a radix of 10,000 survivors at age 100 for each group of cohorts. We chose 10,000 as a radix for life table construction and for computing the standardized number of survivors (lx) and the probability of dying (qx) for the study. Figure 10.3 shows shifts in the survival curve to the right (higher ages) from one group of cohorts to the other. Obviously, each successive group of centenarians, comprising five birth cohorts, is surviving to higher ages than the previous group. This shift to the right is observed for both the male and the female cohorts.

Table 10.4 shows the computed life table probabilities of dying (qx) by birth cohort from 1874 to 1900 and by sex. When looking at the table, it is very important to note that the actual size of the cohorts is increasing quickly for later cohorts, and that the size of the female cohorts is much larger than the size of the male cohorts. The table also shows that qx is generally lower for later cohorts for both females and males. qx steadily increases with age, and then starts fluctuating.

Figure 10.4 provides a graphical presentation of qx, as shown in Table 10.4. The general trend observed from this figure is that the smaller the studied group of cohorts (earlier group of cohorts and/or male group of cohorts), the sooner fluctuations appear to prevent these cohorts from following the mortality trajectories associated with higher ages.

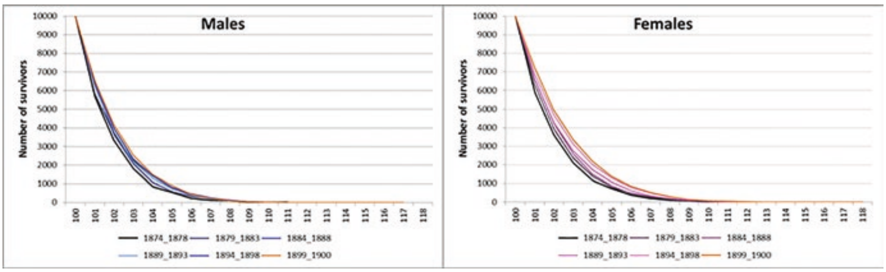

Fig. 10.3 Survival curves from age 100 for the extinct Japanese birth cohorts born between 1874 and 1900 by sex and by group of 5 consecutive cohorts, except for the last two cohorts 1899 and 1900

Table 10.4 Computed life table probability of dying (qx) by single year of age and birth cohort from 1874 to 1900 by sex

Females						
Age	1874_1878	1879_1883	1884_1888	1889_1893	1894_1898	1899_1900
	(n = 1648)	(n = 2513)	(n = 4413)	(n = 8079)	(n = 16,036)	(n = 9858)
100	0.40837	0.36490	0.33809	0.33457	0.31111	0.28069
101	0.38769	0.38158	0.36186	0.35900	0.32226	0.31335
102	0.42211	0.39514	0.38144	0.35287	0.33031	0.32368
103	0.44638	0.41206	0.42585	0.37085	0.35341	0.35226
104	0.36649	0.43875	0.42447	0.39059	0.35719	0.36381
105	0.47107	0.38071	0.44882	0.42105	0.38388	0.38394
106	0.46875	0.39344	0.42857	0.44646	0.39720	0.37679
107	0.52941	0.44595	0.45000	0.44526	0.44057	0.42994
108	0.25000	0.26829	0.40909	0.45395	0.41801	0.43771
109	0.50000	0.43333	0.46154	0.40964	0.48413	0.44910
110	0.33333	0.41176	0.28571	0.46939	0.46923	0.48913
111	0.25000	0.70000	0.26667	0.42308	0.57971	0.53191
112	0.33333	0.33333	0.27273	0.66667	0.48276	0.59091
113	0.50000	0.00000	0.50000	0.40000	0.53333	0.77778
114	1.00000	0.50000	0.75000	1.00000	0.57143	0.00000
115		0.00000	0.00000		0.66667	0.50000
116		1.00000	1.00000		0.00000	0.00000
117					1.00000	1.00000
Males						
Age	1874_1878	1879_1883	1884_1888	1889_1893	1894_1898	1899_1900
	(n = 363)	(n = 670)	(n = 1270)	(n = 2252)	(n = 4170)	(n = 2261)
100	0.42975	0.41493	0.36772	0.37567	0.35827	0.34719
101	0.41546	0.36990	0.42217	0.39403	0.38079	0.36043
102	0.45455	0.38057	0.42241	0.41901	0.41038	0.39407
103	0.53030	0.43137	0.48134	0.40606	0.39406	0.41259
104	0.35484	0.43678	0.46043	0.44218	0.43581	0.38690
105	0.60000	0.40816	0.41333	0.47561	0.40419	0.51456
106	0.37500	0.48276	0.40909	0.51163	0.45729	0.48000
107	0.20000	0.46667	0.50000	0.40476	0.45370	0.57692
108	0.75000	0.62500	0.46154	0.48000	0.49153	0.40909
109	0.00000	0.66667	0.42857	0.38462	0.63333	0.46154
110	0.00000	1.00000	0.25000	0.37500	0.54545	0.85714
111	1.00000		0.33333	0.40000	0.60000	1.00000
112			1.00000	0.66667	0.00000	
113				0.00000	0.50000	
114				1.00000	0.00000	
115					0.00000	
116					1.00000	

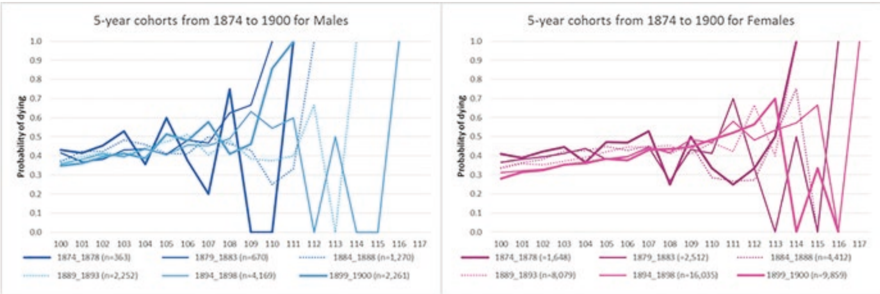

Fig. 10.4 Probability of dying from age 100 onward by single year of age for the extinct Japanese cohorts born between 1874 and 1900, by sex and by group of 5 consecutive cohorts, except for the last two cohorts 1899 and 1900

When we look at individual mortality trajectories by birth cohort, some interesting features appear. The 1874–1878 male cohort displays fluctuations from age 103 onward; while the 1894–1898 female cohort and the 1899–1900 cohort seem to show a steady increase in mortality until age 115 or age 113, respectively. In between, we can see that the age at which the cohorts become extinct tends to shift over time to higher ages, and that the fluctuations tend to decrease with the increase in the number of centenarians in the studied cohorts. More importantly, we can see that the probabilities of dying tend to plateau with age for the cohorts in the middle (1879–1883 female cohorts, 1884–1888 male and female cohorts, and 1889–1893 male and female cohorts). Fluctuations can be observed among the earlier groups of cohorts, especially the 1874–1878 group of cohorts. By contrast, among the most recent 1894–1898 group of cohorts, a regular increase in mortality can be seen up to age 111 for the male cohorts and up to age 115 for the female cohorts. The two most recent extinct cohorts, 1899–1900, display a monotonic increase in mortality until age 107 for males and age 113 for females. This observation suggests that a plateau of mortality occurred among the cohorts born between 1879 and 1893. Among the preceding cohorts, the oldest-old are too rare to allow us to observe anything other than fluctuations in mortality above age 100. Among the cohorts born after 1894, when the numbers of centenarians start to be consequential, the mortality trajectories seem to keep increasing with age, even if the rate of increase is not large.

As a kind of sensitivity analysis, we grouped the cohorts born after 1893 differently. The two female cohorts 1899–1900 seem to follow a lower mortality trajectory than the five previous birth cohorts born in 1894–1898, but they represent only two cohorts of centenarians (n = 9859) versus five cohorts (n = 16,035). The two male cohorts comprise only 2261 centenarians, and suffer from large fluctuations. Therefore, it is tempting to add the two cohorts of 1899–1900 to the previous 1894–1898 cohorts, especially because Fig. 10.4 suggests that the survival patterns of these two groups of cohorts are quite similar. We took this opportunity to perform some sensitivity analyses, proposing alternative groupings (see Fig. 10.5).

Whatever the grouping used starting with the cohort born between 1894 and 1900, mortality seems to increase, at least up to age 107 among males and up to age

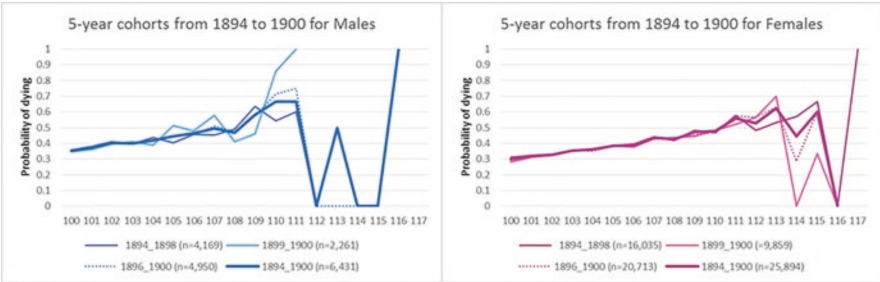

Fig. 10.5 Mortality trajectories (annual probability of dying) from age 100 onward for the extinct Japanese cohorts born between 1894 and 1900 by sex, according to 4 different groupings, 1894–1898, 1898–1900, 1896–1900, and 1894–1900

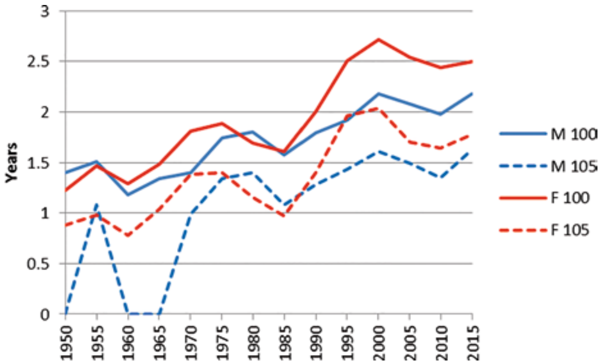

Fig. 10.6 Trends in life expectancy at ages 100 and 105 by sex: 1950–2015 Japan

111 among females. Then, for the following 2 or 3 years, to age 110 for males and age 113 for females, the trend seems to keep increasing, but with some noise. After these ages, the series only show fluctuations due to the small numbers of Japanese males and females reaching the ages of 111 and 114, respectively.

10.7 Trends in Life Expectancy at Ages 100 and 105

Finally, we would like to introduce trends in life expectancy at ages 100 and 105 by sex from complete life tables published by the Ministry of Health, Labour and Welfare. As Fig. 10.6 shows, for both males and females, life expectancy at age 100 and at age 105 increased over time from 1950 to 2015, albeit with some fluctuations. We will have to wait another 10–15 years to determine whether the trend in life expectancies at ages 100 and 105 over the last 15 years represents stagnation, or is merely a fluctuation. Moreover, we have to study further the effect of the Spanish Flu Pandemic of 1918–1920 on mortality among centenarians.

10.8 Conclusion

The aim of this chapter has been to carefully present the data that are available in Japan to study the demography of centenarians, which include population estimates, number of deaths, mortality levels, and maximum reported ages at death (MRAD) or highest reported ages at death (HRAD). Japan leads the adult longevity revolution among the low-mortality countries, and many studies use Japanese data to discuss various longevity issues, such as the yearly pace of increases in life expectancy and the possible limits to human longevity (Oeppen and Vaupel 2002; Ouelette and Bourbeau 2011; Hanayama and Sibuya 2016; Dong et al. 2016). The strengths and limits of the Japanese data are not always well understood. Among the strengths are the quality of the data on centenarians since at least 1963 (Saito et al. 2012) and the size of the centenarian population. Currently, there are more centenarians living in Japan than in the United States, and more than in all of the western European countries taken together. Among the limits of the data is the absence of a long chronological series starting during the nineteenth or the eighteenth century, like those in France and Sweden (Wilmoth et al. 2000). It is important that these strengths and weaknesses are understood, because one of the most important criticisms of the Dong et al. study (2016) about the limits of the human life span is the asynchronous addition of several countries/datasets that the authors undertook because of small sample sizes at the country level (Hughes and Hekimi 2017; Lenart and Vaupel 2017). For example, the Japanese dataset used by Dong et al. comprises 78 Japanese individuals who died between 1996 and 2005. By comparison, our Japanese dataset comprises 541 female and 51 male supercentenarians who died between 1951 and 2015, including 315 female and 32 male supercentenarians belonging to the extinct birth cohorts of 1874–1900.

If we are not using the same dataset when proposing and testing a hypothesis (Rozing et al. 2017; Brown et al. 2017), it is important that we have a large, independent hypothesis-generating sample, such as the Japanese dataset. Western European samples and/or American samples can then be used as hypothesis-testing samples, while avoiding asynchronous addition, or vice-versa.

Traditionally, demographers distinguish between the period and the cohort approach (i.e., cross-sectional vs. longitudinal framework). The available Japanese dataset can be used to test various hypotheses about the mortality trajectory with age, central death rate (mx), and/or probability of dying (qx) in both frameworks. In a longitudinal framework, survivors to the next age can benefit from annual progress, offsetting in part the negative impact of their increased aging. The dataset can also be used to explore the limits of lifespans.

Annex

Table 10.5 Death counts for Japanese who died at the age of 100 years or above from 1951 to 2015, by sex, single age at death, and month of death

Females													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	7,641	6,787	6,982	6,604	5,995	5,426	5,770	5,852	5,699	6,101	6,694	7,524	77,075
101	5,299	4,656	4,737	4,294	4,155	3,774	3,871	3,909	3,889	4,412	4,592	5,164	52,752
102	3,317	3,107	3,102	2,803	2,693	2,403	2,558	2,591	2,584	2,875	3,030	3,393	34,456
103	2,144	1,950	1,991	1,827	1,819	1,529	1,585	1,577	1,617	1,759	1,842	2,150	21,790
104	1,314	1,133	1,191	1,079	994	903	950	992	984	1,093	1,190	1,393	13,216
105	740	679	680	609	619	557	574	568	573	593	652	745	7,589
106	436	374	369	320	364	331	295	338	340	320	385	424	4,296
107	237	176	217	193	182	148	164	190	184	182	202	215	2,290
108	116	94	102	91	96	91	80	87	93	92	103	93	1,138
109	60	61	34	51	38	41	50	39	39	48	69	52	582
110	26	21	27	24	21	20	20	22	22	22	25	24	274
111	11	12	14	10	14	12	11	17	16	11	16	8	152
112	7	7	4	2	7	6	3	2	4	7	5	11	65
113	4	7	1	2	1	1	3	2	1	5	1	0	28
114	0	0	1	1	2	2	1	1	1	0	3	1	13
115	1	0	0	0	0	0	0	0	1	0	0	1	3
116	0	0	0	0	0	1	1	0	0	1	0	0	3
117	0	0	0	1	0	0	0	0	0	0	0	0	1
118	0	0	0	0	2	0	0	0	0	0	0	0	2
119	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	21,353	19,064	19,452	17,911	17,002	15,245	15,936	16,187	16,047	17,521	18,809	21,198	2,15,725

(continued)

Table 10.5 (continued)

Males

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	1,933	1,681	1,673	1,436	1,366	1,189	1,256	1,305	1,280	1,438	1,545	1,881	17,983
101	1,196	1,054	1,077	953	890	769	813	803	811	887	995	1,135	11,383
102	674	674	615	540	511	483	463	526	499	568	607	630	6,790
103	407	351	350	291	289	287	301	265	272	308	368	385	3,874
104	206	189	207	201	174	151	164	156	154	190	193	228	2,213
105	119	80	97	96	86	78	78	95	85	90	126	110	1,140
106	64	52	52	42	44	30	53	45	48	56	55	57	598
107	24	38	30	23	19	22	15	27	21	21	17	28	285
108	18	9	12	9	11	12	8	7	8	7	9	9	119
109	13	7	2	3	4	4	7	2	6	2	7	2	59
110	6	1	2	0	2	0	3	4	1	4	2	4	29
111	2	3	1	0	0	3	1	1	1	0	0	0	12
112	1	0	0	1	2	0	1	0	0	0	0	0	5
113	0	0	0	0	0	1	0	0	0	0	0	0	1
114	0	0	0	0	0	0	0	0	1	0	0	0	1
115	0	0	0	0	0	0	0	0	0	0	0	0	0
116	0	0	0	0	1	1	0	0	0	0	0	0	2
117	0	0	0	0	0	0	0	0	0	0	0	0	0
118	0	0	0	0	0	0	0	0	0	0	0	0	0
119	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	1	0	0	0	0	0	0	0	0	0	0	1
Total	4,663	4,140	4,118	3,595	3,399	3,030	3,163	3,236	3,187	3,571	3,924	4,469	44,495

Both sexes

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
100	9,574	8,468	8,655	8,040	7,361	6,615	7,026	7,157	6,979	7,539	8,239	9,405	95,058
101	6,495	5,710	5,814	5,247	5,045	4,543	4,684	4,712	4,700	5,299	5,587	6,299	64,135
102	3,991	3,781	3,717	3,343	3,204	2,886	3,021	3,117	3,083	3,443	3,637	4,023	41,246
103	2,551	2,301	2,341	2,118	2,108	1,816	1,886	1,842	1,889	2,067	2,210	2,535	25,664
104	1,520	1,322	1,398	1,280	1,168	1,054	1,114	1,148	1,138	1,283	1,383	1,621	15,429
105	859	759	777	705	705	635	652	663	658	683	778	855	8,729
106	500	426	421	362	408	361	348	383	388	376	440	481	4,894
107	261	214	247	216	201	170	179	217	205	203	219	243	2,575
108	134	103	114	100	107	103	88	94	101	99	112	102	1,257
109	73	68	36	54	42	45	57	41	45	50	76	54	641
110	32	22	29	24	23	20	23	26	23	26	27	28	303
111	13	15	15	10	14	15	12	18	17	11	16	8	164
112	8	7	4	3	9	6	4	2	4	7	5	11	70
113	4	7	1	2	1	2	3	2	1	5	1	0	29
114	0	0	1	1	2	2	1	1	2	0	3	1	14
115	1	0	0	0	0	0	0	0	1	0	0	1	3
116	0	0	0	0	1	2	1	0	0	1	0	0	5
117	0	0	0	1	0	0	0	0	0	0	0	0	1
118	0	0	0	0	2	0	0	0	0	0	0	0	2
119	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	1	0	0	0	0	0	0	0	0	0	0	1
Total	26,016	23,204	23,570	21,506	20,401	18,275	19,099	19,423	19,234	21,092	22,733	25,667	2,60,220

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Chapter 11
Centenarians, Semi-supercentenarians and the Emergence of Supercentenarians in Poland

Wacław Jan Kroczek

11.1 Introduction

Before 1795 the Polish-Lithuanian Commonwealth was home to people of several different cultures and languages, and included the territories of the present-day countries of Poland, Lithuania, Latvia, Estonia, Belarus and Ukraine. The partitioning of the Commonwealth in 1795 among the European powers brought about a German Poland, a Russian Poland and an Austrian Poland, each with its own political system, domestic and foreign policy, and official language. Poland did not achieve independence until 1918; hence the centenarians, semisupercentenarians, and supercentenarians discussed in this chapter were born during the partition period.

Russian Poland, also known as Congress Poland, bordered Russia on the east, and consisted of the modern-day voivodeships of Masovia, Lodz, Swietokrzyskie, Podlaskie, and Lublin, parts of the modern-day voivodeships of, Kuyavia-Pomerania, Greater Poland, and Silesia (Fig. 11.1), as well as the western part of modern Lithuania and Belarus. German Poland was formed of Pomerania, Warmia-Masuria and the remaining parts of Greater Poland and Silesia. Austrian Poland was in the south, and included the modern-day voivodeships of Lesser Poland and Subcarpathia, as well as some territory in what is modern-day Ukraine.

The Poland's People Republic was established at the end of World War II, and The Round Table Agreement in 1989 created the independent Republic of Poland that exists today. The system of administrative areas called voivodeships went into effect in 1999 (Fig. 11.2). Official population and death statistics for the Republic of Poland are available only since 2004.

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Fig. 11.1 Polish lands between 1815 and 1918, administrated by three empires, with the modern borders of Poland marked in black

11.2 Birth and Marriage Registration

Birth and marriage records play an essential role in the validation of assertions of achievement of extreme age. Fortunately, and contrary to what one might expect, the great majority of registration records have survived the two world wars. Even most of the registry records from Warsaw survived, in spite of the utter destruction of the city after the unsuccessful Warsaw Uprising in 1944.

Similarly to the Nordic countries, for centuries the registration of births, marriages, and deaths in Poland was a church function – whether Lutheran, Roman Catholic, Greek Orthodox, Orthodox, or Jewish – and the registration records were kept in the locality where the event took place (Skytthe et al. 2010). Depending on where and when they were created, the records might be written in Polish, in German, in Russian, or in Latin.

With the beginning of the secular registration of events in 1946, these registration records were transferred to local government registry offices, the USC (Urząd Stanu Cywilnego). Other arrangements were made for the church registration records for

Fig. 11.2 Administrative divisions of Poland (Voivodeships)

the former Eastern territories, which are today parts of Lithuania, Belarus, and Ukraine. When a birth is 100 years in the past or a marriage or death is 80 years in the past, the record is forwarded to a local archive unit, or, in the case of the former Eastern territories, to the Central Archives of Historical Records. Only recently has the Polish government begun to convert the historical registration records to an electronic database.

The birth registration record in Congress Poland (Russian Poland) was written in narrative style and contained information on the newborn, its parents and their professions, and the date and place of birth. The Russian administration has also reinstated the Julian calendar. As a result, both the Gregorian and Julian calendar were used in Congress Poland. The narrative might be in Polish, using the Latin alphabet, or in Russian, using the Cyrillic alphabet. Sometimes a marriage record was appended, such as in the sample birth record shown in Fig. 11.3. The appended marriage record is useful in validation efforts.

The birth registration record in German Poland was also written in a narrative style. The German language and Gregorian calendar were used. Furthermore, besides recordation in church records, the birth was also recorded in the local branch of the Office of Vital Records, as was the practice throughout the German Empire, with basic information as well as information on the parents' professions and religions (Maier and Scholz 2010). Cooperation between Germany and Poland in validation activity is highly desirable, since only a small amount of these records have made their way over to Germany, and there is evidence from the Gerontology Research Group (GRG) (Cf. Reference #1) that a significant number of alleged German supercentenarians were, in fact, born in German Poland.

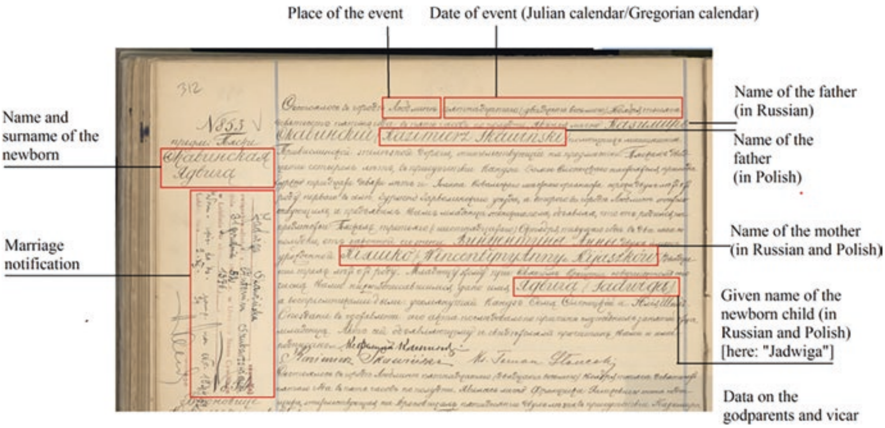

Fig. 11.3 Sample birth record from Congress Poland

In Austrian Poland, unlike the rest of Poland, the birth registration record had a fixed format, rather than a narrative form, and was limited to basic information. The language was sometimes Polish, sometimes German, and sometimes Ukrainian, with its Cyrillic alphabet.

This diversity in language, content, and form of birth registration records poses a challenge for the researcher attempting to validate alleged extreme ages. Another formidable hurdle is the strict Polish privacy law: access to such records is restricted to the subjects of these records, their family members, and institutions with a legally justified interest.

11.3 Other Records

Censuses in independent Poland were conducted in 1921 and 1931, but the 1941 census did not take place because of the outbreak of World War II. Censuses were conducted regularly since after the war, the most recent ones in 2002 and 2011. We will present in this chapter the official counts of the extreme-aged population from the censuses and post-census estimates, with a strong caveat about age misstatement.

Since 1979 every Polish citizen is assigned a unique 11-digit number by the Universal Electronic System for Registration of the Population, called PESEL (Powszechny Elektroniczny System Ewidencji Ludności). The PESEL number has the format YYMMDDZZZXQ, where YYMMDD is the date of birth (the MM coding reflects century of birth in addition to month of birth), ZZZX is a personal identification number where X is an even number for females and an odd number for males, and Q is a "check digit". The PESEL database is maintained by the Ministry of Digitalization, with access limited to scientific organizations.

11.4 Centenarians in Poland

Official counts of living centenarians and deaths among centenarians, by single year of age, gender, and voivodeship (i.e., administrative regions) are available for years beginning with 2004 – but with significant data quality issues, as we will describe.

The latest count of living centenarians, published by the Ministry of Interior, is 4200 as of June 2015. The greatest number of centenarians are in the most populous voivodeships: Masovia has 724, Greater Poland 417, Lesser Poland 378 and Silesia 376 (Fig. 11.4). Szukalski (2002) has noted that Poland exhibits the tendency found in several developed countries for the number of centenarians to double over a 10-year period.

Similarly, the number of centenarian deaths nearly doubled from 2004 to 2014, as can be seen from the counts of deaths published by the Main Statistical Office (Pol. Główny Urząd Statystyczny) and displayed in Table 11.1. It is interesting to note the dip in the number of centenarian deaths at ages 100 and 101 from 2015 to 2016, which happens to also be the case in the Czech Republic, according to data from the Czech Social Security Bureau (cf. Reference #16). One might speculate that this corresponds to a dip in the number of births 100 and 101 years earlier – during World War I.

From Figs. 11.5 and 11.6, respectively, one sees that in these official Ministry of Interior data, the voivodeship of Podlaskie has both the highest percentage male among its centenarians and the highest number of centenarians per one million inhabitants. The latter finding is surprising given that Podlaskie is in the coldest part of the country, and the finding is, in fact, suggestive of data quality issues.

Counts of centenarians in Poland are available back to the time of the first modern Polish census, in 1921 (see Table 11.2). However, meaningful comparisons over time are problematic, partly because of changing borders and population losses due to war, but mostly because of serious data quality issues. One might be tempted to hope that the latest censuses, at least, provide reliable data, but the rather low centenarian sex ratios (= number of females/number of males), in comparison to countries with good-quality data, suggest that quality issues remain formidable.

PolStu2001 was an evaluation study of Poland's population statistics, under the leadership of Dr. Małgorzata Mossakowska. PolStu2001 identified two regions

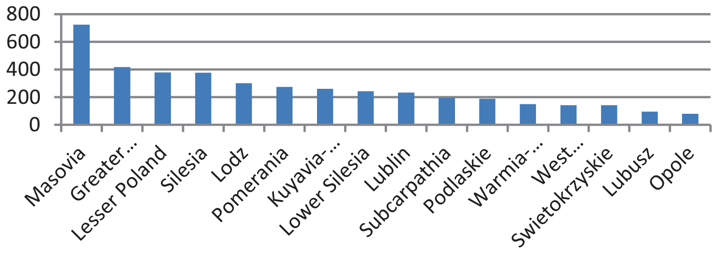

Fig. 11.4 Number of living centenarians by Voivodeship (June 2015)

Table 11.1 Deaths among centenarians by age and year

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
100	**299**	**303**	**328**	**367**	**341**	**452**	**482**	**454**	**513**	**517**	**577**	**573**	**410**
101	**183**	**240**	**202**	**228**	**277**	**308**	**313**	**307**	**371**	**349**	**350**	**432**	**384**
102	**139**	**128**	**100**	**124**	**146**	**160**	**207**	**198**	**219**	**224**	**235**	**254**	**267**
103	**66**	**77**	**68**	**93**	**113**	**103**	**130**	**120**	**122**	**133**	**140**	**173**	**173**
104	**47**	**56**	**48**	**63**	**50**	**64**	**71**	**72**	**86**	**86**	**85**	**106**	**105**
105	**10**	**25**	**24**	**31**	**33**	**24**	**38**	**30**	**42**	**38**	**39**	**68**	**61**
106	**8**	**12**	**17**	**13**	**24**	**16**	**25**	**21**	**27**	**30**	**19**	**26**	**26**
107	**4**	**5**	**6**	**5**	**8**	**7**	**9**	**10**	**10**	**10**	**13**	**16**	**15**
108	**4**	**4**	**4**	**4**	**3**	**8**	**3**	**3**	**7**	**7**	**6**	**11**	**7**
109	**4**	**1**	**1**	**5**	**1**	**4**	**3**	**3**	**4**	**4**	**5**	**2**	**8**
110+	**4**	**6**	**5**	**8**	**5**	**3**	**4**	**3**	**8**	**7**	**6**	**3**	**7**
Overall	768	857	803	941	1001	1149	1285	1221	1409	1405	1475	1664	1463

Source: Main Statistical Office (Pol. Główny Urząd Statystyczny (GUS))

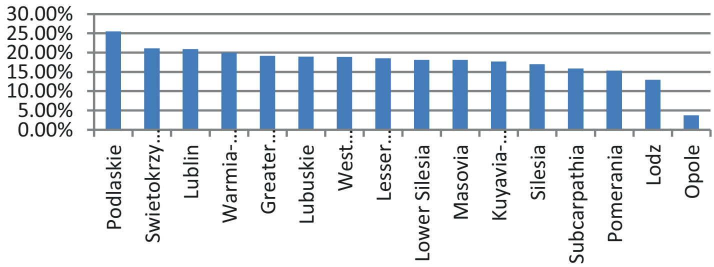

Fig. 11.5 Percentage of centenarians who are male, by Voivodeship (June 2015)

where age exaggeration was particularly pronounced (Fig. 11.7). One is the aforementioned Podlaskie Voivodeship: with its civil and parish registries destroyed, the allegations of its largely rural population formed the basis of its age statistics. The other is the western and northern territory which became part of Poland after 1945. Here much of the problem is from the "repatriates" – persons who were living in present-day Lithuania, Belarus and Ukraine and moved into this territory after the war, typically during the First Repatriation (1945–47) and the Second Repatriation (1953–57). Movement from one country to another necessitated new documents, and apparently age was not then reported very accurately. Mossakowska calculated that the number of repatriate centenarians was three times what was expected, despite no known reason why this group should enjoy greater survival to extreme old age. Parenthetically, this phenomenon of poorer quality of age data for immigrant populations exists in other counties, as well, such as Sweden.

The repatriates cannot be identified in public records because of Poland's privacy laws. The best that can be done, using Fig. 11.7, is to recognize that there are two areas in Poland, which we'll call A and B, one with better age data and the other with poorer age data. Poland B consists of Podlaskie and the northern and western

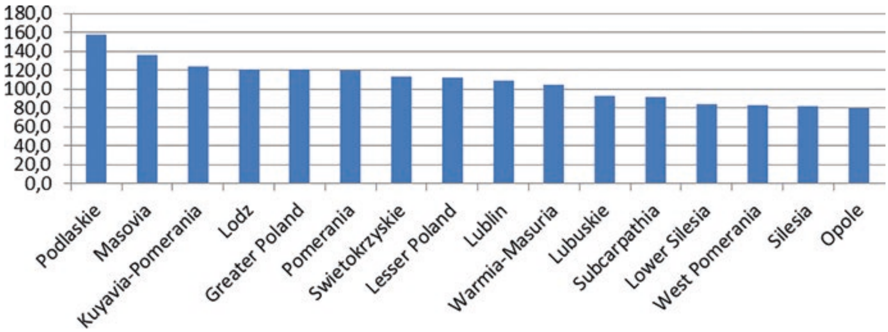

Fig. 11.6 Number of centenarians per one million inhabitants, by Voivodeship (June 2015)

Table 11.2 Number of centenarians, various polish censuses

Year	Overall	Men	Women	Sex ratio	Per one million citizens
1921	2560	1111	1449	1.30	94.2
1931	2617	1160	1457	1.26	82.0
1950	320	94	226	2.40	12.7
1960	432	74	358	4.84	14.5
1970	330	68	262	3.85	10.1
1978	424	85	339	3.99	12.1
1988	1564	363	1201	3.31	413
2002	1541	326	1215	3.73	40.3

Source: Szukalski (2002)

voivodeships of Pomerania, West Pomerania, Warmia-Masuria, Lubuskie, Opole, and Lower Silesia. When possible, studies on centenarians and semi-centenarians which are based on official statistics should be confined to Poland A.

An interesting conclusion of the PolStu2001 program was that there was no person living in 2005 with a proven age of 110 or more (Mossakowska and Jaczewska 2006).

11.5 Semi-supercentenarians

Counts of deaths at ages 105+ and counts of living persons at the same ages are available from the Main Statistical Office (GUS), Social Security Bureau (ZUS), Agricultural Social Security (KRUS) and the Ministry of Interior, respectively, for each year 2004 through 2016, by single year of age, year of birth, gender, and voivodeship. These counts are displayed by voivodeship in Fig. 11.8 for deaths only and by year of birth in Fig. 11.9. Almost half of the deaths were to residents of the northern voivodeships belonging to Poland B (Podlaskie, Pomerania, West Pomerania and Warmia-Masuria). The counts by year of birth form a generally

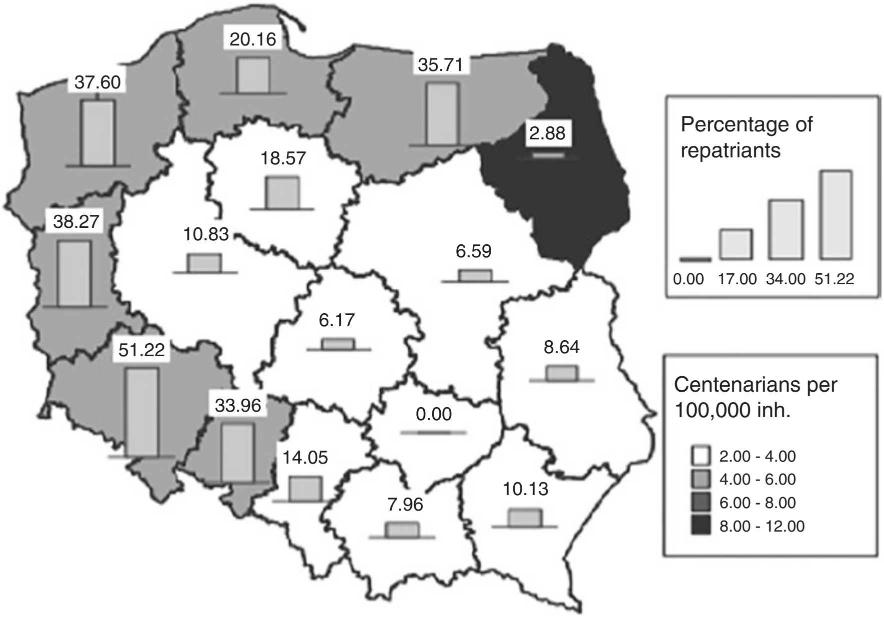

Fig. 11.7 Percentage of centenarians born beyond Poland's borders and number of centenarians per 100,000 persons (Mossakowska and Szybalska 2008)

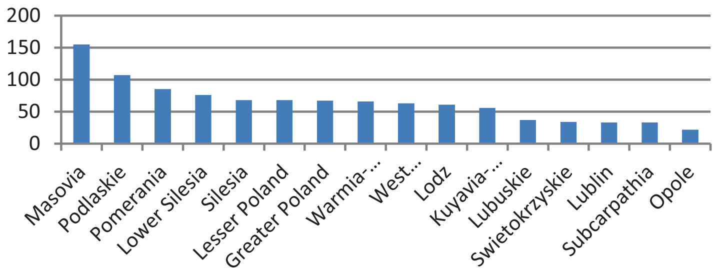

Fig. 11.8 Recorded semi-supercentenarian deaths by Voivodeship (2004–2016 data)

increasing sequence, with the number born in 1910 almost twice the number born in 1903. The total number of semisupercentenarians is 1030.

Using the counts for Poland A only (totalling 556 semisupercentenarians), we calculated mortality rates from age 105 to the highest age recorded in these data, age 111 (Fig. 11.10). The rate at age 105 is slightly below 0.5, the rates at ages 106 and 107 slightly above 0.5, and the rates beyond age 107 are higher. Extreme-age mortality seems to be similar to old-age mortality in Germany, although somewhat higher – perhaps because of the colder Polish climate (Fig. 11.10). The data for Germany come from the research conducted by the Gerontology Research Group's

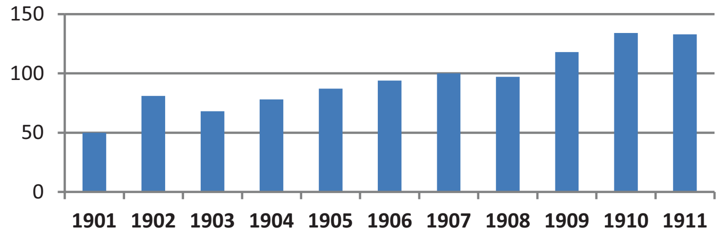

Fig. 11.9 Recorded semi-supercentenarians by year of birth (including the living)

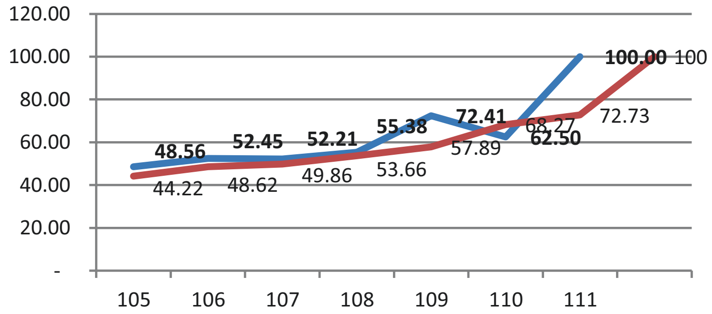

Fig. 11.10 Mortality rates of Polish (blue) and German (red) semisupercentenarians (Data for Germany from the Gerontology Research Group's German correspondents)

German correspondents, Messrs. Thomas Breining and Stefan Jamin (Gerontology Research Group 1990-2017) (Cf. Reference #2).

Since 2012 we have expended great effort to find allegations of achievement of ages 105 and over and to critically evaluate those claims. While we have made much progress, the work is incomplete and we present our research findings only for supercentenarians, in the next section.

11.6 The Emergence of Supercentenarians in Poland

11.6.1 Description of Our Research

From the Local Data Bank database (Bank Danych Lokalnych) developed by the GUS, we have the number of deaths between 2004 and 2016 at recorded ages 110+, by single year of age and the voivodeship where the death occurred. The total is 69; the question, of course, is: what is the quality of these data?

We set out to (a) identify alleged supercentenarians and (b) verify the allegations of achievement of this elevated age, using modern scientific standards of age validation (Thoms 1873) from a combination of early-life evidence (issued within the person's first 20 years), middle-life evidence (which might show a name change), and late-life evidence. (Poulain 2010) When the set of evidence was consistent and sufficient, the case was judged to be validated (Jeune and Vaupel 1999). Considering that access to the Polish census data is not possible, obtaining the original birth registration was essential. Often we needed the cooperation of the subject's family to obtain the necessary evidence.

The identification of potential supercentenarians was difficult. The GUS records are kept strictly confidential. There is no alternative but to search in secondary sources using library and newspaper resources and to contact local registry offices for the needed evidence. Furthermore, extremely aged people in Poland tend to avoid attention.

11.6.2 Reported and Validated Supercentenarians Who Died in Present-Day Poland

It is an understatement that supercentenarians are very rare. One might expect one supercentenarian to emerge from a cohort of 1000 centenarians, using an assumption that the annual probability of mortality at ages 100+ is about 0.5 (Young et al. 2009a, b, Kannisto 1994). Very roughly speaking, if there were 15,441 deaths to recorded centenarians in Poland between 2004 and 2016, one might expect about 15 supercentenarian deaths over the same period. Not only is the count of 69 supercentenarians several times what might be expected, but 25 of the 69 were males –a very unlikely scenario.

A comparison with the German data for 2004–2014 (data for Germany for years after 2014 are not available) provides further evidence that these reported data are implausible. For one thing, the number of German supercentenarians is less than the number for Poland, even though Germany has more centenarians than Poland. For another, Germany's validated supercentenarians are almost all women (93%) (Fig. 11.11).

In fact, most of the deaths at recorded ages 110+ occurred in Poland B, especially in Podlaskie (14, including 6 males) and Warmia-Masuria (10), recalling for us

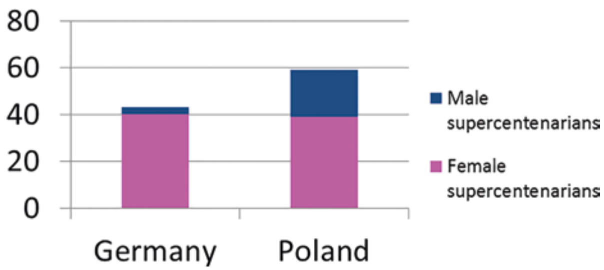

Fig. 11.11 Recorded GUS supercentenarian deaths in Poland between 2004 and 2014 and validated/pending GRG deaths for Germany (Cf. reference #1) in the same period

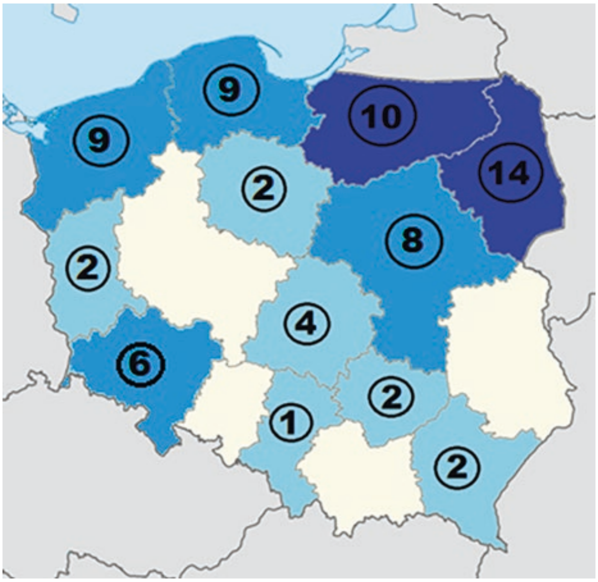

Fig. 11.12 Deaths at age 110+ recorded in Poland, by Voivodeship (years 2004–2016)

Mossakowska's thesis about significant age exaggeration in Podlaskie and among repatriates (Fig. 11.12). In particular, is it possible that cold, remote Podlaskie, with a total population of 1.2 million, could have more supercentenarians than Austria and Switzerland?

While validation efforts are ongoing, as of this writing (September 2017) there are 14 people – all female – who died or are alive in Poland and, beyond reasonable doubt, attained age 110 (Table 11.3; Fig. 11.13). It is perhaps noteworthy that this number is more in line with our expectations given the number of Polish centenarians.

In comparison with other countries in Western and Southern Europe, this number of validated Polish supercentenarians is less than would be expected. The explanation may lie in the troubled history of Poland – population losses during the two world wars, extensive emigration, and general political and economic instability. Now that conditions have improved, we may expect longevity in Poland to become comparable to longevity in other European countries.

The earliest validated supercentenarian is Rozalia Milczarek (1869–1981) of Niedoradz, Lubuskie Voivodeship, who lived 111 years 122 days. She was born before Augusta Holtz (1871–1986), who died in the United States and was thought to be the earliest supercentenarian born in present-day Poland, as well as before the earliest validated supercentenarian who died in the Nordic countries, Wilhelmine Sande (1874–1986). (Skytthe, Hervonen, Ruisdael, and Jeune, 2010).

The next validated supercentenarian in Poland, Jadwiga Zołotucho (1892–2003), who last resided in Ostróda, Warmia-Masuria and was born in Vilnius, Russian

Table 11.3 Validated supercentenarians in Poland (listed in birth order) (*as of Sept. 2017)

Name	Birthdate	Death date	Years	Days	Country of birth	Last residence
1 **Rozalia Milczarek**	Sept. 5, 1869	Jan. 5, 1981	111	122	Russian Empire (now Poland)	Poland (Lubuskie)
2 **Jadwiga Zolotucho**	Mar. 29, 1892	Jury 1, 2003	111	94	Russian Empire (now Lithuania)	Poland (Warmia-Masuria)
3 **Marianna Smolarczyk**	Feb. 16, 1897	Mar. 30, 2007	110	42	Russian Empire (now Poland)	Poland (Świętokrzyskie)
4 **Ludwika Kosztyla**	Aug. 3, 1897	Dec. 1, 2008	111	120	Austria-Hungary (now Poland)	Poland (Subcarpathia)
5 **Michalina Wasilewska**	Dec. 21, 1898	Jan. 3, 2010	111	13	Russian Empire (now Poland)	Poland (Masovia)
6 **Wanda Wierzchleyska**	Mar. 3, 1900	Jan. 14, 2012	111	317	Austria-Hungary (now Ukraine)	Poland (Masovia)
7 **Julianna Garbarz**	June 22, 1900	Jury 18, 2010	110	26	Russian Empire (now Poland)	Poland (Świętokrzyskie)
8 **Marianna Misiewicz**	Jan. 26. 1902	June 28, 2012	110	154	Russian Empire (now Poland)	Poland (Podlaskie)
9 **Józefa Karczewska**	Nov. 23, 1902	Jan. 18, 2013	110	56	Russian Empire (now Poland)	Poland (Łódż)
10 **Józefa Stanislawa Szyda**	Mar. 11, 1903	May 1, 2013	110	51	Russian Empire (now Poland)	Poland (Łódż)
11 **Aleksandra Dranka**	Oct. 3, 1903	Apr. 29, 2014	110	208	Austria-Hungary (now Poland)	Poland (Subcarpathia)
12 **Jadwiga Szubartowicz**	Oct. 16, 1905	Jury 20, 2017	111	277	Russian Empire (now Poland)	Poland (Lublin)
13 **Tekla Juniewicz**	June 10, 1906	living	111*		Austria-Hungary (now Ukraine)	Poland (Silesia)
14 **Czeslawa Łasiewicz**	Jan. 14, 1907	living	110*		Russian Empire (now Poland)	Poland (Podlaskie)

Significance codes: *Age of living people given as of Sept. 2017

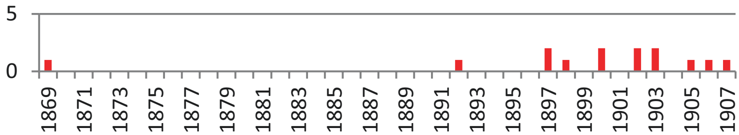

Fig. 11.13 Validated supercentenarians in Poland by year of birth (as of Sept. 2017)

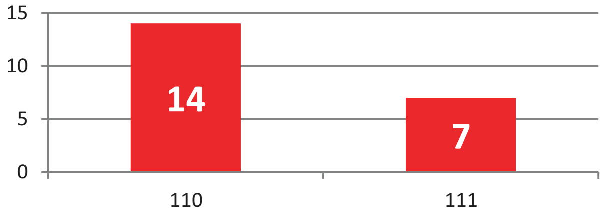

Fig. 11.14 Validated supercentenarians in Poland: number achieving each age (as of Sept. 2017)

Empire (now Lithuania), died 22 years after Rozalia Milczarek. It is surprising that there is no death to a validated supercentenarian in the intervening 22 years; perhaps we will find one or more as we proceed with our validation efforts.

Seven of the validated supercentenarians achieved age 111 (consistent with a mortality probability near 50%) (Fig. 11.14), but none achieved age 112 (although two are still living). By comparison, there are several deaths at ages 112 or more in the GUS unverified data, presumably often for repatriates. The longest-lived supercentenarian is Wanda Wierzchleyska (1900–2012) of Warsaw, who lived 111 years 317 days. Incidentally, Mrs. Wierzchleyska is a repatriate, having been born in Lwów, in present-day Ukraine. Clearly then it would have been a mistake to assume that none of the repatriates reached age 110.

Table 11.3 lists the 14 validated supercentenarians in birth order. So far, no more than two were born in any year. The first time that two Polish supercentenarians were alive at the same time was in 2010 – Wanda Wierzchleyska (1900–2012) and Julianna Garbacz (1900–2010), and the first time that three were alive at the same time was in the first half of 2017 (www.najstarsipolacy.pl).

The supercentenarian whose achievement was the first one that we were able to document is Marianna Misiewicz (1902–2012), while the first supercentenarian to be validated while still alive is Aleksandra Dranka (1903–2014), from the village of Harklowa, Subcarpathia. The first validated supercentenarian from the present-day Lublin Voivodeship is Mrs. Jadwiga Szubartowicz (1905–2017). She was residing in St. Petersburg in 1917 at aged 12 and remembered the Russian Revolution quite clearly. The author met and interviewed each of the last four supercentenarians on the list below and contacted with the families of deceased supercentenarians.

Most of our validated supercentenarian cases are in the eastern Voivodeships (Fig. 11.15). Two of the eastern Voivodeships, Świętokrzyskie and Subcarpathia, had two validated supercentenarians each, which actually matches the number recorded for them in the GUS statistics. These two regions have a very small fraction of repatriates in their elderly populations.

The two supercentenarians from Świętokrzyskie Voivodeship come from the counties of Kielce and Końskie. Namely, Marianna Smolarczyk, (1897–2007) was born and died in Łubno (Kielce County), and Julianna Garbacz (1900–2010) was born in Wólka Zychowa and died in Końskie (Końskie County). Of the 108 total centenarians living in the Voivodeship in February 2016, 50 lived in these two counties (Fig. 11.16).

Fig. 11.15 Distribution of validated supercentenarians by Voivodeship of last residence

Fig. 11.16 Świętokrzyskie Voivodeship: number of centenarians by county, with Kielce and Konskie marked in green

11.6.3 Reported and Validated Repatriated Supercentenarians

Our research identified 25 historical claims of supercentenarianship for persons born in what was once eastern Poland but was subsequently incorporated into the Soviet Union in 1945 and later became part of the independent countries of Lithuania, Belarus and Ukraine. Five were from Lithuania, fourteen were from Belarus, and six from Ukraine (see Table 11.4).

These claims are very difficult to research. First of all, the researcher must deal with various institutions in a different country, some of which are rather reluctant to cooperate, especially with a foreigner. Then, also, the claimants or their families often are not forthcoming – sometimes, no doubt, because they are aware that the claim is false. In fact, if the subject has not even truly reached age 100, there is a financial incentive to continue the charade, since Poland pays centenarians a high

Table 11.4 Repatriated historical supercentenarian cases

	Date of birth	Date of death	Age (days)	Validation status
Lithuania				
Female	Mar. 29, 1892	July 1, 2003	111 (94)	Validated
Female	May 22, 1882	Aug. 15, 1993	111 (85)	False
Male	June 7, 1898	July 9, 2009	111 (32)	Unvalidated
Female	Jan 1, 1896	Feb. 3, 2006	110 (33)	Validated
Male	Feb. 2, 1906	Feb. 4, 2016	110 (2)	False
Belarus				
Female	Feb. 18, 1900	Feb. 28, 2014	114 (10)	False
Female	May 1, 1893	Jan. 1, 2007	113 (245)	Unvalidated
Female	May 8, 1901	Dec. 15, 2014	113 (221)	Unvalidated
Female	Nov. 1, 1887	Jan. 30, 2000	112 (142)	Unvalidated
Female	Aug. 8, 1896	Oct. 12, 2008	112 (64)	Unvalidated
Female	May 17, 1898	July 13, 2010	112 (57)	Unvalidated
Female	Feb. 20, 1886	Mar. 29, 1998	112 (37)	False
Female	Oct. 11, 1904	Nov. 15, 2015	111 (35)	Unvalidated
Female	Aug. 8, 1900	Aug. 5, 2011	110 (362)	Unvalidated
Male	June 7, 1881	Mar. 8, 1992	110 (275)	Unvalidated
Female	Mar. 13, 1900	Dec. 8, 2010	110 (270)	Unvalidated
Female	Sept. 24, 1904	Nov. 19, 2014	110 (56)	Unvalidated
Female	Oct.15, 1896	Nov.10, 2006	110 (26)	Unvalidated
Female	Apr. 10, 1906	Apr. 18, 2016	110 (8)	Unvalidated
Ukraine				
Male	Feb. 27, 1890	Mar. 27, 2006	116 (28)	False
Male	Feb. 2, 1900	Dec. 13, 2013	113 (314)	Disputed
Female	Mar. 3, 1900	Jan. 14, 2012	111 (317)	Validated
Male	July 19, 1894	Dec. 6, 2005	111 (140)	Validated
Female	Aug. 23, 1870	Sept. 24, 1981	111 (32)	Unvalidated
Female	Mar. 7, 1897	Mar. 5, 2008	110 (364)	Unvalidated

allowance for care. By comparison, the families of the truly old often make the achievement public, since in Poland there is great respect for the aged. For instance, the family of Aleksandra Dranka celebrated each of her extreme-age birthdays with fanfare and media attention, and these were memorable events in the life of the local community.

Despite the difficulty, two cases from Lithuania and three from Ukraine were validated. One of the validated supercentenarians from Ukraine is the current oldest validated person living in Poland, Tekla Juniewicz. The other is Col. Jerzy Pajączkowski-Dydyński (1894–2005), who was born to Polish nobility, studied law in Lwów and Vienna, and was a veteran of World War I, the 1920 Polish-Russian War, and World War II. He left Poland together with the Polish government in Kuty on Sept. 17, 1939 and moved to the United Kingdom. Before his death in 2005 he may have been the oldest living male in Europe and the 4th oldest living male in the world.

A well-advertised case of a repatriate from present-day Ukraine is the case of Cpt. Józef Kowalski, who claimed to be the last surviving veteran of the Polish-Russian War of 1920. Allegedly he was born in February 1900 and died in 2013 at the age of 113. Our research could not validate this claim because the birth registration of his village, Wicyń, was incomplete; on the contrary, it raised doubts about the truth of the claim since we found a registration record for the June 1900 birth of a sister.

One claim from Lithuania and one claim from Belarus were disproven. In the latter case all the evidence in Poland supported the woman's claim, and indeed the family was convinced of its authenticity and never sought to evade media attention. However, the early-life evidence obtained from present-day Belarus contradicted the Polish evidence. Apparently, when the woman and her husband came to Poland either during or shortly after World War II, both exaggerated their ages by 10 years.

11.6.4 Validated Emigrant Supercentenarians

In addition to the 11 validated supercentenarians who were born and last resided in Poland, there are 25 other validated supercentenarians who were born in Poland but last resided elsewhere. Ten of them last resided in the United States, nine in Germany, two in France and two in Israel, and one each in Switzerland and Canada. The total of 36 supercentenarians puts Poland in ninth place according to the GRG in the number of validated supercentenarians born in a country, behind the United States, Japan, the United Kingdom, Italy, France, Canada, Germany and Spain, and ahead of such countries as the Netherlands, Belgium, Sweden and Australia (Young et al. 2015). The complete list of these emigrant supercentenarians is given in Table 11.5.

The greatest number of emigrated supercentenarians were born in German Poland (15), followed by Russian Poland (7) and Austrian Poland (3). Most of the emigrants who were born in German Poland last resided in Germany, presumably

Table 11.5 Validated emigrant supercentenarians born in present-day Poland (as of Sept. 2017)

Name	Birth date	Death date	Years	Days	Country of birth	Modern voivodeship	Last residence
1 **Augusta Holtz**	Aug. 3, 1871	Oct. 21, 1986	115	79	German Empire	Greater Poland	USA (Missouri)
2 **Mary Drymalski**	July 24, 1883	Dec. 1, 1993	110	130	German Empire	Kuyavia-Pomerania	USA (Illinois)
3 **Franziska Umrath**	Sept. 5, 1885	Feb. 18, 1996	110	166	German Empire	Pomerania	Germany
4 **Pauline Spyra**	Apr. 24, 1886	Jan. 11, 1997	110	262	German Empire	Silesia	Germany
5 **Meta Berndt**	Nov. 9, 1889	Dec. 28, 2001	112	49	German Empire	Pomerania	Germany
6 **Theresa Bernstein-Meyerowitz**	Mar. 1, 1890	Feb. 13, 2002	111	349	Austria-Hungary	Lesser Poland	USA (New York)
7 **Joseph Rabenda**	Jan. 10, 1892	Feb. 19, 2003	111	40	Russian Empire	Greater Poland	France
8 **Frieda Borchert**	Jan. 5, 1897	June 22, 2008	111	169	German Empire	Lubuskie	Germany
9 **Rosa Rein**	Mar. 24, 1897	Feb. 14, 2010	112	327	German Empire	Silesia	Switzerland
10 **Dr. Maria Pogonowska**	Oct. 30, 1897	July 15, 2009	111	258	Russian Empire	Masovia	Israel
11 **Fannie Buten**	Apr. 13, 1899	Sept. 24, 2010	111	164	Austria-Hungary	Subcarpathia	USA (Pennsylvania)
12 **Maria Gerstman**	Oct. 30, 1900	Dec. 7, 2012	112	38	Russian Empire	Podlaskic	USA (New York)
13 **Anna Lewicki**	Dec. 6, 1900	Jan. 3, 2010	111	28	Austria-Hungary	Subcarpathia	USA (New York)
14 **Rose Berman**	Feb. 28, 1901	Jan. 12, 2012	110	318	Russian Empire	unknown	USA (Florida)
15 **Thea Breckerbaum**	Oct. 6, 1902	Nov. 25, 2012	110	50	German Empire	Greater Poland	Germany

(continued)

Table 11.5 (continued)

Name	Birth date	Death date	Years	Days	Country of birth	Modern voivodeship	Last residence
16 **Maria Jantke**	Oct. 18, 1902	Mar. 9, 2013	110	142	German Empire	Pomerania	Germany
17 **Anna Palarowska (s. Bernadetta**	Oct. 22, 1902	Nov. 2, 2013	111	11	German Empire	Warmia-Masuria	France
18 **Johanna Klink**	Jan. 17, 1902	Feb. 20, 2015	112	34	German Empire	Silesia	Germany
19 **Dr. Alexander Imich**	Feb. 4, 1903	June 8, 2014	111	124	Russian Empire	Silesia	USA (New York)
20 **Margarete Ottmann**	Feb. 23, 1903	Aug. 17, 2014	111	175	German Empire	Opole	Germany
21 **Eva Grafunder**	June 17, 1903	July 14, 2013	110	27	German Empire	Warmia-Masuria	Canada (British Columbia)
22 **Israel Kristal**	Sept. 15, 1903	Aug. 11, 2017	113	330	Russian Empire	Lodz	Israel
23 **Hedy Wegier**	Oct. 25, 1903	May 12, 2015	111	199	German Empire	Silesia	USA (New York)
24 **Elisabeth Franke**	Nov. 10, 1903	Aug. 11, 2014	110	274	German Empire	Lower Silesia	Germany
25 **Ida Tallin**	Sept. 25, 1905	Aug. 5, 2016	110	315	Russian Empire	Podlaskie	USA (Florida)

Subsequent research proved that Rose Berman was actually born in present-day Ukraine (Apr. 2018)

reflecting the post-war expulsion of Germans from Silesia and Pomerania. Figure 11.17 shows the distribution of the 25 supercentenarians by voivodeship of birth.

The oldest supercentenarian born in present-day Poland is Augusta Holtz (1871–1986), who, with a validated age of 115 years 79 days was the world record holder, likely the first person to have reached the age of 115 (see Chap. 22), until she was surpassed by Jeanne Calment in 1990. Two of Poland's emigrant supercentenarians were recognized in the Guinness Book of World Records as the world's oldest living male. One is Israel Kristal, who last resided in Israel (see Chap. 20). The other is Dr. Alexander Imich, quite a remarkable man, proven to have been the last surviving veteran of the aforementioned 1920 Polish-Soviet War. Dr. Imich devoted his life to the scientific study of parapsychology and paranormal

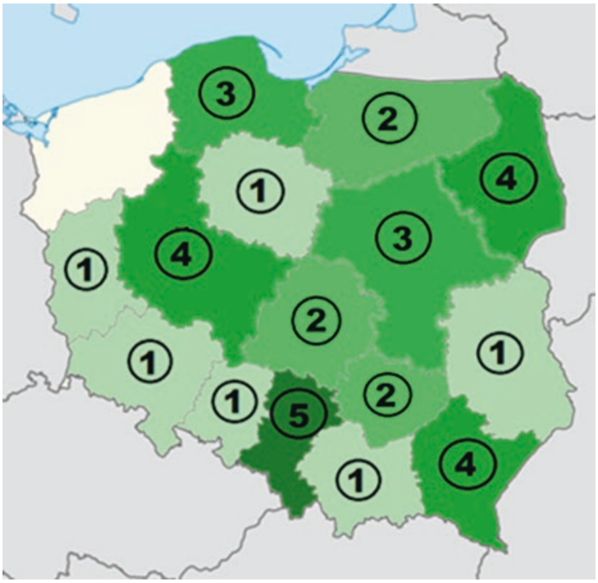

Fig. 11.17 Number of validated supercentenarians born in present-day Poland by modern Voivodeship of birth

phenomena, and continued his studies until a very old age, in fact publishing a book on these subjects when he was in his 90s. He survived imprisonment in a Soviet labor camp during World War II and came afterwards with his wife to New York. The author was still in an e-mail correspondence with Dr. Imich in the year of Dr. Imich's death.

11.7 Conclusion

Official statistics on Polish longevity, while not highly accurate, may be useful for making comparisons or observing trends, particularly if restricted to "Poland A". Our primary focus since we began in November 2012 is to validate allegations of extreme age. With respect to supercentenarians, we were able to validate the status of 14 people, all women, who last resided in Poland. We also observed the interesting phenomenon that about twice as many validated supercentenarians were born in Poland and last resided elsewhere.

We are continuing the search for true supercentenarians in Poland and looking forward to a more comprehensive study of Polish longevity.

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I would like to express my gratitude for the invaluable commitment of Messrs. Przemysław Kuty, Łukasz Szołdra and Michał Sędziak, my Polish colleagues who share my passion for longevity research; and a thank you to Georg Fürholzer of Austria and Victor Bjoerk of Sweden for giving me the joy of visiting Emma Morano, the last survivor of the 1800s.

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This chapter is dedicated to the memory of Mrs. Jadwiga Szubartowicz (1905–2017), supercentenarian and Doyenne of Poland, for her hospitality, friendship and inspiration for life; and to the memory of Ms. Stefania Zacharska (1906–2016) of Tarnowskie Góry, the semi-supercentenarian from my town of birth, whose life story inspired me to study the phenomenon of human longevity.

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Chapter 12
Extreme Longevity in Quebec: Factors and Characteristics

Mélissa Beaudry-Godin, Robert Bourbeau, and Bertrand Desjardins

12.1 Introduction

Rising life expectancy at birth, and in particular lower mortality at advanced ages, has led to a marked increase in the number and the proportion of centenarians, and to new records in longevity in low mortality countries. This explosion in the numbers of centenarians has been studied in the United States (Krach and Velkoff 1999), France (Meslé et al. 2000; Vallin and Meslé 2001), England and Wales (Thatcher 2001; Dini and Goldring 2008), Belgium (Poulain et al. 2001), Denmark (Jeune and Skytthe 2001), Switzerland (Robine and Paccaud 2004), Italy (Poulain et al. 2004), Japan (Robine and Saito 2003; Robine et al. 2003), Australia (Terblanche and Wilson 2014), as well as in Europe (Robine and Saito 2009) and the industrialised countries (Rau et al. 2008; Herm et al. 2012). These studies all document the rapidity of the increase of this population, starting in the mid-twentieth century, and they also highlight its absolute numbers and its proportional share of the general population. The rate of decline in mortality at advanced ages has not slowed in recent years, so this phenomenon can be expected to grow in scale over the coming century, with new records being set in terms of survival into extreme old age.

On 1 January 2015, the USA and Japan had the largest number of centenarians among the selected countries in Table 12.1. However, in view of the relative size of their populations, the situation in Japan is quite exceptional, with 5.1 centenarians per 10,000 inhabitants. This country is known for the values associated with its long life expectancy at birth, for the prevalence of centenarians, and especially for the speed of growth of this particular population group – in the space of 20 years from

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Table 12.1 Number of centenarians and sex ratios of centenarians in selected countries, 1 January 2015

Countries	Numbers			Centenarian rate (Number of centenarians per 10 000 persons)	Sex ratio (Number of women per men)
	Women	Men	Total		
USA	54,525	10,253	64,778	2.0	5.3
Japan	56,187	7,923	64,110	5.1	7.1
France	20,681	3145	23,825	3.7	6.6
United Kingdom	12,330	2240	14,570	2.2	5.5
Canada[a]	6116	835	6951	1.9	7.3
Quebec[a]	*1478*	*145*	*1623*	*2.0*	*10.2*
Belgium	1833	249	2082	1.8	7.4
Switzerland	1349	273	1622	2.0	4.9

Source: Human Mortality Database and Statistics Canada (population estimates)
[a]Population on 1 July

1996 to 2015, the number of centenarians multiplied by 10. France is also outstanding with 3.7 centenarians per 10,000 persons. Canada and Quebec, with 1.9 and 2.0 centenarians per 10,000 persons respectively, show prevalences similar to the USA, United Kingdom, Switzerland and Belgium.

Sex ratios reflect the lower mortality of women. These ratios also vary between the selected countries. There are between 4.9 and 5.5 females for every male centenarian in Switzerland, the USA and the United Kingdom, while France, Japan, Canada and Belgium have ratios higher than 6.6. The very high ratio observed in Quebec in 2015 may be explained by the small size of the population, leading to important annual fluctuations.

The speed of growth in the numbers of centenarians has also varied from one country to another. Whereas growth rates have been relatively steady in France, Belgium, Switzerland and the United Kingdom, there has been some slowing of the growth in numbers in Canada (including Quebec) and the USA from the 1990s onwards (Fig. 12.1). In the case of Japan, the centenarian population has been growing at a much more rapid pace since the 1960s, and the growth curve even shows an acceleration in the last 20 years, so that by 2015 Japan's growth curve is as high as that of the USA and will probably cross the USA in the years to come.

In this study we analyse the evolution of the number of centenarians in Quebec. We chose to focus on Quebec because its mortality data offer the best possibilities for analysis in Canada, in terms of availability and quality. Census data and population estimates as well as civil registration statistics are available to enable the study of this relatively new and rapidly expanding phenomenon, although imperfections in the data mean that hypotheses have to be formulated and corrections introduced to make them representative of the reality. The aim of the study is to analyse the levels and trends in the numbers of centenarians in Quebec and to make comparisons with that observed in other low mortality countries. To this extent, we use the

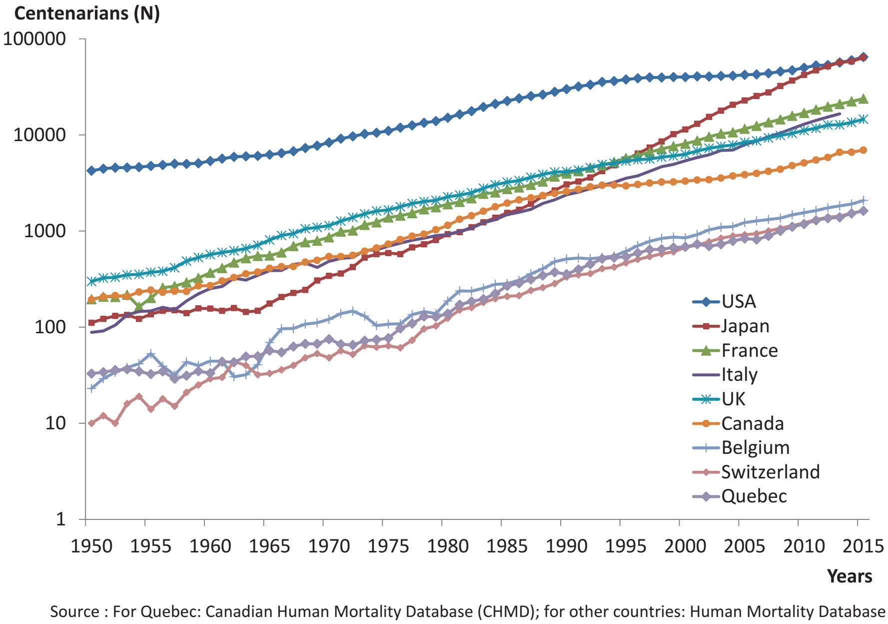


Fig. 12.1 Evolution of numbers of centenarians (Those aged 100 and over), selected countries, 1950–2015

best demographic indicators such as the centenarian ratio, the probabilities of surviving and maximum age at death to give an account of the evolution of this population over the course of the last century, and to measure its place in today's society. As a result, we will be able to identify the factors responsible for the increase in the numbers of centenarians, and to quantify their relative contributions. Projection of the centenarian population for Quebec until 2061 is also presented.

12.2 Sources and Data

12.2.1 Censuses and Civil Registration

The first census was carried out in 1666 by the Intendant Jean-Talon. It was conducted *de jure,* covering French settlements in New France. By 1851, when the first national census took place, 98 colonial and regional censuses had been taken at more or less regular intervals, but none after 1681 were complete, being limited to heads of households and statistics of the household. From 1851 to 1951 "official" censuses took place every 10 years, and thereafter every 5 years, in years ending with 1 or 6. Two different kinds of problem compromise the use of census data to study changes in the numbers of centenarians. The first has to do with publication

Table 12.2 Oldest available age groups showing population numbers in Canadian censuses, 1881–2011

	Age group	
Census year	95 and +	100 and +
1881		x
1891	x	
1901	x	
1911		x
1921		x
1931		x
1941	x	
1951	x	
1956	x	
1961	x	
1966	x	
1971		x
1976		x
1981		x
1986		x
1991		x
1996		x
2001		x
2006		x
2011		x

and treatment of information on the population of persons aged 100 and over. For some census years there are no population numbers for those aged over 100, because the oldest recorded age group is that of persons aged 95 and over (Table 12.2). In addition, where these data are available (since 1971), they are rounded up to multiples of five, to ensure the confidentiality of respondents. This procedure, established by Statistics Canada, creates a problem because the numbers of the population aged 100 and over are very low. Rounding these numbers up therefore causes a loss of precision which impedes the study of mortality at advanced ages.

The second major problem with the census data is the quality of the information on the numbers of centenarians. In a study carried out in Canada on the quality of data on people at advanced ages, Bourbeau and Lebel (2000) showed that while the Canadian data are reliable up to the age of 100, misreporting from age 100 is responsible for false estimates of mortality (Bourbeau and Desjardins 2002; Bourbeau and Lebel 2000). Fortunately the problem can be alleviated using civil registration data which provides information on all events such as births, marriages and deaths taking place each year. Unlike censuses which are time-specific events, civil registration is a system of continuous recording. This system was established in Canada in 1921, but only in 1926 in Quebec. Registration of births, marriages and deaths is the responsibility of the ten Provinces and of the northern Territories; the data are sent to Statistics Canada where they are aggregated and standardised. Nevertheless, as pointed out by Bourbeau and Desjardins (2006) and Desjardins and Bourbeau (2010), methods and procedures for registration and data entry vary from one Province to another, with the result that biases may be introduced into the published results.

The registration of age at death in the civil register is recognised as being of superior quality compared to the population data in the census (Bourbeau and Lebel 2000; Bourbeau and Desjardins 2002; Desjardins 1999; Manton and Yashin 2000; Beaudry-Godin 2010). Over the course of the past century, procedures for checking age at time of death have been improved and standardised. In Quebec, data have been subject to systematic control measures since 1986, involving the checking of the reported age at time of death against the recorded year of birth of the individual concerned. Since 1992, the death certificate has been checked in this way for all deaths reported as taking place at over 103 years of age. And finally, the Institut de la Statistique du Québec has carried out more exhaustive checks since 1997, matching health insurance numbers and dates of birth.

For the purposes of this study we used data on deaths at age 100 and over in Quebec and Canada. We worked with a file obtained from Statistics Canada, which includes a classification of deaths by age and cohort from 1950 onwards and a death count up to the last recorded age (unpublished data). The civil register data can be consulted via the *Canadian Human Mortality Database*, which is available online.[1] However, until 1950 all deaths after age 100 were recorded as simply 100 or over; from 1950, the open ended age group became 110 years and over. The double classification of deaths is also available for the entire period, although before 1950 they are estimates obtained by redistributing the deaths uniformly by age within the generations concerned.

12.2.2 Reconstituted Populations

A number of different methods have been proposed to remedy the problem of misreporting at advanced ages in the census; these include the method of extinct generations and the survivor ratio method. These enable us to estimate population sizes on January 1st of each year and survivors of a cohort at exact age x. These methods are among those used to construct the life tables of the *Human Mortality Database,*[2] the *Kannisto-Thatcher Database*[3] and the *Canadian Human Mortality Database*. The basic principle of the extinct generations method is that in a closed population, the population size of a cohort at age x is equal to the sum of the deaths after this age until the complete extinction of the cohort. This method, developed by Vincent (1951) is only applicable to age groups in which migration is negligible (such as

[1] http://www.bdlc.umontreal.ca/bdlc/index.htm

[2] Available on line at: http://www.mortality.org/

[3] Available on line at: http://www.demogr.mpg.de/databases/ktdb/

those aged over 80). A cohort is considered extinct when it attains the maximal age beyond which the probability of a death is virtually nil. This method enables estimates to be derived of population sizes of the extinct generations i.e. those having attained the maximal age in the most recent registration year. For subsequent generations, the survivor ratio method is used; this assumes that deaths by year of age of a generation X are distributed in the same proportions as those of the 5 or 10 preceding generations.

12.2.3 Data Comparison

A quick and simple way of judging the quality of official population data is to compare the census data with population estimates published by the CHMD[4] (based on the extinct generations and survivor ratio methods). To make the comparison with census data easier we decided to present the CHMD population estimates on July 1st of each year (Table 12.3). The results for the age group composed of those aged 90 and over are shown in Appendix.[5] Note that since 1971 the census data have been corrected for undercoverage of the population. The Statistics Canada estimates (in column 2) show the corrected numbers of nonagenarians. Over the period as a whole, this correction is about 1% for both men and women. Although there are differences, which are sometimes significant, between the number of people aged over 90 according to these two sources, they are not as large as those we find for the centenarian population (Table 12.3). While the maximum difference between sources for the population over 90 is 20.0% for men and 16.8% for women, for those over 100 we find differences in size estimates of 94.0% and 86.9% respectively for men and women in the census year 1976. If we exclude this particular year, which is evidently especially problematic, the census results overestimate the male population aged over 100 by between 5% (1996) and 78% (1971) compared with the results derived from reconstitution methods, while for the female population the census results under-estimate by 1.9% (2011) and over-estimate by 66.7% (1941) using the same comparison. Sampling and data entry errors and over-reporting of ages are among the reasons which may explain these divergences. However, it is worth noting that the differences are considerably reduced in the period since the 1990s (except for a notable difference in 2006).

Comparing census data with population estimates based on the extinct generations method clearly shows the deficiencies of the census results for the population aged 100 and over. For the purposes of this study, to ensure greater accuracy and reliability of the indicators we present, we base our calculations on population estimates derived using the extinct generations and survival ratio methods published by the CHMD.

[4] Canadian Human Mortality Database (CHMD).

[5] See p. 22.

Table 12.3 Comparison of population numbers of those aged 100 and over, according to two sources of data, Quebec, 1921–2011

	Males			Females		
Years	Census data	CHMD estimations[a]	Relative difference (%)	Census data	CHMD estimations[a]	Relative difference (%)
1921	11	5	54,4	18	9	52,4
1931	8	3	65,9	14	10	30,3
1941	**13**	4	67,8	**23**	8	66,7
1951	**19**	6	66,8	**35**	29	17,9
1956	**22**	9	58,3	**40**	23	42,8
1961	**26**	15	41,3	**47**	28	39,6
1966	**28**	16	44,3	**61**	43	28,7
1971	65	14	78,0	125	52	58,5
1976	510	31	94,0	560	74	86,9
1981	110	47	57,3	260	131	49,6
1986	130	82	37,2	310	220	29,1
1991	150	80	47,0	485	353	27,2
1996	110	105	5,0	500	513	−2,6
2001	120	102	15,3	645	613	5,0
2006	135	95	29,9	865	761	12,0
2011	180	152	15,8	1160	1182	−1,9

In **bold**: data obtained by applying mean ratio of population aged 100 and over to population aged 95 and over (100+/95+)

[a]Estimates on July 1st, based on extinct generations and survivor ratio methods

Sources: Census data: Statistics Canada (1996); CHMD estimates: Canadian Human Mortality Database (CHMD) and Statistics Canada (1998)

12.3 Choice of a Longevity Indicator

One of the aims of this study is to compare survival at advanced ages in Quebec with that observed in other low mortality countries. Because population size varies so much from one country to another, we cannot compare mortality in extreme old age using recorded numbers of centenarians or numbers of recorded deaths of centenarians. A comparison must rely on a longevity indicator which is not affected by population size. The most commonly used indicators in comparative analyses of survival to extreme old age are life expectancy, prevalence of centenarians, the extreme longevity index, the ratio of centenarians per 10,000 births and per 10,000 persons aged 60.

Although life expectancy and prevalence of centenarians are measures found widely in the literature, they are not particularly suitable for this type of analysis. Low numbers mean that the values attached to life expectancy at 100 years are imprecise. In addition, life expectancy is not a real measure of the mean number of years an individual can expect to live, because its calculation rests on the hypothesis that mortality rates at different ages remain unchanged over time. As an indicator, life expectancy fails to capture the real conditions of mortality which have affected the many cohorts it is based on. The prevalence of centenarians, which relates the number of centenarians to the total population, is influenced significantly by migration and by a range of phenomena and events which may have affected its age structure. For this reason, it is not a suitable indicator for international comparisons.

The ratio of centenarians per 10,000 births has been used in several studies of centenarians (Poulain et al. 2001; Robine et al. 2003; Robine and Saito 2003; Robine and Paccaud 2004; Robine et al. 2006). This index is obtained by dividing the number of persons aged 100 at a given date (January 1st for example) by the number of births that took place between January 1st and December 31st one century earlier. In mathematical terms:

$$RC_{[0]} = \frac{P^{01.01.y}}{N^{y-100}},$$

Where y refers to any given year.

The major difficulty with this index is that because of migratory flows, the numbers making up the numerator and the denominator are not derived from the same populations. On the one hand, the index over-estimates the prevalence of centenarians because the numerator includes individuals born outside the population being studied. On the other hand, it under-estimates the prevalence of centenarians because it does not consider centenarians born in the study population but who have emigrated and celebrated their 100th birthday outside the territory of the country in question. The extreme longevity index (ILE) proposed by Poulain et al. (2004) is an improved version of the ratio of centenarians per 10,000 births. This relates the number of survivors to age 100 in a given generation to the number of births in the same generation. In mathematical terms:

$$ILE = \frac{S_{100}}{S_0} \cdot 100,$$

where S_{100} = Survivors to age 100 and $S_{0\,=}$ Survivors at age 0 (number of births).

As the authors point out, this index is not affected by over-estimation because it considers only individuals born in the country of study. In addition, it includes centenarians born in the generation in question who may have emigrated and reached the age of 100 outside the country, in cases where their existence is known. As an example, Poulain and Naito (2004) could trace centenarians belonging to the generations studied who originated in Okinawa and died in Hawaii, and to include them in the calculation of the index of longevity. In the context of Quebec, however, there are two problems of a very different kind which undermine the use of this index. The first has to do with the type of data available. Not only is there no accurate information on the numbers of births in Quebec in the late nineteenth century, but it is difficult to identify the immigrants within the centenarian population. We could of course estimate the numbers of births and of immigrants,[6] but this would severely reduce the level of reliability and comparability of the indices of extreme longevity. The second problem arises when this indicator is used for international comparisons. If we compare countries based on probabilities of survival from birth to the age of 100, we are bringing together cohorts which have not been subject to the same mortality regime. Wars and epidemics are among the disruptive factors which have had impacts on child and adult mortality rates and consequently on the numbers of centenarians.

The ratio of centenarians per 10,000 persons aged 60 forty years before (Robine and Paccaud 2004; Robine et al. 2006) seems better suited for the study of survival to extreme old age. This type of indicator enables the influence of disruptive effects to be avoided – not only effects caused by migration but also those associated with infant mortality – while preserving the essential element of adult mortality. This indicator is based on the hypothesis that "the number of centenarians in a country is essentially dependent on the number of individuals aged 60 forty years earlier, and on mortality trajectories after that age".[7]

$$RC_{[60]} = \frac{P(100)^{t}}{P(60)^{t-40}} \cdot 10000$$

The use of this kind of indicator is particularly appropriate given the migration context of Quebec in the nineteenth and twentieth centuries. If we accept the estimations of Lavoie (1972), which the author herself admits are conservative, 1,550,000 Canadians including 510,000 Québécois crossed the frontier into the USA in the period from 1860 to 1900. This corresponds to an annual migration rate of about 10.3%. This massive emigration from Quebec to the United States was followed by a return to Quebec by some of them, but also importantly by the start of a major international immigration into Quebec. By relating the size of the population aged 100 to the size of the same population at age 60, we considerably reduce the impact of migration movements which may have affected the denominator population.

This centenarian ratio was proposed by Caselli et al. (2003) to compare the distribution of centenarians in certain regions of Italy. Their choice of the denominator was mainly influenced by the type of migrations associated with Italian age cohorts at the end of the nineteenth century. Here the generations from 1870 to 1890 were particularly affected by labour migration, which generally takes place before the age of 60. Furthermore, as the authors emphasise, return migrations after the age of 60 were exceptional, with most of such returns taking place a short time after the period of emigration (Robine et al. 2006).

In this chapter, we are interested in the survival at old ages of the generations from 1860 to 1905, which reached the age of 60 between 1920 and 1965 and the age

[6] On this see page 11.

[7] Robine, J.-M. et Paccaud, F. 2004. « La démographie des nonagénaires et des centenaires en Suisse », *Cahiers québécois de démographie*, 33(1), p.63.

of 100 between 1960 and 2005. Although it is generally accepted that migration after the age of 80 is negligible, it is worth pausing here to explore the prevalence of migrations between the ages of 60 and 80 in Quebec. Immigration statistics[8] and the 2006 census[9] show that the proportion of immigrants entering Quebec who were aged over 60 was 0.31% before 1961 and 1.6% in the period from 1966 to 1975. In terms of Québécois leaving the province after the age of 60, Yolande Lavoie (1972) has estimated that more than 98.5% of emigrants in the period from 1900 to 1930 were aged under 50. As Desrosiers et al. (1976) show, Québécois of this period emigrated mainly for economic reasons. These findings taken together lead us to believe that migration movements after the age of 60 were quite rare in Quebec before the mid-1970s (by which time the generations under study were either extinct or already in old age).

In view of the objective of making international comparisons, and considering the nature of the data to be used, as well as the nature of the migration profile prevailing in Quebec in the first half of the twentieth century, our measure of longevity in Quebec is therefore based on the ratio of centenarians per 10,000 individuals of the same generation at age 60. If we accept that there is a very low level of migration after age 60, the populations making up the numerator and the denominator are relatively similar. In other words, we are assuming that migration flows are negligible between age 60 and age 100. However, it is worth pointing out that the population numbers on January 1st of each year do include immigrants, and that this may have some effect on the ratios of centenarians. In particular, lower ratios could be partly explained by the "healthy immigrant effect". However, as argued by Bourbeau (2002), the size of this immigrant group is not great enough at advanced ages to account for a Québécois survival advantage, so we can claim that a finding of lower centenarian ratios would reflect a real survival advantage at advanced ages.

12.4 Results

12.4.1 Evolution of the Number of Centenarians in Quebec

The evolution of the number of centenarians in Quebec in the period 1921–2016 is illustrated in Fig. 12.2. The number of centenarians rose only slightly during the two first decades of the study period, both for men and women. The population aged 100 and over amounted to just 15 individuals at the beginning of the 1920s. It took 30 years for this population to double in size. However, from the 1950s onwards, and especially at the beginning of the 1970s, it grew more or less exponentially; in the space of 20 years, between 1971 and 1991, it increased six-fold, from 66 to 399

[8] *Immigration statistics,* Ministry of Labour and Immigration, Immigration Division, Canada, Ottawa, 1966 to 1996.

[9] Statistics Canada, 2006 Census, Catalogue No. 97-557-XCB2006023.

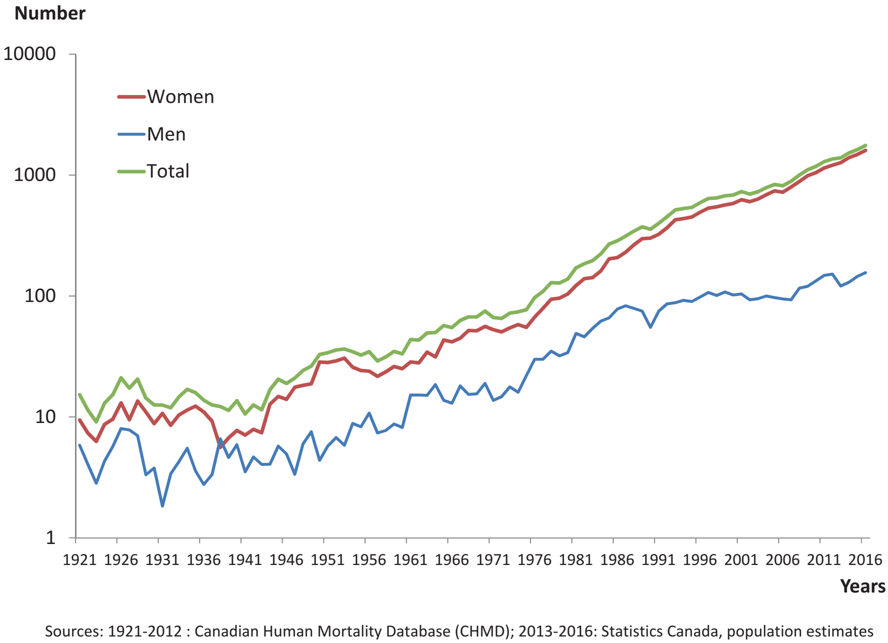


Fig. 12.2 Evolution in numbers of centenarians (Individuals aged 100 and over) by sex, Quebec, 1921–2016

individuals. At the end of the period, on January 1st 2016, the total number of centenarians stood at 1757. The population aged 100 and over has always been composed of more women than men. In 1921 just under two thirds of centenarians were women, while in 2016 the proportion of women was nearly 90%. Thus, in the course of the twentieth century the growth rate of the numbers of centenarians was higher for women than for men. Until the mid-1990s there was a time lag of about 20 years between the growth curves for the two sexes, with total numbers for male centenarians reaching 10 and 100 approximately 20 years later than for females. Since the beginning of the 1990s, the number of male centenarians appears to be stabilising at around one hundred individuals, although there has been a small increase in this figure in the last years of the study period. Over the period as a whole, the female and the male centenarian populations have multiplied by 170 and by 27 respectively.

The last century has seen not only an explosion in the number of centenarians in Quebec, but also the appearance and growth in the number of semi-supercentenarians (individuals reaching the age of 105) and supercentenarians (those reaching the age of 110). The first semi-supercentenarians are found in the mid-1940s (Fig. 12.3). Their numbers remain relatively stable during the succeeding decades, at around 5 individuals, until the end of the 1970s. This period marks a break in the rate of growth of this particular population; thereafter it multiplies seven-fold in the space of 25 years, to reach 68 individuals in 2012. The number of supercentenarians is,

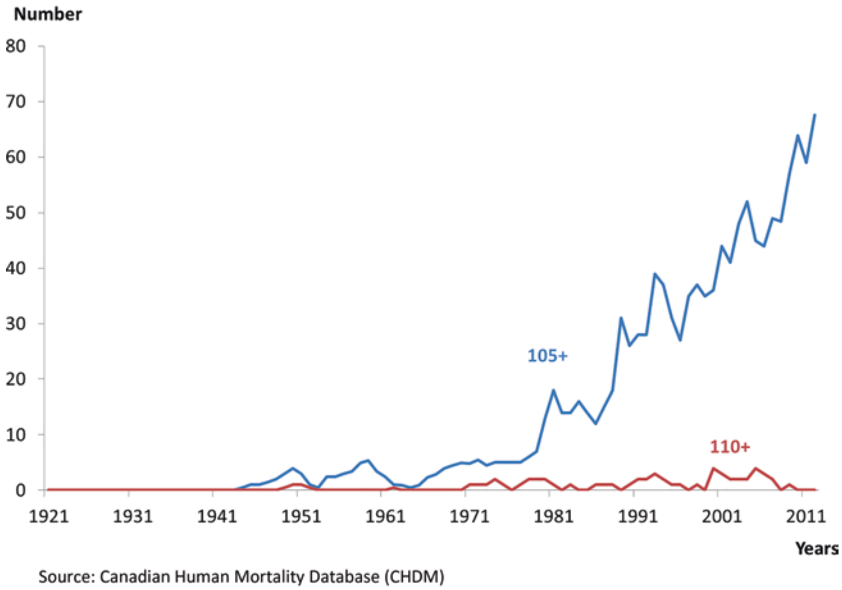


Fig. 12.3 Evolution of numbers of semi-supercentenarians and supercentenarians, Quebec, 1921–2012

naturally, very small throughout the observation period. On the basis of the CHMD population estimates, the 110-year mark was reached for the first time in the 1950s. Although the statistics we have analysed show no increase in numbers, the existence of supercentenarians becomes less exceptional from the 1990s.

12.4.2 Centenarian Ratio

From 1961 to 2011, the ratio of male centenarians rose from 11.6 to 34.7 per 10,000 individuals aged 60 forty years earlier (Table 12.4). This is quite a small increase considering that the ratio of female centenarians multiplied 10 times in 50 years. In 2011 there were 196 women aged 100 per 10,000 women aged 60 forty years earlier. These results are consistent with the probabilities of surviving from 60 to 100 calculated from the *New birth cohort life tables for Canada and Québec, 1801–1991* (Bourbeau et al. 1997).

Our objective was to compare the survival profile at advanced ages in Quebec with those found in other low mortality countries. We therefore estimated the centenarian ratio for seven countries including Canada, using population figures published by the CHMD and HMD (Table 12.5).[10]

The centenarian ratio has increased in all the countries considered. But over the period as a whole the increase has been highest in Switzerland, where the ratio has

[10] Human Mortality Database.

Table 12.4 Ratio of centenarians per 10,000 individuals aged 60 Forty Years earlier, Quebec, 1961–2011

Year	Men	Women	Total
1961	11.6	19.4	15.5
1971	6.3	29.0	17.4
1981	21.5	55.4	37.9
1991	29.4	104.7	66.6
2001	31.2	147.7	90.3
2011	34.7	196.4	118.3

Source: Canadian Human Mortality Database (CHMD)

Table 12.5 Comparison of centenarian ratio (RC_{60}), selected countries, 1961 to 2011

	Japan	France	Canada	**Quebec**	USA	Switzerland	UK	Belgium
1961		5.4	24.0	**15.5**		3.1	8.0[a]	3.7
1971		11.4	34.0	**17.4**		7.3	14.7	9.3
1981		22.6	62.8	**37.9**	59.8	19.9	21.6	13.8
1991	29.2	43.4	99.4	**66.6**	91.3	35.9	34.6	25.6
2001	81.8	72.0	105.2	**90.3**	103.8	57.9	48.9	37.7
2011	227.9	135.3	135.0	**118.3**	111.0	87.4	72.8	63.2

Sources: Human Mortality Database (HMD) and Canadian Human Mortality Database
[a]Population numbers aged 60 in 1922

multiplied almost 29-fold in the space of 50 years. Although Switzerland is the country which has had the biggest increase over time, it is in Japan, France and Canada that we find the highest centenarian ratios. In the case of Canada, it is possible that the quality of the data at advanced ages may partly explain these results up until 2001. Since 2001, data on centenarians are verified more closely by Statistics Canada.

Until 2001, the centenarian ratio in Quebec was notably higher than in European countries. But in 2011 it was below that of France, at 118 centenarians per 10,000 individuals aged 60 forty years earlier. As shown by Beaudry-Godin (2010), data quality cannot be held responsible for the reduced gap between the indices for Quebec and for countries in Europe. But despite this convergence, the population of Quebec still has a profile which displays certain advantages compared with the majority of European countries.

12.4.3 Factors Responsible for the Increase in Numbers of Centenarians

The growth in numbers of centenarians in successive cohorts may be attributed to several main factors such as the increasing size of birth cohorts, migration, and the rising probability of survival from birth to age 100 (Vaupel and Jeune 1995; Thatcher

2001; Robine and Paccaud 2004). To isolate the impact of improved probability of survival to advanced old age on the increase in numbers of centenarians, we distinguished the probability of surviving from birth to age 80 from the probability of surviving from age 80 to age 100. Since Quebec experienced significant migratory movements in the early twentieth century, it is important to take into account this factor that is however difficult to quantify exactly. It is therefore estimated as a residual (Vaupel and Jeune 1995; Thatcher 2001). Thus, the increase in the number of centenarians is decomposed into five multiplicative factors:

- Increase in the size of birth cohorts
- increase in the probability of survival from birth to age 80 for specific cohorts,
- increase in the probability of survival from age 80 to age 100 years for specific cohorts,
- change in the number of persons aged 100 and over relative to the number of persons reaching exact age 100,
- net change due to migration and other factors (errors).

We studied the relative contribution of each of these five factors to the increase in numbers of centenarians for the cohorts from 1881 to 1911.

12.4.4 Increased Cohort Size

The numbers of births by sex were taken from the Canadian census for the 1881 cohort. For the births of the 1911 cohort, we used the estimate proposed by the Institut de la Statistique du Québec. The number of births has increased by about 46% between the two cohorts.

12.4.5 Increase in the Probability of Survival from Birth to Age 100

We calculated the probabilities of survival from birth to age 80 and from age 80 to 100 from the Cohort Life Tables published by Bourbeau et al. (1997) for Canada and Quebec. Mortality during the nineteenth century in Canada and Quebec is poorly known, since the system for registering vital statistics did not begin until 1921 in Canada and 1926 in Quebec. It has been necessary to make up for the lack of data by indirect methods of estimating mortality. Through the “method of lag”, which is original at least in its application (Bourbeau and Légaré 1982), and the use of model life tables, it has been possible to reconstruct a badly known reality.

Between 1881 and 1911, the probability of survival from birth to age 80 for men rose from 0.16 to 0.24, an increase of 48%. For women, the improvement was even more striking, with the probability of surviving from 0 to 80 almost doubling in the same 30 year period from 0.21 to 0.41. The growth rate in the probability of surviving from age 80 to age 100 is notably higher than for the probability of surviving to age 80, doubling for men and multiplying by 6.7 for women over the space of 30 years.

12.4.6 Population at Age 100 and Over in 1981 and 2011

The number of centenarians in the years 1981 and 2011 were taken from the estimates produced by the CHMD on January 1st. These population estimates are based on the method of extinct generations. Numbers of survivors at the exact age of 100 were obtained by adding the population aged 100 in year x (total numbers on January 1st)[11] to the deaths taking place at 100 years of age in the lower Lexis triangle of the year x-1. As an example, the survivors aged 100 of the 1881 cohort are the numbers aged 100 on January 1st 1982 with the addition of the deaths of members of this generation taking place at age 100 in 1981.

Table 12.6 shows the respective contribution of each of the factors discussed above to the increase in the number of centenarians. The number of male centenarians has been multiplied by 3.08 and that of females by 9.38 between 1981 and 2011. For men, this increase is due to the increased size of the birth cohorts by a factor of 1.45, of the probability of surviving from birth to age 80 by a factor of 1.48, of the probability of surviving from age 80 to age 100 by a factor of 2.20, and to a small decrease in ratio of the number of centenarians to the number of persons aged 100 (0.89). A residual factor 0.73 corresponds to the net effect of migration and to possible errors in the components. For women, the corresponding growth coefficients are 1.47, 1.95, 6.68, and 1.08. The residual factor is more important in the case of women (0.45). The increase in the numbers of centenarians in Quebec is

Table 12.6 Breakdown of factors responsible for the rise in numbers of centenarians 1981 and 2011, Quebec

Factors	Men	Women	Total
Increase in the number of births between 1881 and 1911	1.45	1.47	1.46
Increase in survival from birth to age 80 in cohorts 1881 to 1911	1.48	1.95	1.75
Increase in survival from age 80 to age 100 in cohorts 1881 to 1911	**2.20**	**6.68**	**6.25**
Variation in the ratio of the number of centenarians (100 and over) to the numbers of persons aged 100 in 1981 and 2011	0.89	1.08	1.07
Net variation due to migration and to other factors	0.73	0.45	0.45
Increase in the number of centenarians between 1981 and 2011	3.08	9.38	7.60

Source: Canadian Human Mortality Databse (CHMD); Institut de la statistique du Québec; Cohort Life Tables for Quebec (Bourbeau et al. 1997)

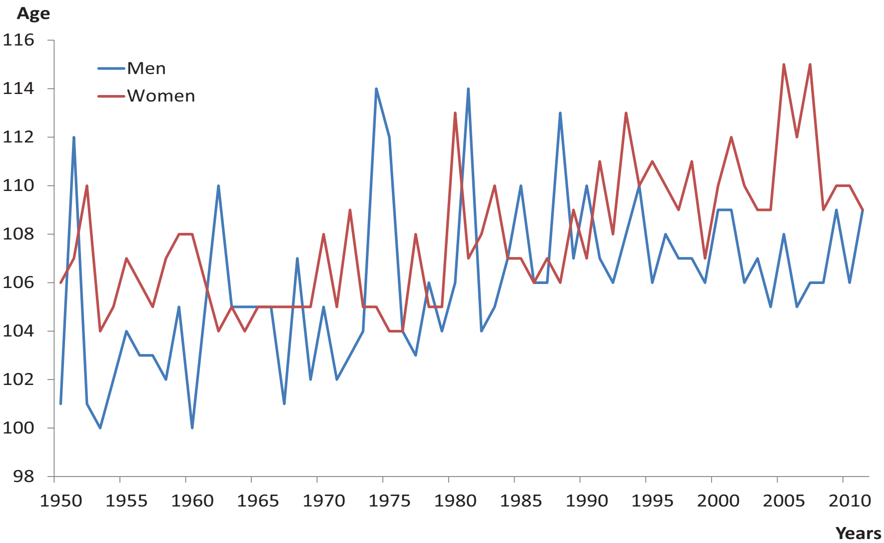
[11] These population estimates on January 1st published by the CHMD are based on the method of extinct generations.

therefore principally attributable to a higher probability of survival at advanced ages, and this applies both to women and to men.

So far, we have focused on indicators of population longevity. However, it is relevant to extend the analysis to the level of the individual, making use of the maximum age recorded at death, which also provides an insight into progress in survival to advanced ages.

12.4.7 Maximum Age at Death

In the case of Quebec, it is difficult to determine a rising trend in the maximum age at death because of significant annual fluctuations (Fig. 12.4). At the most these data enable us to identify supercentenarians, and at the same time to judge the quality of data at advanced ages. Mean highest four ages at death, calculated on the basis of the four highest recorded ages at death, is an indicator which is more representative of the evolution of maximum age at death in the course of the second half of the twentieth century (Fig. 12.5). In Quebec, the increase in mean highest four ages at death has been as great for men as for women. For women, the indicator has been above 106 since the 1980s; for men this level did not become established until the 2000s. Overall there is difference of 2 years between maximum age and mean highest four ages at death.



Source: Canadian Human Mortality Database (CHMD) and Institut de la statistique du Québec (unpublished data)

Fig. 12.4 Evolution of Maximum Age at Death, Quebec, 1950–2011

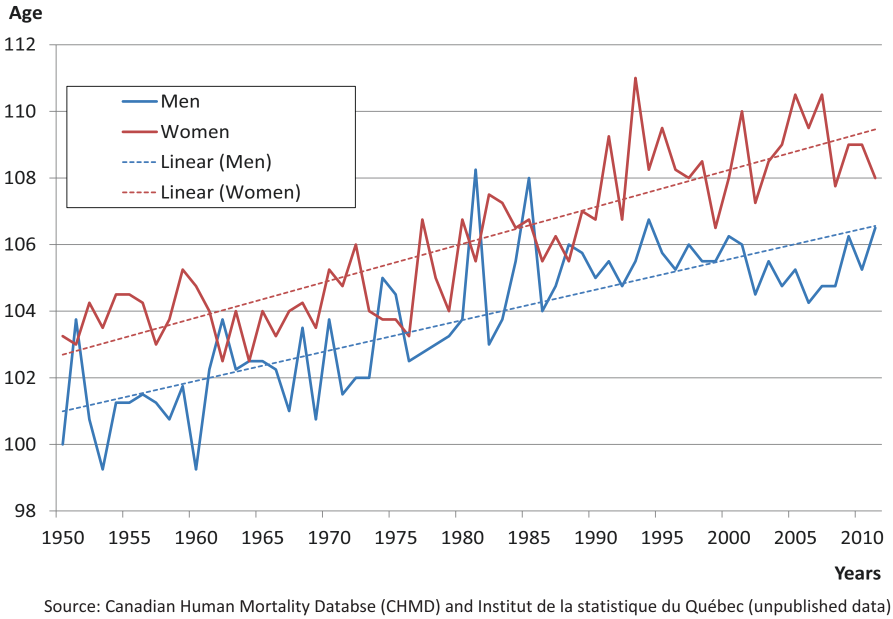


Fig. 12.5 Evolution of Mean Highest Four Ages at Death, Quebec, 1950–2011

The trends in and the values of maximum age at death recorded in Quebec since the 1950s are comparable to those observed in Japan (Wilmoth and Lundström 1996; Robine and Saito 2003) and in Switzerland (Robine and Paccaud 2004). Robine and Saito (2003) studied the evolution of the maximum age at death and of the 10th highest age at death, to eliminate the distortions caused by age misreporting. In the second half of the twentieth century, the tenth highest age at death rose from 100 to 107 for men and from 102 to 110 for women. The gap between maximum age at death and the tenth highest age at death was 3 years for men and 4 years for women. Instead of analysing the mean maximal age at death or the tenth highest age at death, Robine and Paccaud (2004) made a quadratic adjustment of the values associated with maximum age at death to identify clear trends. In these terms, the "adjusted" maximum age at death rose from 101 to 107 for men and from 103 to 109 for women between 1950 and 2011. In the same way as we observe in the case of Quebec, the maximum age at death in Japan and Switzerland also rose steadily throughout the second half of the twentieth century.

12.4.8 Projection of the Centenarian Population

According to the population projections of the Institut de la Statistique du Québec (2014), the growth of the population of centenarians which has been observed since the 1950s is set to continue through the first half of the twenty-first century (Fig.

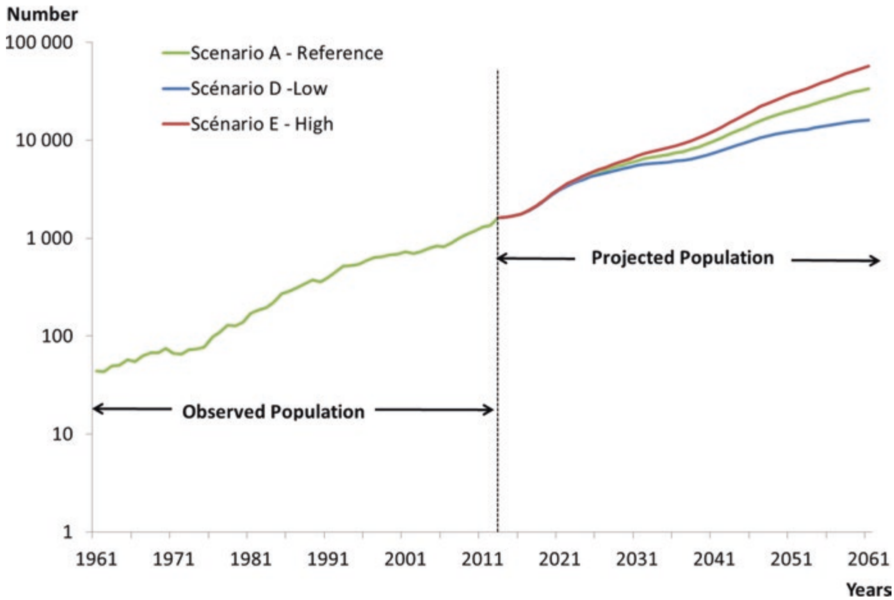


Fig. 12.6 Observed and projected centenarian population, three forecast scenarios, Quebec, 1961–2061. (Source: Canadian Human Mortality Database (CHMD) et Institut de la statistique du Québec, Perspectives démographiques du Québec et des régions. 2011-2061.)

12.6). The scale of this increase in numbers is however mainly attributable to future trends in mortality, because the centenarians of 2061 are those aged 50 and over in 2011. According to the baseline scenario, life expectancy for men will rise from 79.7 to 87.8, and for women from 83.8 to 90.1 by 2061. In the lower and higher scenarios, life expectancy for men in 2061 will be 83.9 and 91.0 respectively. For women, the equivalent values will be 86.7 and 92.6 years. Considering all the hypotheses relating to the baseline scenario, the population of centenarians will multiply by 26 by 2061, rising from 1292 to over 33,600 between 2011 and 2061. In the low and high scenarios, the number of centenarians will multiply by 12 and by 44 respectively. So, the centenarian population is predicted to increase very strongly in the first half of the twenty-first century in all the projection scenarios.

12.5 Conclusion

All the indicators analysed in this study concur in showing clearly a major increase in the numbers of centenarians during the twentieth century, and especially since the 1950s. The total numbers of centenarians, the centenarian ratio, the probabilities of surviving and the maximum age at death have all seen significant growth during this period. However, it is important to note the differences in the trends for the two sexes. While the numbers of women centenarians have increased constantly over the second half of the twentieth century, the numbers of men increased at first and then stabilised during the 1990s. The rising trend for men does however seem to have been re-established since 2000, according to the most recent figures available.

As a conclusion to our analysis we can state that the increase in the probabilities of survival at advanced ages, particularly between 80 and 100, has been the main determinant of the rising numbers of centenarians since the 1970s. In view of medical and technological advances in recent decades, this factor can be expected to continue to play a preponderant role in the future increase in numbers of individuals aged 100 or more.

The findings relating to the ratio of centenarians per 10,000 individuals aged 60 forty years earlier do not justify us in concluding that populations in North America enjoy a survival advantage. On the one hand, Japan has centenarian ratios which are markedly higher than those recorded for Canada and the USA. On the other hand, there is also room to question the quality of the data on advanced ages in these two countries. Our analysis may, at the most, support a suggestion that there is a survival advantage for the North American countries compared with European countries – an advantage which, in the light of recent trends, may be expected to diminish over the coming decades.

Projections of the centenarian population demonstrate the importance of engaging in research targeting those aged 100 and over. Given that this population will occupy an increasingly large place in our societies, it is becoming correspondingly more important to understand their socio-demographic characteristics and behaviours. The information we currently have about their health, marital status, economic situation, level of education etc. is fragmentary, but such knowledge is vital to be able to develop social and economic measures which are appropriate and effective in the context of an aging society.

The growth in the number of centenarians will also have an impact on the maximum reported ages at death. The more centenarians there are, the greater the probability of new records being established in terms of survival to extreme ages. It would not be a surprise if the 115-year lifespan of Julie Winnifred Bertrand was to be surpassed in the records of longevity in Quebec during the twenty-first century.

Appendix

Comparison of Population Numbers of Individuals Aged 90 and Over According to 3 Data Sources, Quebec, 1881 à 2011

	Males	Females				
Years	Census data	Statistics Canada estimates	CHMD estimates[1]	Census data	Statistics Canada estimates	CHMD estimates[1]
1881	467			517		
1891	562			617		
1901	502			594		
1911	540			674		

(continued)

	Males			Females		
Years	Census data	Statistics Canada estimates	CHMD estimates[1]	Census data	Statistics Canada estimates	CHMD estimates[1]
1921	565		461	699		704
1931	616		589	811		829
1941	704		767	1088		1148
1951	1041		1010	1614		1617
1956	1202		1131	1879		1927
1961	1371		1359	2209		2332
1966	1829		1823	2895		3007
1971	2375	2428	2158	4005	4091	3709
1976	3055	3163	2488	5665	5773	4863
1981	3255	3296	3150	7295	7417	7077
1986	3975	4017	3893	10,235	10,470	10,027
1991	5055	5155	4424	14,250	14,515	13,616
1996	5450	5587	5424	18,305	18,601	18,214
2001	6845	6325	6545	23,435	22,635	23,153
2006	9480	7598	8434	30,950	27,968	29,466
2011	12,055	11,744[a]	11,915	38,570	38,232[a]	38,381

[1]Estimates at July 1st based on extinct generations method and survival rates method
[a]Definitive post-census estimate

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Chapter 13
Semi-supercentenarians in the United States

Bert Kestenbaum

Supercentenarians – persons who attained age 110 – who last resided in the United States and were alive and age 110+ at some time during the 20-year period from 1980 to 1999 were the subject of a chapter in Part II ("country reports") of the Demographic Research Monograph entitled Supercentenarians (Maier et al. 2010). We write now a companion piece dealing with semi-supercentenarians – persons who did not attain age 110 but came close, namely men who attained age 105 and women who attained age 108 – who last resided in the United States and were born between 1870 and 1899.

While the term "semi-supercentenarian" is generally used in this volume to refer to persons of both sexes who attained age 105 but not 110, the ages 105 and 108 were chosen so that there might be approximately the same numbers of male semi-supercentenarians and female semi-supercentenarians.

In any country, the number of semi-supercentenarians (as defined for this chapter) will be much greater than the number of supercentenarians, by a factor probably more than 5. Since for the United States the validation of attainment of extreme age is labor-intensive, so that the examination of *all* semi-supercentenarian candidates is hardly feasible, we selected for examination a 10 percent sample of candidates, based on the 8th digit of the social security number – the nearly universal identifier in the United States. This allows for a random, representative selection.

As of this writing, the United States has contributed to the International Database on Longevity (IDL) 338 verified semi-supercentenarians who last resided in the United States and were born in the last three decades of the nineteenth century. We were also able to add 16 verified supercentenarians to the collection of U.S. supercentenarians already in the IDL files. The records used to authenticate the ages at

The views expressed here are those of the author, and no endorsement by the U.S. Social Security Administration should be inferred.

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death of all these cases will be included in the IDL document file to the extent possible. While with respect to supercentenarians the United States' contribution was larger than the total contributions of all other IDL countries, this is not the case for semi-supercentenarians, given that validation was undertaken only for a 1-in-10 sample and that for females attainment of age 108 was required.

Of course, the true number of semi-supercentenarians in scope of our investigation (born 1870–1899, resided in the U.S. at death) is more than 10 times the number that we validated, because surely some not validated candidates truly are semi-supercentenarians. Also, we undoubtedly failed to identify some candidates because of the conservative identification methods we used.

In this essay we discuss at length how U.S. semi-supercentenarians were identified. We also tabulate their characteristics, and compare the distributions of these characteristics between semi-supercentenarians and supercentenarians. The essay also includes a short discussion of the mortality experience of these extreme aged.

At the outset we wish to recognize the collaborative nature of the project and acknowledge the significant role played by the Program on Population, Policy, and Aging at Duke University under the leadership of Dr. James Vaupel. Earlier in the project we benefited from the collaboration of the Population Studies Center at the University of Pennsylvania under the leadership of Dr. Samuel Preston, as well as from assistance by Mr. Robert Young.

13.1 Casting the Net and Passing Muster

Except for countries with very accurate population registries, a systematic search for semi-supercentenarians proceeds through two stages. First a net is cast to "capture" possible semi-supercentenarians. Then the candidates' credentials are critically examined and only those passing inspection receive the stamp of authentication. The net should be wide and the examination rigorous.

In countries without population registries but with centralized death registration, typically the semi-supercentenarian net is cast to grab decedents with recorded ages on the death certificate of 105–109 for men and 108 or 109 for women. Personal information (name and parents' names, date and place of birth) needed in the next stage is collected from the certificate. However, this approach is not feasible in the United States, due to its non-centralized system for death registration.

In the United States the registration of vital events is generally performed by State government: there are registrars in each of the 50 States, and in Washington, DC and New York City, as well. It is true that each year the registration jurisdictions send copies of their files to a Federal agency – the National Center for Health Statistics (NCHS) – that merges the State files and makes a national public-use file available for research. However, the NCHS removes personal identifiers such as names and social security numbers in producing the public-use file, and a file lacking the personal identifiers needed to proceed to the validation stage of semi-supercentenarian identification is of no use to us. The National Center does maintain a publicly-available data system from which the personal identifiers have *not* been removed called the National Death Index (NDI), but this is a system designed to only determine persons' vital status or provide cause-of-death information for known decedents, rather than to produce a list of decedents according to some criteria. More on the National Death Index will come later.

Given these realities about death certificate files, we chose a different net, one that captures persons who at the time of their death in the target age ranges were enrolled in Part B of the Medicare program and resided in the United States. The Medicare program is a two-part Federal government health benefits program for persons ages 65 and over or disabled. Part A, providing hospitalization benefits, generally does not require premium payments from enrollees, in contrast to Part B, providing benefits for medical services, which is funded partly by premiums due from all program participants. The Medicare program is nearly universal: according to estimates from the U.S. Bureau of the Census, more than 96% of the population ages 70 and over participate in the program.

The Federal agency that administers the Medicare program is the Centers for Medicare and Medicaid Services (CMS) in the Department of Health and Human Services. However, the enrollment of most Medicare participants is performed by a different Federal agency, the Social Security Administration (SSA) – which explains why Medicare enrollment information is present on the SSA master file, the Master Beneficiary Record (MBR). The similar CMS master file, the Enrollment Data Base, receives enrollment information from the Master Beneficiary Record, and also receives a much smaller number of enrollment records from the Railroad Retirement Board (yet another Federal agency) for persons whose entitlement to Medicare derives from careers in the railroad industry. It was established some time ago (Kestenbaum 1992) with respect to the very old ages that (a) records of current enrollment in only Part A (for which premiums are generally not charged) and not Part B (which requires the participant to be up-to-date on his or her premium payments) are suspect, and that (b) the SSA master file is more accurate than the similar CMS master file.

Our net was cast to capture persons with records in the Master Beneficiary Record file as it stood in June 2011 that showed enrollment in Medicare Part B at the time of death in the target age ranges, a last address in the United States, and a date of birth in the period 1870–1899. Hence the omission of three small in-scope groups of semi-supercentenarians: those not enrolled in Medicare, those enrolled in Part A only, and those whose eligibility for Medicare derives from their career employment in jobs covered by the Railroad Retirement system (who will have a record in the CMS master file but not the SSA master file). Of course, in-scope semi-supercentenarians whose date of birth or date of death is recorded inaccurately on the MBR record may also be missed.

In fact, our net was cast to *also* capture persons who had attained age 110 according to the enrollment record, if they were not previously confirmed supercentenarians. This was done to capture semi-supercentenarians whose age at death was exaggerated on their enrollment record; in our earlier investigation of supercentenarians we had observed that several persons age 110 and above at death according to their enrollment record were actually younger, and so may be semi-supercentenarians.

We had access to several electronic administrative files that contained records – including dates of birth – for many of our candidates. Specifically, we had access to extracts from (1) the Social Security Administration's "NUMIDENT" file of applications and re-applications for a social security number or card; (2) the Social Security Administration's Supplemental Security Record of enrollments in the Supplemental Security Income (Federal welfare) program; (3) the Centers for Medicare and Medicated Services' master enrollment file, mentioned earlier; and (4) the Office of Personnel Management's annuitant file of former Federal government employees. Because it is so rare to achieve the threshold ages of semi-supercentenarianship, we chose to eliminate any candidate who had a date of birth on any of these files that implied that the candidate did not achieve the threshold age.

Corroboration of candidates' dates of birth and death requires the presence on the record of personal information such as the parents' names and the place of birth – which the Medicare enrollment record does not have. But the enrollment record does (almost always) have the social security number, and with the social security number in hand we proceeded to obtain the needed information from another Social Security Administration file, namely the file of applications and reapplications for a social security number or card. Although, in fact, many of the old completed applications were not available electronically, we obtained microfilm copies from the agency's offsite storage facility in Boyers, Pennsylvania and examined them manually.

Since Medicare records, unlike death certificate records, occasionally have incorrect dates of death (e.g., the recorded date may be the date of recordation rather than the date of occurrence), the date of death requires corroboration, as well as the date of birth. Accordingly, we worked together with the Program on Population, Policy, and Aging at Duke University to submit our list of candidates for a search in the aforementioned National Death Index maintained by the National Center for Health Statistics. The NDI consists of a catalog of all registered deaths in the United States since 1979 and a procedure for searching in that catalog – using either the social security number or sets of selected personal identifiers – and reporting the results of the search, including the extent of agreement between the submitted record and the matching records. A sample of output from the NDI search is shown in Appendix 13.2. A few of our candidates were deceased before 1979; for them it was not possible to corroborate the date of death with the NDI.

With respect to corroboration of the date of birth, clearly a certificate of birth is the ideal evidentiary record. Unfortunately, given the belated development of extensive U.S. birth registration, more often than not a certificate of birth either does not exist or cannot be found. A satisfactory alternative to the birth certificate for establishing date of birth is a record from an early census, when our semi-supercentenarians were very young. In the United States censuses are conducted decennially, in years ending in ‘0’, and are confidential for 72 years, after which they are available to the public.

The 1890 census records were destroyed by fire, and therefore our preferred censuses are the 1880 census and the 1900 census. We did, however, validate with the 1910 census and even the 1920 census, as long as the age at the time of the census was under 25. In actual fact, most of our validations were from the 1900 census. Not only was the 1900 census the earliest census available for most of our candidates, but the 1900 census collected not only age, but month and year of birth, as well, making our validations more precise.

The Church of Latter-Day Saints has embarked on an ambitious and arduous undertaking to computerize and index census records and develop software for searching the computerized, indexed files. This system of records and search software is publicly available on www.ancestry.com, for a modest subscription fee. To illustrate the search process, we show in Appendix 13.1 (a) a record that is input to the search, (b) the page from the census manuscript that is returned by the search, and (c) the summary page returned by the search which presents the census information in a standard, easy-to-read format.

While U.S. decennial census records are the centerpiece of this system, the collection includes some State censuses and some censuses conducted in countries other than the United States. Indeed, we validated 9 candidate semi-supercentenarians with early State census records (New York, Kansas, Minnesota, Wisconsin, Florida) and 11 with early non-U.S. census records (Canada, Ireland, England, Sweden).

After rejecting candidates who either (a) were not semi-supercentenarians according to a Social Security Administration record or an early census record or a National Death Index record, or (b) could not be found in the National Death Index, we were left with 565 candidates to search for in early census records. We were able to validate 338 of the candidates, or 60%.

Why wasn’t the validation rate higher? First of all, about half of the failures were for foreign-born persons. Some of these foreign-born persons immigrated after age 25, or attained age 25 before they were first enumerated in a census, or were first enumerated in the now-unavailable 1890 census and attained age 25 before the next census. Others may have immigrated without their parents, and are therefore difficult to locate in a census record. Second, the destruction by fire of the 1890 census records limited our options, particularly for persons born in the 1880s. Table 13.1 shows the results of the validation effort for 5-year birth cohorts.

Table 13.1 Validation results for 5-year birth cohorts of semi-supercentenarians (10% sample)

Year of birth	All cases	Validated
1870–1874	37	10
1875–1879	54	34
1880–1884	83	37
1885–1889	133	73
1890–1894	132	92
1895–1899	126	92
Total	565	338

13.2 Characteristics and Mortality of Semi-supercentenarians

The validated semi-supercentenarians are categorized by age at death and sex in Table 13.2. Age at death is the difference in completed years between the date of death on the death certificate, obtained from the NDI search, and the preferred date of birth. We preferred the latest among the dates of birth on the early census record and the set of SSA (and CMS) records – unless there was compelling evidence on the census record to discredit the date recorded on SSA records.

At combined ages 108 and 109, females outnumber males by 6.5 to 1. This appears to be roughly consistent with the approximately 9 to 1 sex ratio for validated supercentenarians that we had observed in earlier work.

The progression from one age to the next for males is not as smooth as we hoped for, which is not unexpected when dealing with small numbers of persons, but the overall pattern seems in line with our earlier finding for *supercentenarians* of an annual probability of death of 0.5 or slightly more. For females, the small number of deaths at age 109, relative to the number at age 108, suggests a probability of mortality of more than 0.5 at age 108, but again with a caveat about the sparseness of the data.

In a paper appearing in the *North American Actuarial Journal* (the journal of the U.S. Society of Actuaries) in 2002 on the subject of extreme-age mortality in the United States during the decade 1990–1999 (Kestenbaum and Ferguson 2002), we published "best" estimates of probabilities of death, q_x, unsmoothed, based on a subset of the Medicare Part B experience during the decade. Those estimates were:

Age	105	106	107	108	109
Men	0.470	0.451	0.479	0.535	0.545
Women	–	–	–	0.507	0.567

The pattern suggests that the probability of death is increasing over the 5 ages from something below 0.5 to something above 0.5.

Table 13.2 Validated semi-supercentenarians, by age at death and sex

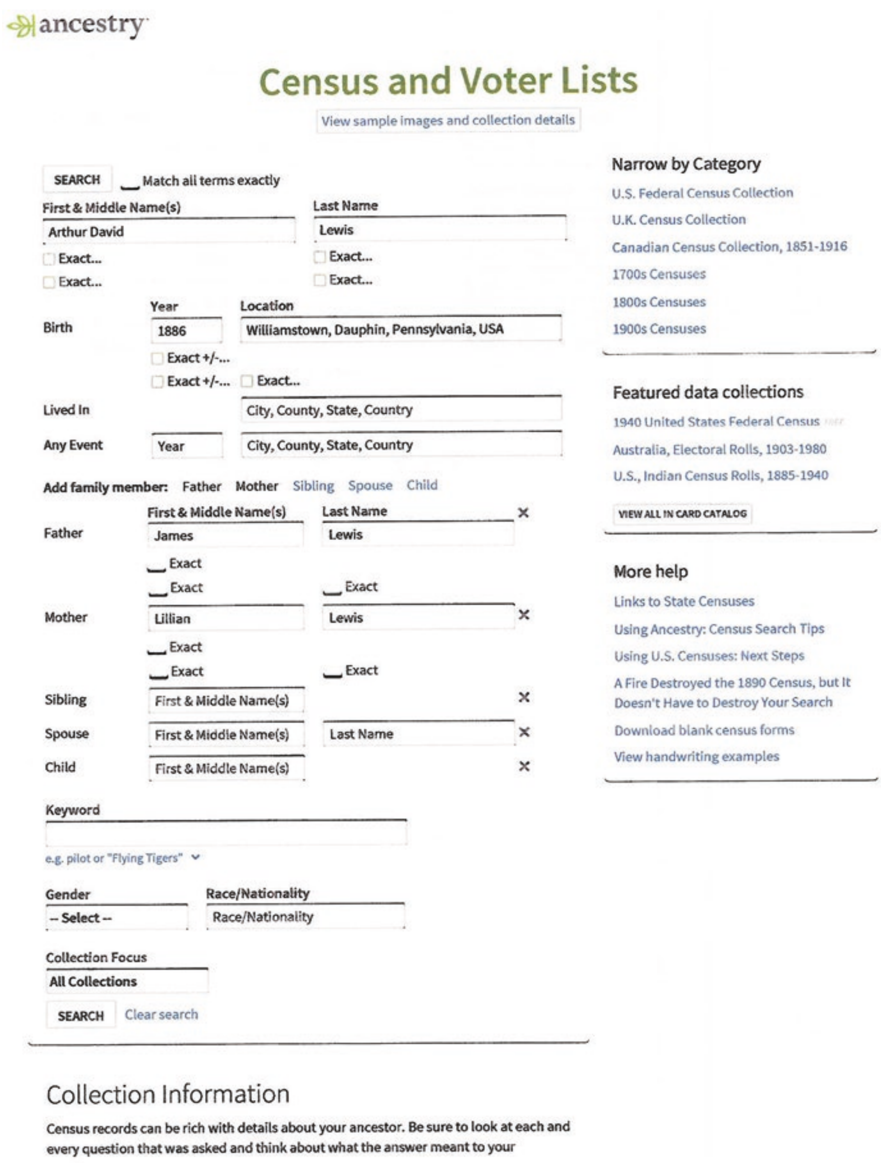
Age at death	Males	Females
105	81	–
106	32	–
107	29	–
108	17	124
109	9	46
Total, all ages	168	170
Total X 10	1680	1700

Only 18 of the confirmed semi-supercentenarians are foreign-born. The State in which were born the largest number of confirmed semi-supercentenarians is Pennsylvania, with 26, followed by Texas (20), and Ohio and Minnesota (16). Pennsylvania, Texas, and Ohio were also in the top five for confirmed supercentenarians; New York was first there.

Acknowledgement The assistance of Renee Ferguson is gratefully acknowledged.

Appendix

Appendix 13.1 Sample Ancestry.com Search



ancestry

Census and Voter Lists

View sample images and collection details

SEARCH Match all terms exactly

First & Middle Name(s): Arthur David
Exact...
Exact...

Last Name: Lewis
Exact...
Exact...

Birth — Year: 1886 — Location: Williamstown, Dauphin, Pennsylvania, USA
Exact +/-...
Exact +/-... Exact...

Lived In: City, County, State, Country

Any Event: Year — City, County, State, Country

Add family member: Father Mother Sibling Spouse Child

Father — First & Middle Name(s): James — Last Name: Lewis
Exact
Exact Exact

Mother — Lillian — Lewis
Exact
Exact Exact

Sibling — First & Middle Name(s)

Spouse — First & Middle Name(s) — Last Name

Child — First & Middle Name(s)

Keyword

e.g. pilot or "Flying Tigers"

Gender: -- Select --

Race/Nationality: Race/Nationality

Collection Focus: All Collections

SEARCH Clear search

Narrow by Category

U.S. Federal Census Collection
U.K. Census Collection
Canadian Census Collection, 1851-1916
1700s Censuses
1800s Censuses
1900s Censuses

Featured data collections

1940 United States Federal Census
Australia, Electoral Rolls, 1903-1980
U.S., Indian Census Rolls, 1885-1940

VIEW ALL IN CARD CATALOG

More help

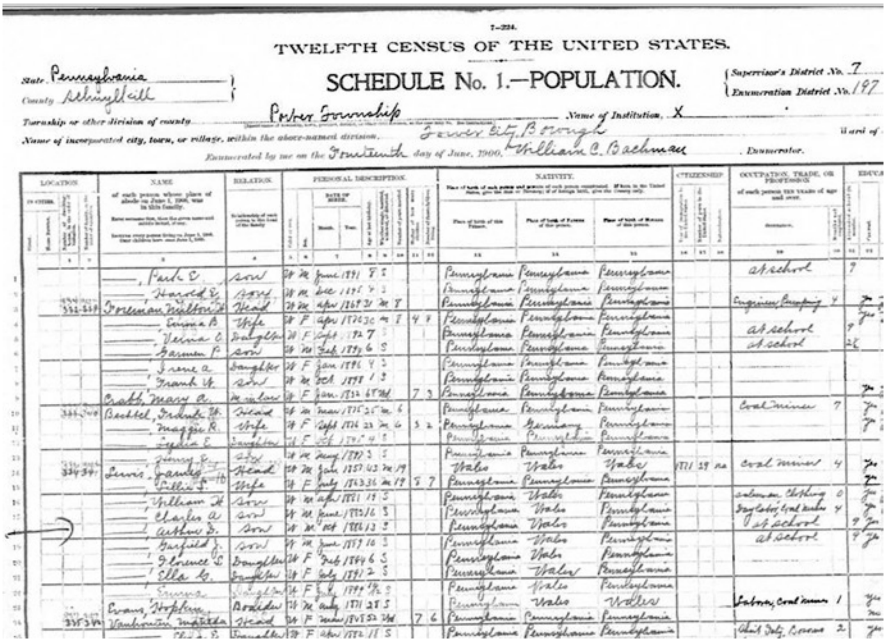
Links to State Censuses
Using Ancestry: Census Search Tips
Using U.S. Censuses: Next Steps
A Fire Destroyed the 1890 Census, but It Doesn't Have to Destroy Your Search
Download blank census forms
View handwriting examples

Collection Information

Census records can be rich with details about your ancestor. Be sure to look at each and every question that was asked and think about what the answer meant to your

http://search.ancestry.com/search/category.aspx?cat=35

Appendix 13.2 Sample Ancestry.com Search, Cont'd


7–224.

TWELFTH CENSUS OF THE UNITED STATES.

SCHEDULE No. 1.—POPULATION.

State Pennsylvania

County Schuylkill

Supervisor's District No. 7

Enumeration District No. 197

Township or other division of county Porter Township

Name of Institution X

Name of incorporated city, town, or village, within the above-named division, Tower City Borough

Enumerated by me on the Fourteenth day of June, 1900, William C. Bachman, Enumerator.

Appendix 13.3 Sample Ancestry.com Search, Cont'd

1900 United States Federal Census for Arthur D Lewis

Record Index

Surname: Lewis
Given Name: Arthur D
Relationship: Son
Race: White
Gender: Male
Age: 13
Marital Status: Single
Birthplace: Pennsylvania
Father's Birthplace: Wales
Mother's Birthplace: Pennsylvania
Residence: Porter, Schuylkill, Pennsylvania

Source Information

Record Url: http://search.ancestry.com/cgi-bin/sse.dll?indiv=1&db=1900usfedcen&h=42513073

Source Citation: Year: *1900;* Census Place: *Porter, Schuylkill, Pennsylvania;* Roll: *1485;* Page: *18A;* Enumeration District: *0197;* FHL microfilm: *1241485*

Source Information: *Ancestry.com. 1900 United States Federal Census [database on-line]. Provo, UT, USA: Ancestry.com Operations Inc, 2004.*
Original data: United States of America, Bureau of the Census. Twelfth Census of the United States, 1900. Washington, D.C.: National Archives and Records Administration, 1900. T623, 1854 rolls.

Appendix 13.4 Sample National Death Index Results

Mississippi	005999	02/24/1987	I	B	X	-	X	- - - - - - - - -	X	X	+13				X		-	0
California	201081	12/31/1985	I	B	N	-		- - - - - - X - X	X		-01		X	X	X		-	0
New York City	049216	09/10/1991	I	B	X	-		- - - - - - - X X	X	X	+19			X			-	0
California	161290	08/28/2012	X	-	N	-	N	- - - - - - - - -	X	X	+56		X	X			-	0
Maryland	032092	12/02/1982	I	B	X	-	X	?	X	X	+73						-	0
California	036569	02/18/1986	I	B	N	-		- - - - - - - - -	X		-01		X		X		-	0
California	059657	04/13/1982	X	-	X	-		X - - - - - - - -	X		-01		X				-	0
California	038272	02/21/1994	I	B	X	-	?	- X - - - - - - -	X	X	+26						-	0
South Carolina	013329	05/11/1998	I	B	X	-		X - - X - - - - -	X	X	+75						-	0

USER RECORD: (POSSIBLE MATCHES = 017) NDI Search No: 2001-K051#01 CONTROL NO: 179181884A USER DATA: 61992

POSSIBLE DECEDENT NAME	FATHER'S SURNAME	S S N	BIRTH DATE MO DAY YEAR	AGE	SEX	RACE	Marital Status	Res State	Birth State
ARTHUR LEWIS	-	1 7 9 1 8 1 8 8 4	10 / 06 / 1886	105	M	WH	-	PA	-

POSSIBLE NDI RECORD MATCHES (IN RANKED ORDER)

STATE OF DEATH	CERTIFICATE NUMBER	DATE OF DEATH	FN	MI	LN	FATHER'S SURNAME	LN/ FS	S S N	BIRTH MO	DATE DAY	+/- YEAR	AGE	SEX	RACE	Marital Status	Res State	Birth State	Status Code
*Pennsylvania	055428	06/24/1992	X	-	X	-	-	X X X X X X X X X	X	X	X	X	X	X	-	X	-	1
Texas	061681	03/21/2006	X	-	X	-	-	- - - - - - X - -	X	X	+28		X	X	-		-	0
North Carolina	040491	08/19/1998	X	-	X	-	-	- - - X - - - - -	X	X	+21		X	X	-		-	0
Louisiana	033533	11/23/1984	I	B	X	-	-	- - - X - X - - -	X	X	+19		X		-		-	0
California	053639	03/22/1998	I	B	X	-	-	- - - - - - - - -	X	X	+28			X	-		-	0
Texas	107876	10/16/1997	I	B	X	-	-	- - - - - - - - -	X	X	+22			X	-		-	0
Florida	031345	03/12/1983	I	B	X	-	-	- X X - - - - X -	X	X	+12			X	-		-	0
Texas	010981	02/09/1989	I	B	N	-	-	- - - - - - - X -	X	X	+45		X	X	-		-	0
New York	063627	09/15/1979	I	B	X	-	-	- - - X - - X - -	X		-01			X	-		-	0
Maryland	020735	07/05/1998	I	B	X	-	-	- - - - X - - - -	X	X	+49				-		-	0
Connecticut	029184	09/08/1995	I	B	X	-	-	- - - - - - - - -	X	X	+18				-		-	0
Ohio	096331	12/28/1980	I	B	X	-	-	- - X - - - - - -	X	X	+25				-		-	0
Michigan	025231	04/19/2008	I	B	N	-	-	- X - - - - - - -	X	X	+28			X	-		-	0
New Jersey	054499	09/26/1993	I	B	N	-	-	- - - - - - - X -	X	X	+28			X	-		-	0
California	042718	02/20/1988	X	-	N	-	-	- - - - X - - - -	X	X	+51				-		-	0
Texas	130728	10/27/2010	I	B	N	-	-	- - - - - X - - -	X	X	+48				-		-	0
Texas	037227	04/04/2006	I	B	N	-	-	- - - X - - - - -	X	X	+77				-		-	0

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Part V
Case studies of Exceptional Longevity

Chapter 14
The First Supercentenarians in History, and Recent 115 + −Year-Old Supercentenarians. An Introduction to the Following Chapters

Bernard Jeune and Michel Poulain

We established the Committee of Age Validation of Exceptional long-livers (CAVE) at our Supercentenarian Workshop in Tallinn in June 2016 with the aim of documenting the first supercentenarians in history[1]. Another aim of this committee was to validate the longest-living supercentenarians; i.e., those who have reached the age of 115 years or older. The following chapters are the result of this work, and are therefore extensions of the chapters on the age validation of long-livers in earlier books (Jeune and Vaupel 1995; Jeune and Vaupel 1999a, b; Maier et al. 2010).

Young (1905), Ernest (1938), and Bowerman (1939), who disproved almost all of the alleged supercentenarian cases from the 1700s and 1800s, believed that the Canadian Pierre Joubert, who allegedly died at the age of 113 in 1814, could have been the first supercentenarian in history (Jeune 1995; Desjardins 1999a, b). He was reported as such by the Guinness World Records. However, in the 1980s, the Canadian demographer Charbonneau (1990) systematically verified the list of Canadian centenarian cases from the 1800s onward, including that of Pierre Joubert. He found the death certificate of Joubert's wife in the 1786 parish register of a little village southeast of Montreal, where the couple resided. It specified that she was a widow when she died, which obviously was not in accordance with the claim that her husband survived to 1814. Going back in time in the same register, Charbonneau found Pierre Joubert's true death certificate from 1766, which indicated that he died

[1] The members of CAVE are: Bertrand Desjardins, Bernard Jeune (chairman), Michel Poulain, Jean-Marie Robine, Yasuhiko Saito and Robert Young.

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at the age of 67. The Pierre Joubert who died in 1814 was his son. This kind of mistake is not unusual, because in the past it was common practice to give a parent's name to a child, or to give the name of a child who died to a younger sibling (see Thoms 1873; Young 1905; Ernest 1938).

However, Bowerman (1939) – who, like Thoms (1873) before him, was very sceptical about early supercentenarian cases – claimed to be convinced by a few other cases from the 1800s apart from that of Pierre Joubert, including the cases of Thomas Peters (died on 26 March 1857 at the reported age of 111 years) and Geert Adriaans Boomgaard (died on 3 February 1899 at the reported age of 110).

We would have expected the first supercentenarian to be a woman. But according to Bowerman (1939), the first women who reached the age of 110 died in the beginning of the 1900s. They were: Margaret Ann Neve (died on 4 April 1903 at the reported age of 110), Louisa Kirwan Thiers (died on 17 February 1926 at the reported age of 111), and Delina Filkins (died on 4 December 1928 at the reported age of 113). Another probable candidate, whose age has been relatively well documented by Thatcher (1999), was an Irish woman, Kathrine Plunkhet, who died at the age of 111 on 14 October 1932 (born on 22 November 1820), i.e. having reached the age of 110 in 1930.

We now know that the exceptional age reached by Thomas Peters is impossible to validate simply because no birth certificate or other documents referring to his early life have been found. For the other cases, validation appears to be possible; especially for Boomgaard, Neve, and Filkins, for whom several documents were available. In the following chapters, we present the validation of the ages of these first supercentenarians in the history of mankind (see Chaps. 15, 16 and 17). The age validation of these individuals was possible because they all lived in the same place most of their lives. In these three cases, several documents were found that, when taken together, make it very plausible that they reached the very high ages claimed, and were among the very first supercentenarians in the history of the world. However, this does not exclude the possibility that others – including a woman who is not publicly known – reached the age of 110 before they did.

Delina Filkins was probably the first person to reach the age of 113 years (see Chap. 17). This record, set in 1928, seems to have held more than 50 years, until Augusta Holz became the first person known to have reached the age of 114 years in 1985, and then the age of 115 years in 1986 (see later). During the 1990s, several women and one man reached age 115 or older (see Maier et al. 2010). The man was the Danish-American Chris Mortensen, who in 1998 became the first validated man to reach the age of 115 years (the Japanese man Izumi, who was reported dead at the age of 120 years in 1986, and was once considered the longest-living individual in the world according to Guinness Record Book, turned out to have died at the age of 105 years).

Since 2000, no long-livers in the world have successfully challenged the three longest-living individuals, all of whom died in the late 1990s. The French woman, Jeanne Calment, who died at the age of 122 years in 1997, is still the person who has lived longest (Robine and Allard 1998; Robine 1999); the American woman, Sarah Knauss, who died at the age of 119 years in 1999, is still the person who has lived second-longest (Young 2010); and the Canadian woman, Marie-Louise

Meilleur, who died at the age of 117 years and 230 days in 1998, is still the person who has lived third-longest (Desjardins 1999a, b; Desjardins and Bourbeau 2010). Their cases have all been documented in our previous books (Jeune and Vaupel 1995; Jeune and Vaupel 1999a, b; Maier et al. 2010).

However, remarkably, five other women have reached the age of 117 years since 2015 (three of them in 2017): the Japanese woman Mikao Osawa, who was born on 5 March 1898 and died on 1 April 2015; the Italian woman Emma Morano, who was born on 29 November 1899 and died on 15 April 2017; Violet Brown from Jamaica, who was born on 10 March 1900 and died on 15 September 2017; the Japanese womn Nabi Tajima, who was born on 4 August 1900 and died on 21 April 2018, and a third Japanese woman Chiyo Miyako, who was born on 2 May 1901 and died on 22 July 2018. Thus, the lives of four of these women spanned three centuries. Regretfully, the cases of Violet Brown and Nabi Tajima have not yet been thoroughly validated. So far, their cases have been investigated by the Gerontological Research Group (GRG) that require only few criteria for age validation.

The case of Miako Osawa is reported and documented (see Chap. 21). As was noted in the chapter, the documentation process might have been taken further, but it seems very probable that she reached the age of 117 years. The authors reported that they had not been able to get in contact with Nabi Tajima, despite several attempts. However, the third Japanese woman included in the chapter is Chiyo Miyako, who is relatively well documented and very probably reached the age of 117 years.

The chapter by Gondo et al. starts with the life story of Jiroemon Kiruma, who was born on 19 April 1897 and passed away on 12 June 2013 at the age of 116 years. The age validation of his case is thoroughly documented in a paper by Gondo et al. (2017), which includes a family reconstitution and additional documents from his educational institutions and workplaces. It is now assumed that Kiruma is the longest-living man in the world after the Danish-American Chris Mortensen, who held this record for 15 years. Chris Mortensen was born on 16 August 1882 and died on 25 April 1998 (Wilmoth et al. 1996; Skytthe et al. 1999).

Another long-living man was the Holocaust survivor Israel Kristal, who was the oldest man in the world from January 2016 until he died on 11 August 2017 at the age of 113 years (almost 114 or maybe 114 years: he was probably born on 15 September 1903, but may have been born on 1 May 1903). As Kroczek and Young show, the age validation of this case has been extremely difficult, especially because Kristal was born near Lodz in Poland, which was part of the Russian Empire at that time, and was occupied by Germany during the two world wars (see Chap. 22). Therefore, his name and his parents' names, as well as the names of the villages where he was born, was married, and worked, were spelled differently in the different documents. Despite the lack of an original birth certificate, it seems very probable that Kristal had really reached the age of 113 when he died in Haifa in Israel.

The case of Emma Morano is reported and documented by Jeune and Poulain (see Chap. 18). The documentation for her case is exhaustive, including documents on the dates of birth, marriage, and death of her parents, of all of her siblings, and of her husband and son, which were collected from various archives in four municipalities in the Piemonte province in the North of Italy.

Ana Vela Rubio is a Spanish woman who reached the age of 116 in 2017. She was born on 29 October 1901 and died on 15 December 2017. As she migrated from Andalusia to Barcelona in the 1950s, the validation of her case was not easy. Despite facing difficulties, Romez-Redondo and Domènech succeeded in carrying out a thorough age validation. They describe this process along with Rubio's amazing life story (see Chap. 19).

Finally, Young and Kroczek present an extensive account of the age validation of 10 women from the US who reached the age of 115 or older (see Chap. 22). Among these cases is that of Augusta Holz, who seems to have been the first woman in the world to reach the age of 115. She should have been included in the previous chapter on US women aged 115+ (Young 2010), but no document proving her date of birth had been found when the chapter was published. According to her birth record, which was recently found in a little village in Poland (formerly part of Germany), Holz was born to German parents on 3 August 1871. The documentation of her emigration to the US at the age of 11 months was also recently found. As she died in the US on 21 October 1986, we now know that Holz reached the age of 115 before Jeanne Calment, who reached the age of 115 in 1990.

The other nine individual US cases are Edna Parker (115 years, 1893–2008), Gertrude Baines (115 years, 1894–2009), Besse Cooper (116 years, 1896–2012), Dina Manfredi (115 years, 1897–2012), Gertrude Weaver (116 years, 1898–2015), Jeralean Talley (115 years, 1899–2015), Susannah Mushatt Jones (116 years, 1899–2016), Bernice Madigan (115 years, 1899–2016), and Antonia Gerena Rivera from Puerto Rico (115 years, 1900–2015).

It should be emphasized that for some of these cases, there are lingering uncertainties about the exact dates of birth. It is therefore important that Young also presents an invalidation of the case of Lucy Hannah, who was presented as a validated 117-year-old in the previous chapter of our 2010 book, and was ranked as the fourth-longest-living person in the world (Young 2010). This is an interesting case that shows how a marriage record found later on can invalidate the information given in the 1880 census, in which a four-year-old "Lucy" was reported, despite further age data consistency in later censuses and documentation from the Social Security Administration. Lucy Hannah is now shown to have been born in 1895 instead of 1875 and to have died at the age of 97 instead of the age of 117.

The age criteria have been discussed in all our books on long-livers (Jeune 1995; Jeune and Vaupel 1999a, b; Poulain 2010). A certain degree of family reconstruction is necessary to avoid mistakes caused by, for example, namesakes between siblings. A younger sister was often given the name of an older sister who died as an infant or a child. Having information on the dates of birth of other siblings is, therefore, very important. It is also important to know the ages of the long-liver's children if the person in question has died in order to evaluate whether the spacing of the ages between, for example, a mother and her children, is plausible. The few age validation criteria used by the GRG represent a good start (early and mid-life evidence of the date of birth, and the death record) but they are not sufficient to allow us to conclude that the age at death of an individual case has been verified. In trying to assess the possibility of namesakes, age validation should include a certain degree of family reconstitution, such as the dates of marriage of the parents and the names and dates of birth of all of the siblings.

At the end, Young and Krozcek note that a growing number of individuals have reached ages 115+ since Augusta Holz first passed this threshold in 1986. They concluded that reaching the age of 115 or older "is becoming more common over time". It is certainly remarkable that four women reached the age of 117 years in the 2015–2017 period after 20 years with no validated cases of 117-year-olds.

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Chapter 15
Geert Adriaans Boomgaard, the First Supercentenarian in History?

Dany Chambre, Bernard Jeune, and Michel Poulain

15.1 Introduction

Documented cases of people reaching age 110 have existed at least since 1950, and the number of validated supercentenarians has increased substantially since 1970. It has been estimated that globally, there have been more than 1000 supercentenarians (Maier et al. 2010).[1] However, we still do not know when in history the first supercentenarian appeared, or even whether supercentenarians existed before 1950.

We would have expected the first supercentenarian to have been a woman. However, Margaret Ann NEVE, the first woman known to have reached 110 years of age, died on 4 April 1903 (see Chap. 16 in this book); whereas Geert Adriaans BOOMGAARD, a man, died a few years earlier on 3 February 1899. Here we present the validation of the age at death of Geert Adriaans BOOMGAARD at the reported age of 110.

[1] Maier, H., J. Gampe, B. Jeune, JM Robine, and J.W.Vaupel (Eds.) (2010) Supercentenarians. Springer Verlag, Heidelberg, Germany.

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15.2 Birth, Marriages, and Death Records

The first step in the age validation of a dead person is to check the consistency of the information included in the birth and death records. Figures 15.1 and 15.2 show the baptism and death records of Geert Adriaans BOOMGAARD (GAB). The baptism record of GAB is dated Tuesday, 23 September 1788. He is identified as the son of Adriaan JACOBS and Geesje GEERTS. The death record indicates that Geert Adriaans BOOMGAARD died on 3 March 1899 at age 110 years; was born and had been living in Groningen; was first widowed upon the death of Stjintje BUS and again upon the death of Grietje Abels JONKER; and was the son of Adriaan Jacobs BOOMGAARD and Geesje GEERTS.

When comparing the two records, we see that the reported age at death is consistent with the reported dates of baptism and death, and that the names given for his mother are similar. However, the family name of the father differs in the two records:

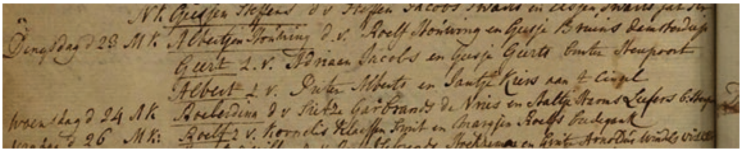
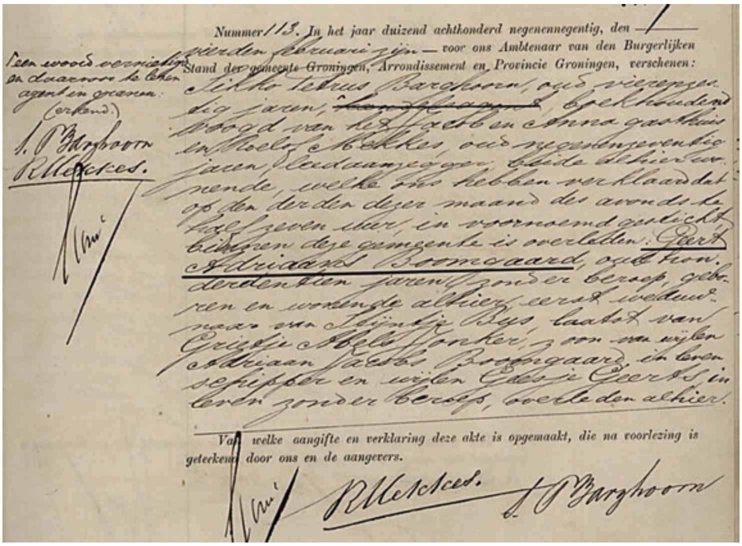


Fig. 15.1 Baptism record of Geert, son of Adriaan JACOBS and Geesje GEERTS on Tuesday, 23 September 1788 in Groningen (Parish register, Groninger Archieven)



Nummer 113. In het jaar duizend achthonderd negenennegentig, den vierden februari zijn — voor ons Ambtenaar van den Burgerlijken Stand der gemeente Groningen, Arrondissement en Provincie Groningen, verschenen:

Van welke aangifte en verklaring deze akte is opgemaakt, die na voorlezing is geteekend door ons en de aangevers.

Fig. 15.2 Death record of Geert Adriaans BOOMGAARD, who died in Groningen on 3 March 1899 (Civil death register, Groninger Archieven) it is listed as Adriaan JACOBS in the baptism record and as Adriaan Jacobs BOOMGAARD in the death record. Therefore, these two documents are clearly not sufficient for the validation of the age at death of GAB, as they do not unequivocally confirm that the two individuals mentioned in these records are the same person. To validate GAB's age, additional information is needed, such as documents on the marriage of his parents (Fig. 15.3) and on his own two marriages.

The marriage of GAB's parents took place in Sint Martin church in Groningen on 3 May 1785, and the names of his parents were Adriaan JACOBS and Geesje Geerts BONTEKOE (Fig. 15.3). Even if these names correspond with the names that appear in GAB's baptism and death records, the surname of his mother, BONTEKOE, is indicative of the large degree of variability of surname spellings at the end of the eighteenth century.

The marriage record of GAB's first marriage to Stijntje BUS on 4 March 1818 gives the following information: Geert Adriaans BOOMGAARD aged 29, son of Adriaan Jacobs BOOMGAARD and Geesje GEERTS (GAB's date of baptism is given as 23 September 1788). Stijntje BUS died on 24 March 1830 at age 33. GAB married his second wife, Grietje Abels JONKER, on 17 March 1831. In the marriage record, GAB is identified as follows: Geert Adriaans BOOMGAARD, 42 years old, son of Adriaan Jacobs BOOMGAARD and Geesje GEERTS. At that time, variation in the spelling of given names and surnames was common, as can be seen from the baptism records of all of the children of Adriaan Jacobs BOOMGAARD and Geesje Geerts BONTEKOE (see Table 15.1).

Adriaan JACOBS, the father of GAB, was identified with the surname BOOMGAARD in the baptism record of a son named Jacob in 1787, and with the surname BOOMGAART in the baptism record of a second named Jacob in 1793. Between these 2 years, we found also two documents in which the surname BOOMGAARD was mentioned:

- BOOMGAARD in the marriage record of the father's sister-in-law Geertje Geerts BONTEKOE (married to Jacob Thomas DE WAARD on 19 November 1791);
- A.J. BOEMGARD in the document stating that the father Adriaan JACOBS received the 'Schippers Gildepenning' in 1792.

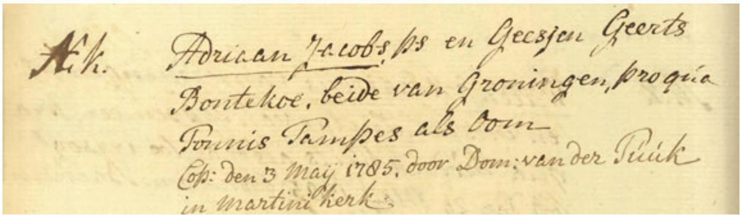

A.k. Adriaan Jacobs jzs en Geesjen Geerts
Bontekoe, beide van Groningen, proqua
Tonnis Tampes als Oom
Cop: den 3 May 1785, door Dom: van der Tuuk
in Martini kerk

Fig. 15.3 Marriage record of the parents of Geert Adriaans BOOMGAARD in Groningen on 3 May 1785 (Parish register, Groninger Archieven)

Table 15.1 The siblings of Geert Adriaans BOOMGAARD and the names of their parents

Jacob (n°1)	1787 Sept 12th	Ariaan Jacobs Boomgaard	Geesje Geerts	Infant?	
Geert	1788 Sept 23th	Adriaan Jacobs	Geesje Geerts	1899 Feb 3th	110 years
Grietje	1791 Feb 23th	Adriaan Jacobs	Geesje Geerts	Infant?	
Jacob (n°2)	1793 April 26th	Ariaan Jacobs Boomgaart	Geesje Geerts Bontekoe	Infant?	
Jacob (n°3)	1795 April 3th	Arriaan Jacobs	Geesijn Geerts	1828 June 20th	33 years
Tonnis	1797 August 29th	Aderjaan Jacobs	Geesje Geerts Bontekoe	Infant?	
Christoffer (n°1)	1800 Feb 9th	Adriaan Jacobs	Geezien Geerts	1806 Oct 27th	6 years
Annegien	1803 May 11th	Aarjaan Jakops	Geesien Bontekoe	1892 March 29th	88 years
Nicolaas	1805 Dec 29th	Adriaan Jacobs	Geessien Bontekoe	1806 Nov 20th	10 months
Christoffer (n°2)	1807 Oct 28th	Adriaan Jacobs	Geesjen Geerts Bontekoe	1894 Jan 24th	86 years

The use of surnames was not made mandatory until the beginning of the nineteenth century. Before this point in time, it was normal practice to use only the name of the father and to add an 's' at the end. Thus, since GAB's great-grandfather was named Nicolaas PETERS, his grandfather was named Jacob NICOLAAS, his father was named Adriaan JACOBS, and GAB himself was named Geert ADRIAANS. At that time, an additional surname was only occasionally given in a baptism or marriage record.

With the annexation of the Kingdom of Holland by the French Empire on 13 July 1810, a system of civil registration was introduced, and the requirement to provide a fixed surname on administrative documents was progressively imposed. In the register of surnames, *Register van naamsaanneming* (Groningen Archieven n°6429), the father of GAB, Adriaan JACOBS, declared on 6 June 1826 that he had taken the surname of BOOMGAARD for himself, his three sons, and his daughter: Geert ADRIAANS, aged 33; Jacob ADRIAANS, aged 28; Christoffer ADRIAANS, aged 18; and Annechien ADRIAANS, aged 22.[2] These were indeed the four children of Adriaan JACOBS, but the age of GAB was reported as 33 years, while it should have been 37 years. Such errors are often found in administrative documents when

[2] Den zesden January achttienhonded zesentwintig (06/01/1826), Adriaan JACOBS verklaarde dat hij aanneemt tot zijn geslachtnaam de naam van BOOMGAARD, dat hij heeft drie zonen en eene dochter, namelijk Geert ADRIAANS oud 33 jaren, Jacob ADRIAANS oud 28 jaren, Christoffer ADRIAANS oud 18 jaren en Annechien ADRIAANS oud 22 jaren. Registers van naamsaanneming, inventaris nummer 6429, Naamsaanneming in Groningen, 1811–1826, P.J.C. Elema, Index 286, Inventaris nummer S-3823.

an age is declared by another person. Moreover, the transcription process could have introduced such an error. By itself, this error does not call into question the year of birth of GAB. From this point onwards, GAB was systematically referred to by the name Geert Adriaans BOOMGAARD.

The examination of the sibship of GAB is an important part of the validation process. GAB was the second of 10 children. As can be seen in Table 15.1, the time intervals between the births of the 10 children were very short – the longest interval was 3 years and 3 months between the births of Christoffer and Annegien. In line with the usual practice at that time, the deaths of the younger children in GAB's family were not recorded in the parish register. However, the appearance in the register of two or three entries for the same name – as was the case for the names Jacob and Christoffer – indicates that the previous bearers of the name had died. It is possible that GAB's sibling Tonnis also had the given name of Geert, and died in 1899 at age 101. Tonnis is the only sibling in the family who could have plausibly been confused with GAB considering GAB's year of marriage in 1818. But since the name Tonnis Adriaans or Tonnis Adriaans BOOMGAARD did not appear after this point in time in any of the numerous documents we have examined, the chances that Tonnis was confused with Geert are very low.

The reconstitution of the family of GAB (Table 15.2) with his 12 children from two marriages supports the claim that GAB was born in 1788, as his age is mentioned systematically in each record of baptism of his children. These data on the births – and, in some cases, the deaths at young ages – of GAB's children have been extracted from the civil registers. As can be seen in Table 15.2, four of GAB's 12 children died before reaching 1 year of age, and a fifth child died before the age of two. Only Jansje Hinderika survived until the age of 50, and all of GAB's children had been dead for several years before he died in 1899. He was 96 years old when Jansje Hinderika died in 1885. However, GAB's father, Adriaan Jacobs Boomgaard, died in Groningen on 2 February 1844 at the age of 80 years and 10 months; and one

Table 15.2 The children of Geert Adriaans BOOMGAARD: the mother of the first eight was Stijntje BUS, and the mother of the last four was Grietje Abels JONKER. The age of GAB is mentioned in the third column

Geesje	1818 November 24th	30	1859 November 15th	40 years
Anna	1820 May 31th	31	1844 June 13th	24 years
Adriana	1821 September 26th	33	1838 January 1st	16 years
Hinderika Margareta	1823 November 28th	35	1825 October 14th	1 years
Teunis	1825 September 30th	37	1862 July 21th	46 years
Jansje	1827 March 15th	38	1827 June 9th	2 months
Jansje Hinderika	1828 August 10th	39	1885 May 24th	56 years
Jacoba	1830 February 19th	41	1830 March 7th	16 days
Anna Henderika	1831 November 25th	43	1832 March 9th	3 months
Abel Gerardus	1833 February 6th	44	(*)	?
Jacob	1834 May 7th	45	1879 February 22th	44 years
Geert	1837 March 12th	48	1838 August 23th	1 years

(*) Probably died in 1861 (his boat *Helena Jacoba* was on sale in Antwerp on 31 October 1861) of his uncles, Niklaas Jacobs Boomgaard, died in Groningen on 6 March 1845 at the age of 84 years and 11 months.

Based on the information we found in the relevant marriage and birth records, it appears that GAB's major life events were consistently recorded from 1818, the date of his first marriage, until 1837, the year of birth of his last child. However, these records do not contain information on two long periods of his life: from 1788 to 1818 and from 1837 to 1899. To cover these periods, we needed to find other types of documents. Of these documents, the most important came from the population register (bevolkings register).

15.3 Lists of Inhabitants, Censuses, and Population Registers

The French regime introduced population registers by ordering municipalities to establish lists of inhabitants by household, and to keep these lists updated by registering births and deaths, as well as immigration and emigration events. Such lists can be found in the archives. It appears, however, that the updating process was not efficient, as only a few signs that the lists were updated can be found in the documents. When the Netherlands recovered its independence after the Vienna Congress in 1815, the requirement that municipalities maintain lists of inhabitants was extended, but the lists drawn up in 1819, 1822, and 1825 were not updated continuously. Thus, these lists cannot be considered population registers or population censuses. More detailed lists were produced for all of the municipalities of the Netherlands (including Belgium) on 1 January 1830, but the first census that collected detailed data was not carried out until 1846. Population registers were not maintained on a continuous basis in the Netherlands until the 1850s onwards, but the first list of inhabitants for the city of Groningen that we found in the archives of the city in the Bevolkingsregisters (population registers) section is from 1822 (Groninger Archieven n°6537). In this list, the household of GAB was recorded as number 123, and consisted of five persons, including his wife and three daughters. The entry did not indicate the ages of the family members, and it was not updated to include the children who were born in the following years (Fig. 15.4).

The list of inhabitants of Groningen that was compiled in 1830 (Fig. 15.5) was more complete, as all members of the household were mentioned along with their ages and places of birth. The list contains mentions of GAB, aged 41; his wife, Stijntje BUS, aged 32; and their five children. This list had not been updated.

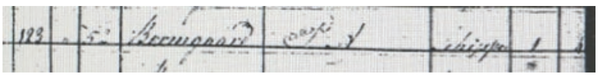


Fig. 15.4 Extract from the list of inhabitants of Groningen compiled in 1822 (Groninger Archieven n°6537)

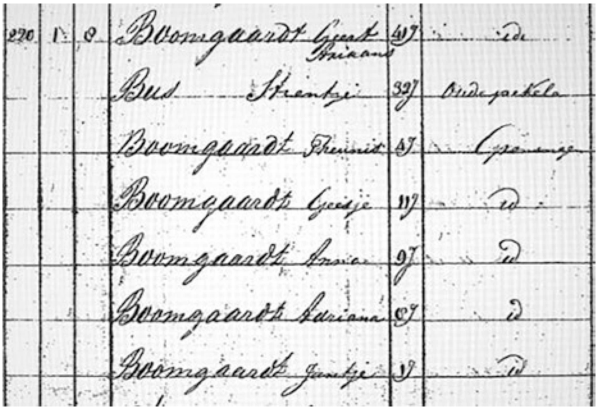


Fig. 15.5 Extract from the list of inhabitants of Groningen compiled in 1830

Fig. 15.6 Extract from the list of inhabitants of Groningen compiled in 1840

The information on the ages and the composition of the family in the following list dated 1840 is consistent with the information in previous lists (Fig. 15.6).

In 1850, the list of inhabitants became a population register. The composition of the household was updated in the register with the removal of mentions of Geesje (born in 1818) and of Teunis (born in 1825). These daughters left the household upon marriage; Geesje in 1850 and Teunis in 1855 (Fig. 15.7). GAB is mentioned as a scheepskapitein (boat's captain) and his son Teunis as a zeeman (seaman). Both men were probably at sea at the time the list was first compiled, and were added to the register when they returned.

In the population register of 1860, GAB, his wife, and two children are listed: Janske Hinderika (born in 1828) and Jacob (born in 1834). For the first time, the complete date of birth of GAB is mentioned. The date given, 21 September 1788, is consistent with GAB's date of baptism, 23 September 1788. This household was later deregistered, and GAB and his wife were transferred to the list of inhabitants

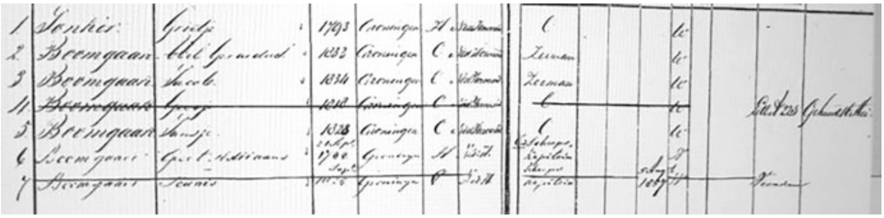


Fig. 15.7 Extract from the first population register of Groningen compiled in 1850

Fig. 15.8 Extracts from the population register of Groningen established in 1860: GAB and his wife were first registered as residents of a private household; were then deregistered (above), and were finally registered as residents of a convent (below)

of a convent (old people's home) in 1864. GAB's wife died on 18 May 1864 (Fig. 15.8).

In the population registers of 1870, 1880, and 1890 we found that GAB was still listed as a resident of the convent. In the last register, his name was removed and was replaced with his date of death, 3 February 1899 (Fig. 15.9).

We found the archives from the old people's home, the Jacob and Anna Gasthuis, where GAB and his wife were mentioned when they entered in 1864, and where GAB lived for 35 years until he died in 1899. The population register did not give the date of the change of residence, but an accounting book of the Jacob and Anna Gasthuis for the year 1864[3] mentioned the names of GAB and his wife among the 13 *conventualen* who resided there.

Given this confirmation that GAB was living in this nursing home from 1864 until his death, it would appear that GAB's life from the birth of his last child, Geert, in 1837 to his death in 1899 is well-documented in the archives. In light of the wealth of information we have about GAB's life, it is highly unlikely that the GAB

[3] This accounting book was published in 1865: W. Laman Trip, boekhouder, Groningen 1865, 31 p. folio, manuscript. It includes a list of 13 '*conventualen*' (elderly residents) who were between the ages of 61 and 88.

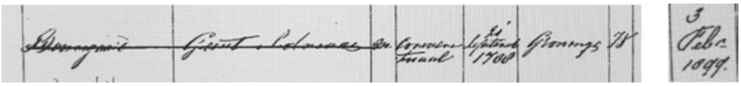


Fig. 15.9 Extracts from the population register of Groningen established in 1890. GAB's name was first listed, and was later removed and replaced with his date of death

who died in 1899 was his last son, Geert Boomgaard; especially as the son's death at age 1 year was reported in the civil register in 1838. This kind of mistake was made in the case of the famous Canadian Pierre Joubert, who was believed to have been the first supercentenarian for more than a century.

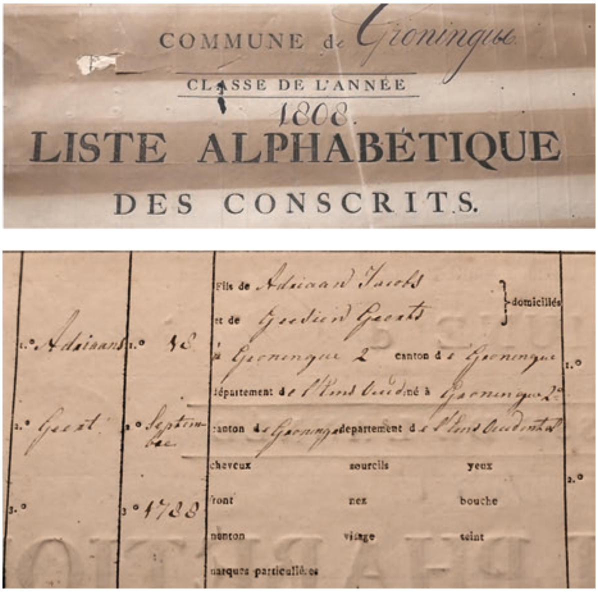
But can we be certain that the GAB who married Stijntje Bus in 1818 was the same GAB who was born in 1788? Before the marriage, he was registered as a seaman, and had previously had a military career. The records indicate that GAB had been conscripted into Napoleon's army and had fought in the French leader's campaigns – apparently against his will, as he subsequently said he considered Napoleon a tyrant. In the following sections, we describe the information we have about GAB's military career, and about his subsequent careers as a seaman and a marine captain.

15.4 The Military Career

GAB's military career started with his conscription in 1811. An Imperial Decree dated 3 February 1811 ordered the recruitment of 3000 conscripts from the class of 1808, which was made up of boys born in 1788.[4] For the department of *Ems-Occidental*, 288 conscripts were registered in a unique list within a conscript register. The list of conscripts is presented in alphabetical order, and GAB's name appears in the first position (Fig. 15.10). He is identified as ADRIAANS Geert, son of Adriaan JACOBS and Geesien GEERTS, born on 18 September 1788. GAB's profession is given as *pilote* (pilot), and his father's profession is given as *batelier* (boatman). GAB's place of residence is listed as uncertain, probably because he was at sea. The complete list of the 288 conscripts from the class of 1808 for the department of Ems-Occidental was also published in the local newspaper, the *Ommelander Courant*.[5]

[4] There was no conscription in the Kingdom of Holland in the years 1806–1810. As soon as the Kingdom of Holland was integrated into the French Empire in 1810, the classes of 1808, 1809, and 1810 were conscripted, starting with the 1808 class at the beginning of 1811. Thus, GAB was conscripted at age 23 (*Décret Impérial qui ordonne un appel de trois mille conscrits sur la classe de 1808, dans les sept départements de la Hollande*. Bulletin des Lois de l'Empire Français, Tome Quatorzième, juillet 1811, contenant les lois rendues pendant le premier semestre de l'année 1811, Bulletin des Lois N° 348, décret n. 6499 du 3 février 1811, pp. 117–119).

[5] « Ommelander Courant van Dingsdag den 16 April 1811 »: «NAAMLYST van de 288 CONSCRITS, welke, uit de Klasse van het jaar 1808, door het Departement van de Wester-Eems


COMMUNE de Groningue
CLASSE DE L'ANNÉE
1808.
LISTE ALPHABÉTIQUE
DES CONSCRITS.

Fils de Adriaan Jacobs
et de Geertien Geerts
domiciliés
canton de
département de
canton de
département de
cheveux sourcils yeux
front nez bouche
menton visage teint
marques particulières

Fig. 15.10 Conscript's register: alphabetical list of conscripts of Groningen for the class of 1808

According to various documents that describe Napoleon's campaign,[6] we know that GAB served in *the 33e régiment d'infanterie légère* (in short, *33e léger*), and that he left Groningen on 16 April 1811 for Givet in the French Ardennes, where this regiment was quartered. His role was that of a drummer. We do not know why he was assigned this job. Was he a drummer because he was deemed weak, short, or afraid to fight? We have found no answer to this question in the official documents or in the press articles about GAB. In January 1812, the 33e léger regiment became part of the Corps d'Observation de l'Elbe, which was under the command of Maréchal Davout (field marshal), and was headquartered in Stettin.

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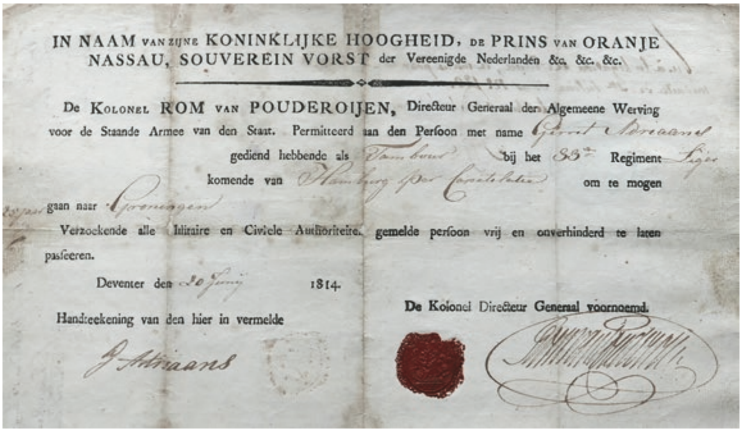
geleverd zyn, met aanwys van de NOMMERS, NAMEN, ARRONDISSEMENTEN, CANTONS, WOONPLATZEN, REMPLACANTEN en CORPSEN, by welke zy geplaatst zyn, als mede de namen van de Officieren en Onderofficieren by de Garde van den Heer Prefect, wordt op HEDEN uitgegeven, te Groningen by den OMMELANDER COURANT – DRUKKER. De prys is 2 stuivers»

[6] Archieven van het gemeentebestuur van Groningen, 1594–1815 (toegang 1605): inv. nr. 12,571. – liste alphabétique des conscrits, 1808 (staten bevattende gegevens over de dienstplichtigen van de gemeente Groningen. Met aantekeningen tot 1811). Op 11 April 1811 bij het 33e regt. Lichte inf. (jagers), 4e bat., 4e comp., 4e div. Van de Armée in Duitsland. F.H.A. SABRON, Geschiedenis van het 33e Regiment Lichte Infanterie onder Keizer Napoleon I., Breda, 1910


IN NAAM VAN ZIJNE KONINKLIJKE HOOGHEID, DE PRINS VAN ORANJE NASSAU, SOUVEREIN VORST der Vereenigde Nederlanden &c. &c. &c.

De Kolonel ROM van POUDEROIJEN, Directeur Generaal der Algemeene Werving voor de Staande Armee van den Staat. Permitteerd aan den Persoon met name Gerrit Adriaans gediend hebbende als Tambour bij het 33e Regiment Léger komende van Hamburg per Capitulatie om te mogen gaan naar Groningen

Verzoekende alle Militaire en Civiele Authoriteiten, gemelde persoon vrij en onverhinderd te laten passeeren.

Deventer den 30 Juny 1814.

Handteekening van den hier in vermelde

G. Adriaans

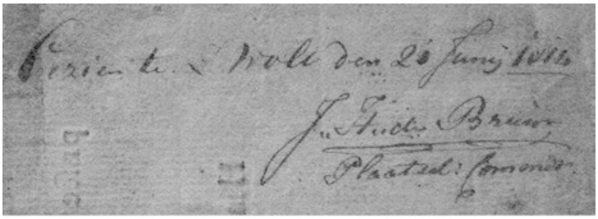
De Kolonel Directeur Generaal voornoemd.

Fig. 15.11 Laissez-passer given to Geert Adriaans BOOMGAARD (aged 25) that granted him permission to return to Groningen after Hamburg's capitulation in May 1814

Several documents explain that some of the soldiers in this regiment were objectors. It is possible that GAB was among these objectors, and that this was the reason why he did not participate in the Russian campaign. According to a press article about GAB,[7] "before the [regiment's] departure for Russia in 1812, he was spared by a temporary indisposition, and thus avoided the battles at Moscow and Beresina and the horrible Russian attack." ("*voor het optrekken naar Rusland in 1812 werd hij bewaard door een tijdelijke ongesteldheid, zoodat de Moskou- en de Berezina-allende en de vreeselijke aanvallen der Russen voor hem gespaard zijn gebleven …*"). It is important to note that at that time, the press was not allowed to mention soldiers who were objectors. It is possible that GAB was kept as an objector in a camp in Wesel until July 1813, when he was reintegrated into the *33^{e} léger,* which was moving on to Hamburg.

On 16 July 1813, Davout set up his headquarters in Ratzebourg to prepare for the resumption of hostilities. Davout and his army won the battle of Lauenbourg on 18 August 1813, and then returned to Hamburg on 4 December 1813, where they continued to defend the city until May 1814. The soldiers of the 33e léger were allowed to leave Hamburg on 31 May 1814. After participating in the battles of Lauenbourg and Ratzebourg, GAB was discharged and was given a laissez-passer to return to Groningen. The descendants of GAB have the original laissez-passer, which proves that GAB was demobilised in June 1814 and was allowed to return to Groningen through Deventer, Zwolle, Meppel, Dwingeloo, and Assen (Fig. 15.11). The translation of this document is as follows: "The Colonel ROM van POUDEROIJEN, Director General for the general recruitment of the land Army of the State, allows the person with the name Gerrit Adriaans, 25 years, who served as drummer in the Regiment 33e Léger, coming from Hamburg after capitulation, to travel to

[7] « *Nieuwsblad van het Noorden* », 8 November 1935: « *Geert Adriaan Boomgaerd 1788–1899* »



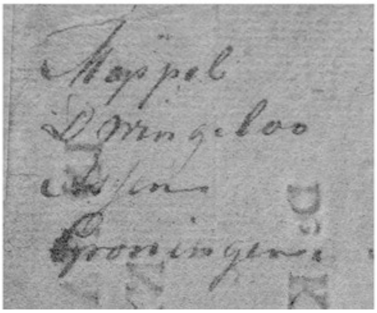


Fig. 15.12 Back page of the laissez-passer given to Geert Adriaans BOOMGAARD that granted him permission to return to Groningen

Groningen. Request to all military and civil authorities to let that person pass freely and openly. Deventer 20 June 1814" (with the signature of the person as well as the Colonel Director General and his seal).

The back page of this document includes some additional information on GAB's itinerary: he was in Zwolle on 21 June, and then travelled back to Groningen through Meppel, Dwingeloo, and Assen (Fig. 15.12).

15.5 The Saint Helena Medal

By a decree of 12 August 1857, Napoleon III created the Saint Helena Medal (Médaille de Sainte-Hélène) to commemorate Napoleon's campaigns from 1792 to 1815. For the purposes of awarding this medal, a list was compiled of all the men who took part in the military campaigns of the First Empire. All veterans of these campaigns were invited to be included in this list by providing documents proving that they had served in the French army, such as a certificate of honourable service or a proof of survival.

Using the laissez-passer mentioned above, GAB sent a request to be awarded the Saint Helena Medal to the Chancellery of the French Delegation in The Hague (Légation de France). This document confirms that he served in the French army. On the back of the document, there is a note stating that the request for the medal


MÉDAILLE DE SAINTE-HÉLÈNE

INSTITUÉE PAR S. M. NAPOLÉON III.

NAPOLÉON 1er

A ses Compagnons de gloire Sa dernière pensée!

Sainte-Hélène 5 Mai 1821.

Le Grand Chancelier de l'Ordre Impérial de la Légion d'Honneur certifie que

M. Adriaans, Gerrit, à Groningue (Pays-Bas).

ayant servi durant la période de 1792 à 1815, a reçu la Médaille de St. Hélène

Inscrit à la Grande Chancellerie No. 3171

Fig. 15.13 Diploma of the Saint Helena Medal awarded in 1857 to Geert Adriaans BOOMGAARD

was registered under N°120. The text, which is accompanied by the stamp of the French Legation in The Hague, reads as follows: 'Vu à la Légation de France, et inscrit pour la médaille de Ste Hélène sous n° 120. Le chancelier de la Légation. Signé Desvernois' (Checked at the Legation of France and registered for the St Helena Medal under the number 120. The chancellor of the Legation. Signed Desvernois).

The distribution of medals started in October 1857, and GAB was among the first to receive a medal: a total of 450,000 medals were awarded, and GAB's medal bore the number 3171. At an official ceremony that took place on 8 January 1858 in Groningen, three veterans were presented with their medals by the mayor.[8] GAB's medal was accompanied by a diploma (Fig. 15.13), The two items were kept first by Mr. Johan Christiaan Herman Winterwerp, a great-grandson of the supercentenarian who was living in Garmerwolde (Ten Boer). Currently, the items are kept by Mr. Winterwerp's son, Fokko Winterwerp, who gave us permission to take this photo. The name that appears on the diploma is Gerrit Adriaans from Groningen. Adriaans is the surname that was used at conscription, and Gerrit is the French version of Geert (Fig. 15.13).

[8] *Nieuwe Rotterdamsche Courant* 11 Januarij 1858: "Groningen, 8 Januarij. De Burgemeester dezer gemeente heeft heden aan 3 personen de St. Helena-medaille plegtig uitgereikt."

15.6 The Career as a Seaman and a Marine Captain

Adriaan JACOBS, GAB's father, was a seaman. In the edition of the Rotterdamsche Courant dated 27 May 1790, the following information appears: "After Bremen the tjalkschip De Jonge Geerten from Groningen with boatman Adriaan JACOBS left on 5 June." ("Na Bremen (binnen door) het tjalkschip De Jonge Geerten van Groningen, schipper Adriaan JACOBS, vertrekt den 5 Junij"). A new boat with the same name was registered on 22 February 1805, and was subsequently mentioned in 1812, 1814, and 1824. The fact that Adriaan JACOBS named his boat De Jonge Geerten (other spellings include De Jonge Geert and De Jonge Gerrit) is an additional indication of GAB's date of birth: it is likely that in 1791, Adriaan JACOBS wanted to show his pride in his three-year-old son, Geert.

GAB also became a seaman. After returning from serving in Napoleon's army, GAB started working on his father's boat in 1815. On 24 February 1818, GAB registered his own boat, a bijlanderschip named De vrouw Christina (Middelburgsche Courant of 30 June 1818). The name Christina is probably linked to Stijntje BUS, whom he married on 4 March 1818 (Stijntje = Christina). Between 1821 and 1836, this boat was registered as a smakschip named Christina. In 1836, he became captain of another boat, a kofschip named Margreta (Groninger Courant of 10 June 1836). That boat was also mentioned under the alternate spellings Margrieta (Rotterdamsche Courant of 30 June 1838) and Margrietha (Groninger Courant of 5 September 1853). The name of this second boat was probably linked to the name of his second wife, Grietje Abels JONKER (Grietje = Margreta).

The last trips of the Margrietha with GAB serving as the captain were as follows:

- 09/12/1852: departure from Ramsgate to Hamburg
- 22/04/1853: departure from Hamburg to Dublin
- 17/06/1853: departure from Liverpool to Nerva (i.e., Narva)
- 20/07/1853: departure from Nerva to Petersburg (i.e., St Petersburg)

GAB returned from Petersburg in August 1853. According to a news report from Calmar, Sweden, that appeared in a Groningen newspaper on 5 September 1853, the boat Margrietha helmed by Captain G.A. Boomgaard was stranded on the island of Öland on 3 September 1853 while sailing from Petersburg to Groningen. The report noted that the local people helped to save the boat and to rescue the freight (Groninger Courant of 20/09/1853). This was probably GAB's last trip (he was 65 years old). At this point, GAB's son Jacob took over as captain of the boat. The Groninger Courant of 6 January 1854 published a "List of Dutch boats which during the year 1853 had crashed, burned, been scrapped, demolished or lost: Margrietha, captain Boomgaard" ("Lijst van Nederlandsche schepen, welke in het jaar 1853 verongelukt, verbrand, afgekeurd, gesloopt of vermist zijn: Margrietha, kapit. Boomgaard"). In the January 1856 edition of the Staat der Nederlandsche Zeemagt en Koopvaardij-vloot, GAB is mentioned for the last time as a captain in reference to his activities in 1855.

As a seaman, GAB was involved in several professional associations. He was registered on 4 August 1825 in the *Zeemans-Collegie Tot Nut der Zeevaart* in

Rotterdam as member number 103. In the *Zeemans-Collegie Groninger Eendracht* of 1830, he was registered as member number 3. He was also mentioned as a *Directeur*[9] of the directorial college of this institution in 1850. In addition, he was listed in December 1852 as a *Directeur* of a new association called "the Society for mutual insurance of seamen against loss and stranding" ("*Maatschappij tot onderlinge verwaarborging van zeeschepen tegen verlies en stranding*").[10]

15.7 Press Articles and the End of His Life

Articles published in local or national newspapers may be of some help for the validation of the age of oldest olds. Obviously, the number of press reports about a long-lived individual increases as the person grows older. While most centenarians are mentioned in local newspapers, only extreme cases are mentioned in national and international newspapers or in scientific journals. The content of press articles may be helpful for discovering other types of documents beyond the traditional civil registration records. They also tend to provide a lot of qualitative information about the character, the lifestyle, and the life course of the centenarian. But because such articles tend to be based on subjective reports, the information they contain may be erroneous or misinterpreted, and should therefore be viewed with caution.

Some of the press articles on GAB focused on his participation in Napoleon's campaigns. In interviews, GAB explained that he served in Napoleon's army grudgingly (*met grooten tegenzin*),[11] and that he went by foot to Givet to join the 33e léger. Nevertheless, he spoke passionately *("met gloed"* or "*met voorliefde*")[12] about his adventures in the army – despite having described Napoleon as a tyrant,[13] He said he was very happy when the Oranje Prins returned to the Netherlands in 1813, and was pleased that had been able to return to his fatherland soon after the campaigns and continue his cherished work.

Other articles in the press, especially those about his marine career, provide some information about GAB's character and lifestyle: "He lives a very quiet life." ("*He leefde steeds kalm voor zich zelf heen*").[14] "The old man, who can easily take care of himself, lives in a very simple way. He goes to bed at 9 p.m. and gets up at 7 a.m." ("*De grijsaard, die ruim uit eigen middelen bestaan kan, leeft zeer zuinig. Hij*

9 *Berichten betrekkelijk het Zeewezen en de Zeevaartkunde verzameld en uitgegeven door Jhr.G.A. Tindal en Jacob Swart, Nieuwe Volgorde, Jaargang 1850*, Amsterdam, De Wed.G.Hulst van Keulen, 1850, **p. 23**.

10 *Bijdragen tot de kennis van den tegenwoordigen staat der provincie Groningen, uitgegeven door de commissie voor de statistieke beschrijving van der provincie Groningen*, Eerste deel, Groningen, De Erven C.M. van Bolhuis Hoitsema, 1860, p. 103.

11 « *Het Nieuws van de dag: Kleine Courant* », dated 26 September 1894

12 « *Rotterdamsch Nieuwsblad* », dated 21 September 1893: « *Een 105-jarige* »

13 « *De Gooi- en Eemlander* », dated 14 September 1895: « *Een kras oudje* »

14 « *Rotterdamsch Nieuwsblad* », dated 21 September 1893: « *Een 105-jarige* »

begeeft zich des avonds om 9 uur te bed en staat om 7 uur op …").[15] "The venerable man enjoys smoking several pipes of tobacco every day, yet he also likes to smoke a cigar from time to time, as he considers it a purgative" ("*De eerbiedwaardige man rookt met smaak heel veel pijpen tabak per dag, doch hij behoeft wel eens een sigaar, die het gebruikt als purgeermiddel*").[16] "His voice is free of trembling … he recently stopped drinking strong alcohol, and now drinks only a glass of wine now and then" ("*Hij spreekt zonder trilling van stem … In den laatsten tijd gebruikt hij geen sterken dranken: alleen neemt hij af en toe een glaasje wijn*").[17] "While the Methuselah of Groningen can no longer see, hear, or move, his wits and his stomach have not yet abandoned him" ("*Het verstand en de maag hebben den nestor nog niet in de steek gelaten, maar zien, hooren en gaan kan de Groningensche Methusalem niet meer*").[18]

A newspaper article with quotes from his last interview, which was given on 21 September 1898, the day he became supercentenarian, gave some information about his health decline: "As far as we can tell, his ability to walk, hear, see, and think has been declining in recent years, but he is still very cheerful. Nevertheless, during the last four weeks has he spent most of his time in his armchair or in his bed. And when he was not sleeping …" ("*Zooals men weet, waren zijn vermogens om te gaan, te hooren, te zien en ook om te denken in de laatste jaren zeer afgenomen. Toch was hij tot voor korten tijd wel opgewekt. Maar in de laatste vier weken slaapt hij verreweg het grootste gedeelte van den dag, in zijn armstoel of op bed. En als hij niet slaapt in zijn liefste bezigheid eten, wat hem dan ook nog den been houdt*").[19]

The images we have of GAB's final years are also worth examining (Figs. 15.14, 15.15, 15.16 and 15.17). In Fig. 15.14, GAB is pictured at age 100 together with his two surviving siblings, Annegien (aged 85) and Christoffer (aged 80). At this point, the last of GAB's children had passed away several years before. Figures 15.16 and 15.17 show GAB in the same position in his armchair at ages 107 and 110. The decline in his health is evident, especially during the last 3 years of his life. We can see that at age 107, he was using a cane, whereas at age 110, he was in a wheelchair. In the last photo (Fig. 15.17), he is wearing a stick, probably because he was not longer wearing his traditional wig.

[15] « *Rotterdamsch Nieuwsblad* », dated 21 September 1893: « *Een 105-jarige* »

[16] « *Rotterdamsch Nieuwsblad* », dated 21 September 1893: « *Een 105-jarige* »

[17] « *Het Nieuws van de dag: Kleine Courant* », dated 26 September 1894

[18] « *De Telegraaf* » dated 21 September 1897: « *De oudste Nederlander* »

[19] *« De Grondwet »* dated 11 October 1898

Fig. 15.14 and 15.15 G.A. Boomgaard at 100 years old, taken by J.G. Kramer. In the photo on the left, he is sitting in his flowered armchair with his two surviving siblings: his younger brother Christoffer (aged 80) and his younger sister Annegien (aged 85)

Fig. 15.16 and 15.17 The photo on the left was taken at GAB's 107th birthday. The photo on the right shown of G.A. Boomgaard at 110 years. Both photos were taken by W.B. Bekkering. Both photos are preserved at the Groninger Archieven

15.8 Discussion

Fortunately, we were able to find a long list of documents covering almost all periods of GAB's life that allowed us to validate reports that GAB reached the exceptional age of 110 years. In the first step of the validation process, the baptism and death records of GAB were compared, and were found to provide consistent information. However, the surnames of GAB and of his parents listed in the two records differed somewhat. GAB was baptised as Geert ADRIAANS, and died as Geert Adriaans BOOMGAARD. GAB's parents were listed as Adriaan JACOBS and Geesje GEERTS in the baptism record, and as Adriaan Jacobs BOOMGAARD and Geesje GEERTS in the death record.

We found that these surname changes occurred because new rules for civil registration were introduced during the French regime. In line with these rules, another surname had to be added to the traditional surname, which was the name of the father with an additional 's'. We found the document from 1829 for the registration of surnames, *Register van naamsaanneming* (Groninger Archieven n°6429) in which GAB's father, Adriaan JACOBS, declared that he was taking the surname of BOOMGAARD for himself, his three sons, and his daughter. The surname BOOMGAARD had already appeared in the baptism records of several of GAB's siblings at the end of the eighteenth century.

The reconstitution of GAB's family and the dates of birth of all of his siblings also support the validity of GAB's reported age. He was the second-born in a family of 10 children. Only six of these children lived longer than one year, and the dates of death of the four other children are unknown. This is not considered problematic as infant deaths were not recorded in parish registers before the new civil registration was introduced. However, the name Jacob was given to a child in the family three times, and the name Christoffer was given to a child in the family two times. This pattern indicates the death of the preceding child. The name Geert was not given to any other sibling. The birth intervals in the family were narrow and regular, which suggests that there are no missing children. It therefore seems impossible that a younger brother of GAB who had been given the name Geert was the person who died in 1899.

The kinship records of GAB's eight children with his first wife Stijntje BUS and four additional children with his second wife Grietje Abels JONKER contain no signs that call the validation of his age into question. He married at age 29, remarried at 41, and had children between ages 30 and 47. Amazingly, none of GAB's children reached age 60, and his 12 children died long before he did. His youngest child was given his father's name of Geert. This child was reported to have died at the age of one. However, even the child's date of death was not accurately reported, a father-son mistake seems absolutely impossible given the wealth of information we have found on GAB's life course.

The above-mentioned demographic information covered the period between 1818 (the year of GAB's first marriage) and 1837 (the year of birth of his last child). To complete the age validation process, information about GAB's life during the

Fig. 15.18 Grave of GAB in the Groningen Zuiderbegraafplaats

period before 1818 and during the period from 1837 until his death in 1899 was needed. The lists of inhabitants and the population registers stored in the *Groninger Archieven* played an essential role in this part of the process, as they allowed us to follow the successive places of residence and the demographic events of GAB and his family from 1822 to 1899. We found that all of this information supported the claim that GAB's year of birth was 1788. A birth date of 18 September was given at GAB's conscription in 1811. However, a birth date of 21 September 1788 was mentioned for the first time in the 1860 population register. This date of birth is more plausible given that GAB was baptised on 23 September. In fact, *Groningen Zuiderbegraafplaats* reported that the birth date of 21 September appeared on GAB's gravestone (Fig. 15.18).

We found numerous documents covering the period from 1837 to 1899 that referred to GAB's career as a seaman, the marriages of his children, and his entry into a nursing home. When GAB reached age 100, numerous articles about his life, which included interviews and photos, appeared in the press. All of these press mentions support the validity of GAB's reported year of birth and age at death.

For the period before GAB's first marriage, we found only one document that mentioned him. In 1791, GAB's father named his new boat *De Jonge Geert* – a name that appears to have been chosen to honour his three-year-old son Geert (the next child, Grietje, was born on 23 February 1791). However, we have no information about GAB's school education or his apprenticeship as a seaman. Thus, there is no documentation on GAB's life course prior to age 20.

Later, on 22 February 1810, Geert ADRIAANS and his father Adriaan JACOBS were registered as members of the Reformed Church.[20] They were listed as living together at *Harderinge Brug*. It is important to note that in order to be registered as a member of the Reformed Church, the individual must have reached the age of majority. As the civil majority age was fixed at 21 years by the *Code Civil des Français*, the registration provides further confirmation that GAB had reached age 21 year at that point in time.

In 1811, GAB was among the 288 conscripts of the class 1808, which was made up of boys who had been born in 1788 and were living in the French department of Ems-Occidental. He participated in Napoleon's campaigns as a *tambour* (drummer) up to the end of May 1814. He became a seaman like his father in 1815. In 1818, around the time of his marriage to Stijntje BUS, he got his own boat.

An article published on 9 August 1927 in the *Nieuwe Rotterdamsche Courant* looked in detail at the age validation of GAB. The author of the article pointed out two problems with the process: that GAB's surname changed (from Adriaans to Boomgaard), and that his father reported his age as 33 when he registered the surname of BOOMGAARD in 1826. This may have been an error in the oral declaration or in the transcription. The article concluded that despite these problems, "no more doubt is possible" ("*geen twijfel meer mogelijk*") about GAB's age.

Nevertheless, two outstanding questions remain: Is the conscript GA registered in 1811 the same person as the soldier who came back from Hamburg in June 1814? Is the soldier who came back from Hamburg in June 1814 the same person as the GAB who died in Groningen on 3 February 1899?

Regarding the first question, we believe that the conscription list and most of the other information collected by the Ministry of the Army during the Napoleonic occupation are valid. We also think that it is highly improbable that the soldier GAB who returned from Napoleon's campaigns in June 1814 was not the GAB who left Groningen 3 years before to join Napoleon's army. This person could not have been a younger brother, as we have shown above; and another soldier who took GAB's identity in the army would have been recognised as an imposter when, for example, he joined GAB's father to work as a seaman, or when he witnessed the signing of the marriage certificate of a younger brother a few years after he returned.

Regarding the second question, we found positive evidence by comparing the signatures of Geert Adriaans on the *laissez-passer* of 1814 and several signatures of GAB found in the documents between 1818 and 1863 (Figs. 15.19, 15.20, and

[20] W.G. Doornbos, P.C.J. Elema en D.F. Kuiken, *Lidmaten van de Hervormde Gemeente Groningen, 1800–1840*, Indexnummer 135, Studiezaal, Groninger Archieven.

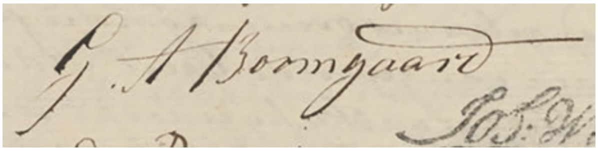


Fig. 15.19 Signature of Geert Adriaans on his marriage record on 4 March 1818

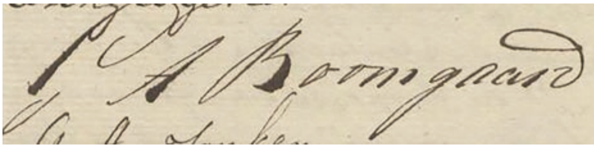


Fig. 15.20 Signature of Geert Adriaans on his second marriage record on 17 March 1831

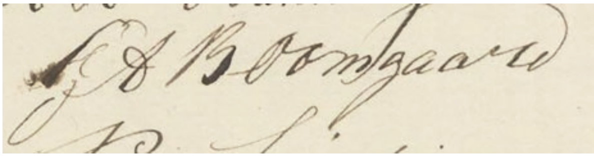


Fig. 15.21 Signature of Geert Adriaans on the marriage record of his daughter Jansje Henderika on 2 May 1860

15.21). Given how the capital letters G and A are formed, we think the same person wrote these signatures. We therefore believe that the soldier who came back from Hamburg in 1814 and the man who died on 3 February 1899 was the same person. We can thus state that Geert Adriaans Boomgaard was born on 21 September 1788 and died on 3 February 1899 at the exceptional age of 110 years, 4 months, and 13 days. He may have been the first supercentenarian in history – although it is also possible that some as yet unknown man or woman was actually the first person to reach the age of 110.

Acknowledgements We acknowledge Albert Beuse at the Groninger Archieven for helping us to find and to take copies of several documents. We thank Fokko Winterwerp for copies of some important documents and for allowing us to take a photo of "la médaille de Saint Hélène".

Chapter 16
Margaret Ann Harvey Neve – 110 Years Old in 1903. The First Documented Female Supercentenarian

Michel Poulain, Dany Chambre, and Bernard Jeune

Margaret Ann Harvey was born on 18 May 1792 on Pollet Street in the centre of St Peter Port in Guernsey, and was baptised 10 days later in the nearby Town Church, according to a record in French in the parish register, which is conserved in the Priaulx Library (Fig. 16.1): Marguerite Anne, daughter of Sire Jean Harvey and Elizabeth Guille, his wife, born on 18 May 1792 and baptised on the 28th of the same month; her 'Parrain' was Sire Nicolas Le Patourel and her 'Marraine' were Elizabeth Guilmotte and Marie Elizabeth Guille.

The island of Guernsey is the second-largest of the Channel Islands after Jersey, and is situated about 50 km from Normandy in France. Today, Guernsey is a dependency of the British Crown without being strictly part of the United Kingdom or a member of the European Union.

The parents of Margaret Ann were John Harvey and Elizabeth Guille. Her father was born on 3 July 1771 and died on 4 December 1820 at the age of 49, whereas her mother was born on 10 November 1771 and died on 1 May 1870 at the exceptional age of 98. Both of her parents spent their whole lives in Guernsey, and were married in the Town Church of St Peter Port on 21 December 1790 (Fig. 16.2).

Margaret Ann was the first of eight children born between 1792 and 1806 (Table 16.1). We found the dates of birth and death of all of her siblings, and the contents of all of their baptism and death records have been carefully checked. All

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H. Maier et al. (eds.), *Exceptional Lifespans*, Demographic Research Monographs, https://doi.org/10.1007/978-3-030-49970-9_16

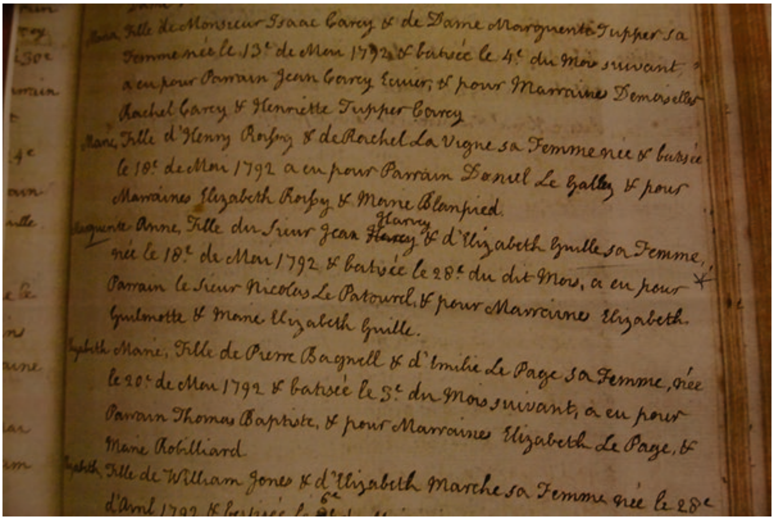

Fille de Monsieur Isaac Carey & de Dame Marguerite Tupper sa Femme née le 13e de Mai 1792 & batisée le 4e du Mois suivant a eu pour Parrain Jean Carey Ecuier, & pour Marraine Demoiselle Rachel Carey & Henriette Tupper Carey.
Marie, Fille d'Henry Rossy & de Rachel La Vigne sa Femme née & batisée le 10e de Mai 1792 a eu pour Parrain Daniel Le Gallez & pour Marraine Elizabeth Rossy & Marie Blampied.
Marguerite Anne, Fille du Sieur Jean Harvey & d'Elizabeth Guille sa Femme, née le 18e de Mai 1792 & batisée le 28e du dit Mois, a eu pour Parrain le Sieur Nicolas Le Patourel, & pour Marraine Elizabeth Guilmotte & Marie Elizabeth Guille.
Elizabeth Marie, Fille de Pierre Bagnell & d'Emilie Le Page sa Femme, née le 20e de Mai 1792 & batisée le 3e du Mois suivant, a eu pour Parrain Thomas Baptiste, & pour Marraine Elizabeth Le Page, & Marie Robilliard.
Elizabeth Fille de William Jones & d'Elizabeth Marche sa Femme née le 28e d'Avril 1792 & batisée le 6e

Fig. 16.1 The baptism record of Marguerite Anne HARVEY born on18 May 1792 in St Peter Port (Priaulx Library)

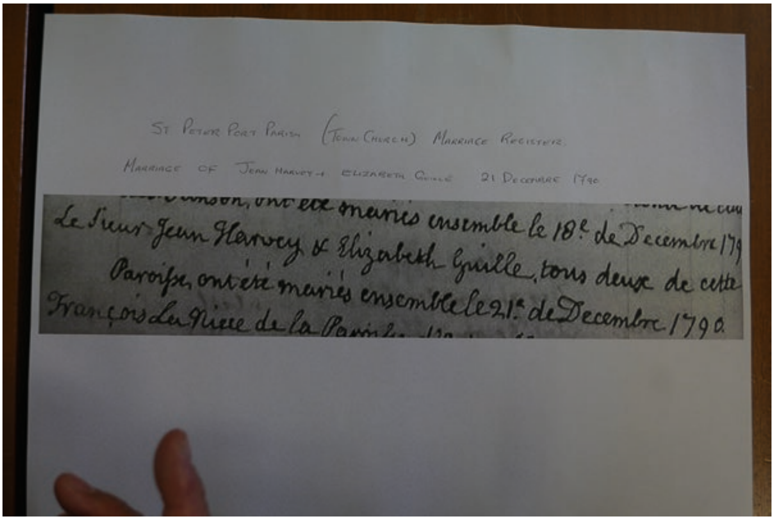

St Peter Port Parish (Town Church) Marriage Register
Marriage of Jean Harvey + Elizabeth Guille 21 Decembre 1790
Le Sieur Jean Harvey & Elizabeth Guille, tous deux de cette Paroisse, ont été mariés ensemble le 21e de Decembre 1790.

Fig. 16.2 The marriage record of John HARVEY and Elizabeth GUILLE in St Peter Port on 21 December 1790 (Priaulx Library)

of her siblings were born and died in St Peter Port, except Thomas, who emigrated first to Jersey and thereafter to Oregon in the US, where he died in Portland. Only two of Margaret Ann's sisters died before 5 years of age: Augusta, who was born on 6 November 1797 and died at the age of three; and Marie, who was born on 24 February 1799 and died as an infant. The following child, Augusta Marie, who was

Table 16.1 Siblings of Margaret Ann Harvey with dates of birth and death and ages at death (based on parish registers kept in Priaulx Library)

Name	Date of birth	Date of death	Age at death
Margaret Ann	18 May 1792	4 April 1903	110
John	30 August 1793	6 September 1865	72
Elisabeth	19 February 1796	28 August 1884	88
Augusta	6 November 1797	11 September 1801	3
Marie	24 February 1799	6 November 1799	< 1
Augusta Maria	14 November 1801	16 April 1887	85
Thomas	11 May 1803	10 April 1873	69
Louisa	19 August 1806	4 December 1821	15

born on 14 November 1801, was named after both girls. She died at the age of 85. Another sister, Elisabeth, who was born on 19 February 1796, reached age 88 (Table 16.1).

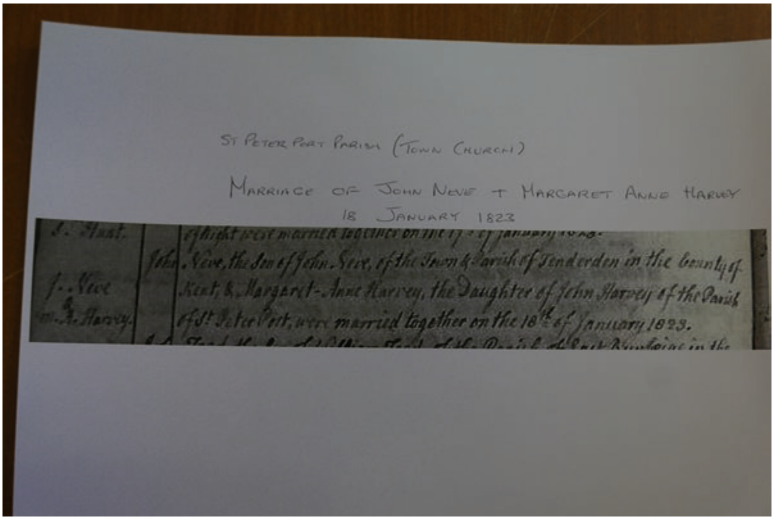
During her childhood, Margaret Ann Harvey lived on Pollet Street, and went to the primary school in St Peter Port, which she left at the age of 14. In 1807, she moved with her family to Bristol, where she continued her secondary school education in a renowned school directed by Miss Cottle. There she met well-known poets from this period, such as Hazlettem, Lamb, and Macaulay, who came to Bristol to visit Miss Cottle's parents, both of whom were poets.

In 1815, just after the battle of Waterloo, she went to Brussels for further education, and especially to learn languages. She visited the battlefield of Waterloo and collected either a metal epaulette or a felt buckle; the written accounts of the visit differ on that point. Back in Bristol, she met General Dumouriez, who took part in the French Revolution, and was famous for his participation in the battles of Jemappes and Valmy. He later deserted the army and fled to the UK. In London, she also met Field Marshal Blücher, the head of the Prussian army at Waterloo. We have found no written account of the reasons for these meetings, but her oldest brother was a colonel, and some of her ancestors were officers. It also appears that she was very interested in history.

Margaret Ann married John Neve on 18 January 1823, when she was 30 years old (Fig. 16.3). Her husband had been baptised on 5 January 1779 at High Halden, Ashford Borough, Kent, England. His first wife was Ann Tanner, who died on 16 March 1816, also at High Halden.

The Priaulx Library collection in St Peter Port includes many travel journals, such as Mrs. Neve's honeymoon diaries. These diaries describe the places she visited, including the battlefield of Waterloo, which she visited for the second time 8 years after the battle.

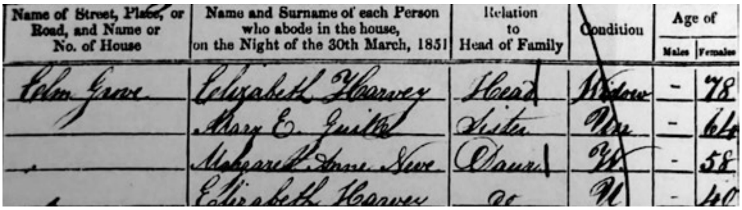
She lived with her husband for 25 years in Tenderden in Kent. They had no children, but John had two daughters from his first marriage. John Neve died on 30 June 1849 at the age of 70, and was buried at St Mary, the Virgin Churchyard, High Halden, Ashford Borough, Kent, England. After his death, she moved back to Guernsey to live in Rouge Huis, St Peter Port. According to the 1851 census, she


St Peter Port Parish (Town Church)

Marriage of John Neve + Margaret Anne Harvey
18 January 1823

J. Neve & M. A. Harvey. John Neve, the Son of John Neve, of the Town & Parish of Tenderden in the County of Kent, & Margaret-Anne Harvey, the Daughter of John Harvey of the Parish of St Peter Port, were married together on the 18th of January 1823.

Fig. 16.3 The marriage record of John NEVE of the parish of Tenderden in the county of Kent and Margaret Ann HARVEY of the parish of St Peter Port on 18 January 1823 in Town Church (Priaulx Library)



Name of Street, Place, or Road, and Name or No. of House	Name and Surname of each Person who abode in the house, on the Night of the 30th March, 1851	Relation to Head of Family	Condition	Age of Males	Age of Females
Colm Grove	Elizabeth Harvey	Head	Widow	-	78
	Mary E. Guille	Sister	Unm	-	64
	Margaret Anne Neve	Daur	W	-	58
	Elizabeth Harvey	do	U	-	40

Fig. 16.4 Margaret Ann NEVEN born HARVEY, enumerated in the 1851 census with her mother Elizabeth HARVEY, aunt Mary Elizabeth GUILLE, and sister Elizabeth HARVEY

was living there on 31 March 1851 with her mother, Elisabeth Harvey, born Guille (1771–1870); her aunt, Marie Elisabeth Guille (1784–1871); and her sister, Elisabeth Harvey (1796–1884) (Fig. 16.4). Margaret's age was correctly reported in the census, but there were slight inaccuracies in the reported ages of her mother and of her aunt. There was a larger error in the reported age of her sister, who was listed as 40 years old, even though she was effectively age 55. The same degree of underestimation also occurred in the 1861 census for both her aunt and her sister, whereas the ages of Margaret and her mother were accurately reported.

As we can see from the first photo taken around 1860, the family living in Rouge Huis was quite wealthy (Fig. 16.5). We understand from letters written by Margaret Ann to her mother when travelling abroad that their income came from investments in bonds and shares in various railways, mines, and other companies. In their

Fig. 16.5 A unique photo of the family of Margaret Ann living in Rouge Huis about 1860. From left to right: Mrs. Elisabeth Harvey (born Guille in 1771, the mother of Margaret Ann, died on 1 May 1870 at the age of 98), Miss Harvey Elisabeth (born in 1796, sister of Margaret Ann, died on 28 August 1884 at the age of 88), Miss Guille Mary Elisabeth (born in 1784, the sister of Margaret Ann's mother, died on 17 December 1871 at the age of 87), and Mrs. Margaret Ann Neve (born Harvey in 1792)

transactions of these bonds and shares, they were advised and supervised by her brother, John. While John was living with his wife and seven children in nearby St Peter Port, because he was a colonel, he spent most of his time in London. In each of Margaret Ann's letters to John during this period, her concerns and questions about these bonds and shares make up almost half of the content, with the remainder being about the education of John's seven children, which Margaret Ann and her sister were involved in. In these letters, she reports on the progress of each child in history, languages, and other disciplines.

In addition to being interested and engaged in the education of her brother's children, Margaret Ann read a great deal, especially historical books and literature. Among her favourite authors were Milton and Dante. She could read Dante in the original Italian language. She spoke French and Italian fluently. She could also read books in German and Spanish, and the New Testament in Greek.

In her daily life, needlework and gardening were important activities. She walked to the local church every Thursday and Sunday even after reaching the age of 100. Besides these daily activities, she very much liked to travel in European countries. As a young woman, she had lived in Belgium and Spain for several months. She often took the ferry to France, where she visited Paris and other places in France, and then frequently travelled from there to Italy. She also travelled farther afield, to Poland, Russia, and the Nordic countries. Her last trip abroad was to Poland in 1882, when she was 90 years old. She often travelled with her sister Elisabeth, and wrote letters to her family while she and her sister were travelling in Europe. She

Fig. 16.6 Margaret Ann Neve, born Harvey, photographed 2 months after her 110th birthday (Island Archives)

wrote numerous letters to her mother and to her brother, John, in particular. She also maintained a diary every year from 1817 to 1893.

After the death of her mother (in 1870, at 98 years old) and her aunt (in 1871, at 87 years old), she lived alone with her sister for a period of time. Both were enumerated in the 1881 census.

After the death of her younger sister on 28 August 1884, she continued to live in Rouge Huis with other relatives. The 1901 census showed that Margaret Ann, aged 108, was living with two single nieces, the daughters of her brother John, aged 58 and 57.

Numerous articles appeared in the local press about her birthday celebrations at 100, 103, 104, 106, 107, 108, and 110 years; and we found several photos of and press releases about these celebrations in the Island Archives in St Peter Port and in Priaulx Library (Fig. 16.6). At her 100th birthday, she received congratulations from Queen Victoria.

Prior to her death, Margaret Ann had never been seriously ill, although she had the flu at the age of 105, and bronchitis at the age of 108. She could still walk in the garden at the age of 108, and she could still read large type without glasses. She was slightly deaf and slept a lot at this age. She died on 4 April 1903 at the exceptional age of 110 years and 322 days. Her death record, which is kept by the register in the Greffe of the Royal Court, confirms her parent's name and her age, and notes that she died of "décadence naturelle". She was buried in the Brothers' cemetery close to Rouge Huis. On the occasion of her burial, the flags in Guernsey were flown at half-mast.

16.1 Discussion

It is our view that Margaret Ann Harvey Neve's exceptional age has been thoroughly validated by the documentation mentioned above. Thus, to our knowledge, Mrs. Neve is the first documented female supercentenarian. Considering the data collected on her parents and siblings, there is no possibility of an erroneous linkage, as her name appears only once in the birth records, her family's birth intervals were narrow, and the dates of death of all of her siblings have been checked. As she married but had no children, we found no mention of her name in the civil registration records between her marriage and her death in 1903. This lack of records might have made it difficult to prove that the person who died at age 110 in 1903 was the same person who married in 1823 at age 30. Fortunately, she was enumerated in six successive censuses from 1851 to 1901, and a comparison of the ages reported in these censuses and her exact ages shows only minor deviations (Table 16.2). Moreover, numerous letters and her voluminous diaries help us to follow her life during that long period. Upon reaching age 100, she became famous in Guernsey. Thus, there are many photos of her and press articles about her life. We therefore have no doubt about the validity of this exceptional case.

Table 16.2 Comparison of the age of Margaret Ann and other family members, as enumerated in successive censuses from 1851 to 1901

	Margaret Ann Neve Harvey		Elizabeth Harvey Guille (mother)		Mary Elizabeth Guille (aunt)		Elizabeth Harvey (sister)	
Date of birth	18.5.1792		10.11.1771		25.6.1784		19.2.1796	
Date of death	4.4.1903 at 110		1.5.1870 at 98		17.12.1871 at 87		28.8.1884 at 88	
	Age reported at census	Exact age	Age reported at census	Exact age	Age reported at census	Exact age	Age reported at census	Exact age
30 March 1851	58	58	78	79	64	66	40	55
7 April 1861	65	68	89	89	70	76	56	65
2 April 1871	78	78			86	86	73	75
3 April 1881	88	88					85	85
5 April 1891	98	98						
31 March 1901	108	108						

Acknowledgements We greatly thank the following for helping us to find and to take copies of the documents in the different archives:

- Miss Sue LAKER, Deputy Chief Librarian and Dinah BOTT, Communications Assistant, both at the Priaulx Library
- Nathan Coyde, Archives Manager, Island Archives, States of Guernsey
- Steve Payne, Head Clerk to the Strongroom, The Greffe, States of Guernsey

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Harvey/Neve Letters 1845–1902, from the collection at The Priaulx Library Guernsey. (13)
Harvey Diaries headed Neve, 1817–1893 (some years missing) at The Island Archives, States of Guernsey. (14)

[1] This chapter is based on the documents we found in the archives in the Priaulx Library, the Island Archives of the States of Guernsey, and in the Greffe of the Royal Court, all in St Peter Port; as well as on our review of numerous articles in the press (1–11), an article in The Quarterly Review of the Guernsey Society (12), a transcription of the Harvey/Neve letters 1845–1902 stored at The Priaulx Library Guernsey (13) and the Harvey Diaries headed Neve, 1817–1893 (some years missing) at The Island Archives, States of Guernsey (14).

Chapter 17
113 in 1928? Validation of Delina Filkins as the First "Second-Century Teenager"

Robert Douglas Young

17.1 Introduction

This chapter investigates the early American claim of Delina Filkins (see Fig. 17.1) to be 113 years old in 1928 (Star-Gazette 1928a). This case is particularly important as a milestone on the map of the documented human lifespan. Filkins's case, if accepted as validated, marks the first person in demographic history to have attained the ages of 111, 112, and 113. Her age mark of 113 years, 214 days would not be surpassed until 1980. Given the importance of such a case, it is necessary to review the evidence that may establish whether or not this case is validated according to the modern scientific standards set for age validation. While this case has been previously accepted by some authorities, until now a scientific layout of the case investigation has not been published in a book or major scientific journal. This book chapter intends to fill that void, examining the Delina Filkins case utilizing documentary evidence old and new.

Delina Filkins' life history is fairly mundane, until very late in life. Most of her life was spent on the family farm, and later with relatives in extreme old age. Delina remembered being taken to the opening of the Erie Canal (1825) by her dad at age 10 (Lincoln Star 1928). She attended school until age 11 (Herkimer Web, online) before starting work at home, which was to spin flax into yarn. Having attended local dance balls as a teen, Delina met her husband at one, and she married John Filkins in February 1834, age 18 (see Document B, which includes the marriage entry). Thereafter, Delina was a homemaker and raised six children (a seventh apparently died in infancy). Delina was known for her hard work and self-reliant philosophy. When asked what her secret to long life was, her answers parallel those given by many self-directed individuals: "quiet living and working hard, with no excitement" (Ithaca Journal 1924) and "work, not worry" (Ithaca Journal 1925). A

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Fig. 17.1 Delina Filkins (source: http://www.grg.org/images/DFilkins101.png) accessed Nov. 24, 2017

woman of habit, Delina got up every day at 5:30 A.M. (Press and Sun-Bulletin 1926) and went to bed every day at 7 pm (Democrat and Chronicle 1927). Delina refused to be confined to bed even in extreme old age, still getting up at age 112. Delina walked with a cane (Press and Sun Bulletin 1927) and read the newspaper and Bible with glasses. Only in her last year was she confined mostly to a day chair.

Delina was in good health well past age 100, able to walk, carry a conversation, and read. She was known for her tough personality and self-sufficiency. Even at 111, Delina still got up out of bed and made her own breakfast (St. Louis Post-Dispatch 1926). She survived two operations at age 107 and 110[1] (Press and Bulletin 1926; Star-Gazette 1928a, b) remarkably well and rode in an automobile for her 112th birthday (Democrat and Chronicle 1927). While Delina was a woman of her time, she changed with the times, notably updating her wardrobe even past age 105 (St. Louis Post-Dispatch 1926). Delina began to attract local notice for her age when she turned 100, and national coverage at age 109 and above. Even famed aviator Charles Lindbergh wrote her a letter (Star-Gazette 1928a, b). When Delina passed away in December 1928 at age 113 years and 7 months, her death was widely reported, even on the AP wire (Baltimore Sun 1928).

[1] The operation at age 107 is described as a "hernia" operation, according to the Star-Gazette article. No cause was given for the operation at age 110, other than to say that Delina was confined to bed for only a short period of time.

Below is an excerpt from Dr. A. Ross Eckler’s article on Delina Filkins, published in *the Leatherstocking Journal* in 1980 (Eckler 1980):

> Delina Filkins, Who Really Did Live to Be 113
>
> Delina Filkins was born in Stark township, Herkimer County, New York, on May 4, 1815, and died in Richfield Springs, New York, on December 4, 1928, at the age of 113 years and 7 months. Her age at death seems beyond dispute, for it is correctly given in eleven different State and Federal censuses in Herkimer County Courthouse from 1850 through 1925.
>
> The daughter of William and Susanna (Harwick) Ecker, Delina married John Filkins in 1834 and they settled on a farm in the township of Stark (on the south side of Bush road, a short distance east of the Aney Road intersection) for the next 89 years. There she raised a family of six - Joseph, Cornelia, William, Alonzo, Barney, and Frank. After her husband’s death in 1890, she continued to live on the farm with her youngest son Frank and his family. In 1923 they moved to the township of Warren, and two months before her death she came to Richfield Springs.
>
> Today, five great-granddaughters and one great-grandson survive: Mabel Harter, Hilda Royce, Hazel King, and Gordon Filkins of Jordanville; Mildred Kitts of Richfield Springs; and Evelyn Smith of East Winfield. They remember well how “Old Grandma” used to fall asleep in her rocking chair next to the wood stove, ending up leaning against its hot surface. She wore a long dark dress topped with a long white apron; to press the apron she would fold it carefully and place it under the cushion of her chair. At Christmas, the old lady loved to receive candy but wouldn’t share it with the others; instead, she hoarded it in her dresser.
>
> Although slightly deaf, Delina was in good health until shortly before her death, getting around with a cane and even making her own bed. She remembered clearly the opening of the Erie Canal in 1825 when she was a 10-year-old girl. She remembered how the smoky glare from a twisted rag in a grease-filled saucer gave way to candles, to kerosene lamps, and to Mr. Edison’s electric light. She remembered the Indians who still lived in the neighborhood when she was a young housewife, and how she baked pies for them when they “came up from the swamps” so they would leave her boys alone.
>
> As Delina grew older, birthdays became community events. She received greetings from Presidents Harding and Coolidge and from Governor Smith of New York, and visitors from miles around. One photograph from the 1920’s shows car after car lined up outside her house. When she reached 113, Owen D. Young commissioned artist Leona Bell Jacobs to do her portrait; one painting is in the Canajoharie Library and Art Gallery (though not always on display) and the other is in the Owen D. Young Central School.
>
> When asked the inevitable question, she replied, “Well, I don’t know exactly. I always worked hard and I think that had a lot to do with it. I have not been sick much, and the only medicine I ever took was steeped herbs.” She might have added heredity; her father lived to be 97.

It’s clear from the above description that Delina was very much well-situated in her life, well-known, surrounded by family and community [industrialist Owen D. Young founded Radio Corporation of America (RCA) and lived in the area] and active in society even in late life: even at age 113, Delina stated that she intended to vote for Herbert Hoover for US President (Evening News 1928), all the more remarkable when one considers that in the USA, women were not allowed to vote for President until 1920, when Delina was 105.

17.2 The Validation of Delina (Ecker) Filkins

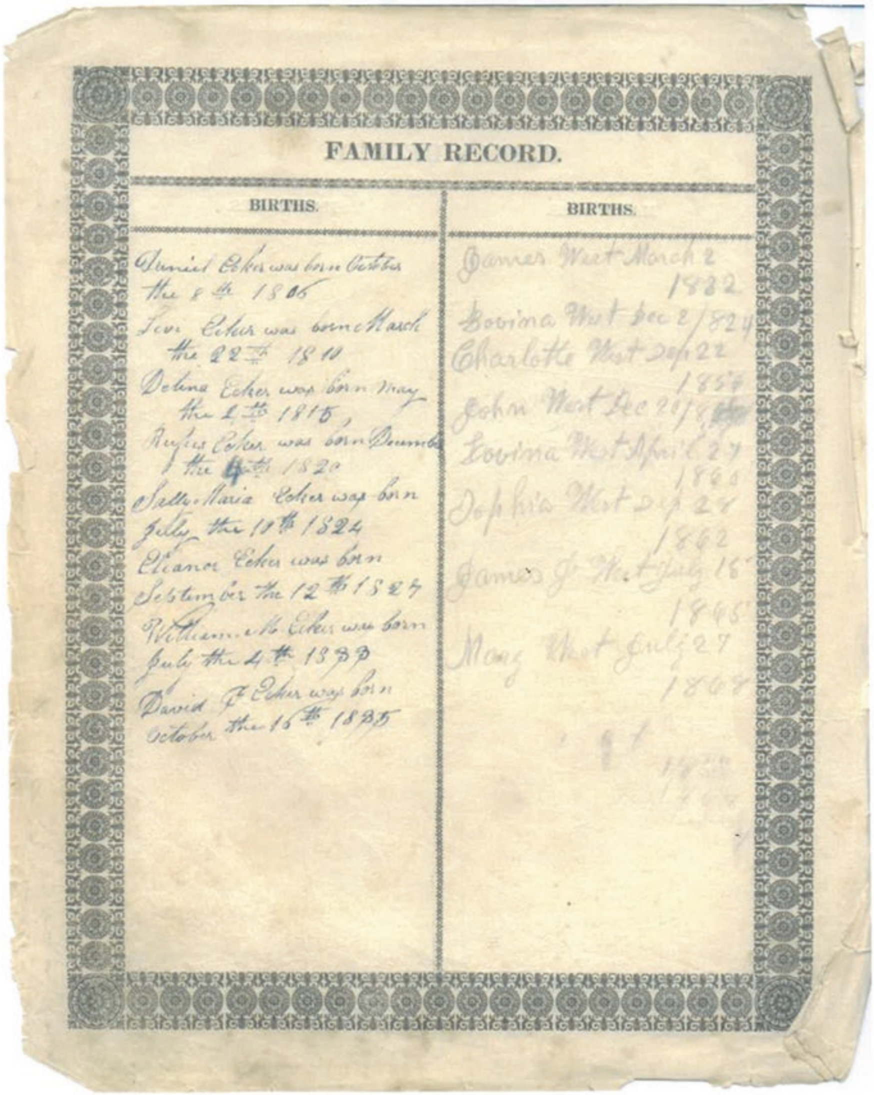
The Delina Filkins case is rather unique: it is the only claim to age 113+ before 1950 to be generally accepted as "validated" by early authorities such as actuaries (Bowerman 1939, 1950). Her case nonetheless needs to be scientifically validated (Poulain 2010). Often, the biggest issue with attempting to validate a claim to age 110+ is the lack of records. The Delina Filkins case fits into a transitional period of American history. At the time of her birth, there were no state birth, marriage, or death records (New York state began statewide birth registration decades later, in 1881). However, US Census records began in 1790 and, moreover, private family records still exist. Delina was part of what may be described as a "landed gentry" Old Dutch/German colonial family in upstate New York, where abundant records exist; lived her entire life in the same small-town area; and was well-known within her family and community. Born in Stark, Herkimer County, New York, a small town of less than 2000 residents in the Mohawk valley, Delina lived nearly her entire life in the same place, only moving in the last two months to Richfield Springs, a town not far to the west. Even then, she went to live with a relative, grandson Berton, so the evidence trail of her life within the family context remained solid.

One must also investigate motivation for the age claim. Many of the age-misrepresented claims debunked by Thoms in his 1873 work (Thoms 1873) were cases that began with oral history tales, not facts, and often came to light in the community beginning with folktales of fantastical ages (indeed, Thoms is also credited with coining the term "folklore" in 1846). The USA was not immune to this local extreme-longevity mythology, with unverified claims sometimes to 120+ being heard of.

With Delina Filkins, her case is different. A check of numerous census and other documents throughout her life course firmly and consistently establish her age over a documentation period in excess of 90 years, suggesting that there was no late-life identity switching or age inflation with the Filkins case. Only the issue of early-life documentation remains an area of uncertainty, one we will take a look at more closely below.

17.3 Close Examination of Records for Delina (Ecker) Filkins

Delina Ecker was born May 4, 1815 in Stark, Herkimer County, New York, to parents William (1782–1879) and Susanna (1787–1863) Ecker. Delina was one of at least seven siblings: Daniel (1805–1846), Levi (1810–1869), Delina (1815–1928), Rufus (1820–1914), Sally Maria (1824–1910), Eleanor (1829-fl. 1830?), and William M. (1833–1864/5), all of whose births are listed in the Ecker family bible (see Fig. 17.2). An eighth person listed in the Filkins family bible, David F. Ecker (1835–1923), was presumed to be William and Susanna's child (according to



FAMILY RECORD.

BIRTHS. | BIRTHS.

Daniel Ecker was born October the 8th 1806
Levi Ecker was borne March the 22th 1810
Delina Ecker was born May the 1th 1815,
Rufus Ecker was born December the 4th 1820
Sally Maria Ecker was born July the 19th 1824
Eleanor Ecker was born September the 12th 1827
William M Ecker was born July the 4th 1833
David F Ecker was born October the 16th 1835

Fig. 17.2 1815 Family Bible birth entry for Delina Ecker

several family trees and the 1850 census) but is later listed in the 1855 New York state census as the grandchild of William and Susanna (and son of Daniel). David's father, Daniel, passed away in 1846 and William and Susanna must have assumed "parenting": the 1850 US census lists David as their child, then age 19. But it's clear that this was an assumed parental relationship: the New York state 1875 census lists William, 92, as the "grandfather" living with David F. Ecker.

Delina married John Filkins in February 1834 (age 18) and had at least six (likely seven) children: Joseph (1836–1891), Cornelia (1837–1900), William (1939–1909), Alonzo (1841–1929), Barney (1848–1928), and Frank (1854–1932) (some Filkins family trees add a seventh child, Evelyn, born 1850—who likely died as an infant). Delina's husband John died in 1890 and afterwards Delina lived with her son, Frank, and grandson Berton. Delina outlived all of her children except Alonzo and Frank. Barney died just two months before Delina.

In 2017, in my building of a family tree for Delina (Ecker) Filkins, I looked for unique identifiers, such as the names of parents, siblings, spouse(s), children, location, et cetera to establish whether the document is the correct match or not. I decided to go with Ancestry.com, where I was able to (re)locate many records for the family tree of Delina (Ecker) Filkins, including census matches, Dutch reformed church records, burial records (including the tombstone and cemetery), death records (for some), and news reports on Delina Filkins herself.

Below is Table 17.1, a short run-down of Delina Filkins's genealogical life history, as established by documented records:

Analyzing the above data in Table 17.1 to check for claimed age, the Delina Filkins case, unlike many, is near-perfect in its consistency. Table 17.2, below, specifically focuses on Delina Filkins and her recorded age.

While there are some names-misspelled issues (for example, "Delana" Filkins in the 1850 census; "Delaney" in 1910), **all** of the ages given in every census document either supports, or accords with, the age claimed (which is quite unusual in its level of consistency). This case passes the 100th birthday test (age 100 in 1915), which is used to eliminate late-life age inflation (which is often due to family mythology). These is no gap larger than 10 years.

Note that the 1840, 1830, and 1820 censuses provided only "age ranges" for wives and children in the family, but these are among the most important records. The range of "20–30" in 1840 is consistent with a birth from 1811–1820; the range of "15–20" in 1830 is consistent with 1815–1819; and the range of "0–10" in 1820 is consistent with 1811–1819. The 1840 census matches up well with what was expected: husband John Filkins (age 30); wife Delina (age 25); and children Joseph (5–10—4 according to family trees); Cornelia (3); and William (1). With the 1830 census, Delina would be in the age range of "15–20", which is listed under father, William Ecker. This is among the strongest records, as there are NO females age 10–15 listed. This document helps to remove doubt, as it suggests that the youngest age Delina could have been in 1830 was 15. Given June 1 1830 minus May 4 1815=15, there's almost no margin for error here. Note the age ranges of the relatives listed nearly match up with what's expected: the male 40–50 could be the father, William Ecker; the female 40–50 could be her mother, Susanna; sons 20–30 could be Daniel and Levi; son 10–15 could be Rufus; daughter 5–10 could be Sally; daughter 0–5 could be Eleanor. The only mystery listing is a female 20–30, but given that Daniel would have been 25 at the time, he likely had a young wife. Finally, the oldest census record thus far located that accords with an 1815 birth for Delina Ecker is the 1820 census. The male age 26–44 is clearly her father William Ecker, age 37. The female age 26–44 is likely mother Susanna. The male age 10–15

Table 17.1 Timeline of documents recording Delina Filkins with family

Timeline of Life Events			
Year	Name, Age	Event	Unique Identifiers
1820	Not stated	Federal census (Aug 7)	R: Danube, Herkimer, New York, United States
			Head of household: William Ecker (free white male 26–44), (father)
			Free white female 26–44: 1 (Susanna Ecker?, mother)
			Free white female 45+: 1 (could be grandparent)
			Free white males 10–15: 1 (Daniel)?
			Free white males 0–10: 2 (Levi, unknown)
			Free white female: 1 in 0–10 age range
1830	Not stated	Federal census (June 1)	R: Stark, Herkimer, New York, United States
			Head of household: William Ecker (40–50)
			Females 40–50: 1 (Susanna?, mother)
			Males 20–30: 2 (Daniel, Levi)
			Males 10–15: 1 (Rufus)
			Females 20–30: 1 (unknown)
			Females 15–20: 1 (Delina?)
			Females 5–10: 1 (Sally?)
			Females under 5: 1 (Eleanor?);
1840	Not stated	Federal census (June 1)	R: Stark, Herkimer, New York, United States
			Head of household: John Filkins (30–40)
			Females 20–30: 1 (Delina?)
			Males 5–10: 1 (Joseph?)
			Females under 5: 1 (Cornelia?)
			Males under 5: 1 (William?)
1850	**Delana Filkins 35**	Federal census (June 1)	R: Stark, Herkimer, New York, United States
			S: John Filkins
			BP: New York
			Children: Joseph, Cornelia, William L., Alonzo, Barnard

(continued)

Table 17.1 (continued)

Timeline of Life Events			
Year	Name, Age	Event	Unique Identifiers
1855	**Delina Filkins 40**	State census	R: Stark, Herkimer, New York, United States
			S: John Filkins
			BP: New York
			Children: Joseph, Cornelia, William L., Alonzo, Barnard
1860	**Delina Filkins 45**	Federal census (June 1)	R: Town of stark, Herkimer, New York, United States
			S: John Filkins
			BP: New York
			Children: Joseph, Cornelia, Alonzo, Barnard
1865	**Delina Filkins 50**	State census	R: Stark, Herkimer, New York, United States
			S: John Filkins
			BP: New York
			Children: Joseph, Cornelia, Alonzo, Byron, Franklin
1870	**Delina Filkins 55**	Federal census (June 1)	R: New York, United States
			S: John Filkins
			BP: New York
			Children: Joseph, Cornelia, Barney, frank
1875	**Delina Filkins 60**	State census	R: Stark, Herkimer, New York, United States
			S: John Filkins
			Children: Joseph, Cornelia, Barney, frank
1880	**Delina Filkins 65**	Federal census (June 1)	R: Stark, Herkimer, New York, United States
			S: John Filkins
			BP: New York
			Children: Joseph, Cornelia
1892	**Delina Filkens 77**	State census	R: Stark, Herkimer, New York, United States
1900	**Delina Filkins 85 (also listed as born May 1815)**	Federal census (June 1)	R: Stark, Herkimer, New York, United States
			BP: New York
			Son: Frank Filkins
1905	**Delina Filkins 90**	State census	R: Stark, Herkimer, New York, United States

(continued)

Table 17.1 (continued)

Timeline of Life Events			
Year	Name, Age	Event	Unique Identifiers
1910	**Delaney Filkins 95**	Federal census (Apr 15)	R: Stark, Herkimer, New York, United States
			BP: New York
			Son: Frank Filkins
1915	**Delina Filkins 100**	State census	R: Stark, A.D. 01, E.D. 01, Herkimer, New York, United States
			Son: Frank Filkins
1920	**Delina Filkins 104**	Federal census (Jan 1)	R: Stark, Herkimer, New York, United States
			BP: New York
			Son: Franklin Filkins
1925	**Delina Filkins 110**	State census	R: Warren, A.D. 01, E.D. 01, Herkimer, New York, United States
			Son: Franklin Filkins
1928	**Delina Filkins 113**	Death	Father: William ecker
			Spouse: John Filkins
			Sons: Alonzo, frank
			R: Herkimer County, New York, USA

R residence, *BP* birthplace

Table 17.2 Age validation check for Delina Filkins case

Time	Sort of document	Documented age/date of birth	Record accords with
1820	US Federal census	0–10 (age range given)	May 4, 1815
1830	US Federal census	15–20 (age range given)	May 4, 1815
1840	US Federal census	20–30 (age range given)	May 4, 1815
1850	US Federal census	35	May 4, 1815
1855	New York census	40	May 4, 1815
1860	US Federal census	45	May 4, 1815
1865	New York census	50	May 4, 1815
1870	US Federal census	55	May 4, 1815
1875	New York census	60	May 4, 1815
1880	US Federal census	65	May 4, 1815
1892	New York census	77	May 4, 1815
1900	US Federal census	85; "May 1815"	May 4, 1815
1905	New York census	90	May 4, 1815
1910 (Apr.)	US Federal census	95	May 4, 1815
1915	New York census	100	May 4, 1815
1920 (Jan.)	US Federal census	104	May 4, 1815
1925	New York census	110	May 4, 1815
1928	Obituaries	113; May 4, 1815	May 4, 1815

is likely Daniel; 2 males under 10 could include Levi and an unknown child (unless Rufus, 4 months before his alleged birth from the family Bible, was already born); one female age 0–10 likely was Delina. A female aged 45+ could be her grandmother.

With numerous news reports from 1924 to 1928 covering Delina's 109th–113th birthdays, followed by multiple published obituaries, there can be no doubt that Delina Filkins passed away December 4, 1928, and that her claimed date of birth of May 4, 1815 firmly stretches back over more than a century of records (1928–1820 = 108 years). Located census records (including 1820, 1830, and 1840) include 10 Federal census matches, 7 state census matches, the two family Bible entries, and the death reports: a total of 20 documented data points that all agree with the claim that Delina Filkins was born May 4, 1815 (the April 15, 1910 census arguably supports 1814, but given it was just 19 days to her 95th birthday, her age was very likely rounded, and in any case, that still supports 113+).

If the first observation is that the ages in the census documents all match the age claimed, the second that can be said is that the identity of Delina (Ecker) Filkins located in the context of her family strongly matches the census records. We have the correct husband (John) and almost the correct sibling names: Joseph, Cornelia, William, Alonzo, Barnard/"Barney"/Byron, and Frank. We also have even the correct names of additional relatives, such as grandson Berton [mentioned in the news reports, the family Bible (marriage in 1898), and also some of the census matches]. The oldest census record, from 1820, strongly implies the existence of Delina, as William Ecker had one daughter under age 10.

But what about family records? The Filkins family Bible (see Figs. 17.2 and 17.3) fortunately still exists. We can make out from the cursive handwriting on the old, yellowed parchment that "Delina Ecker was born May the 4th, 1815". We can also see birth entries for older brothers Daniel ("born Oct the 8th 1805"), Levi ("born March the 22nd, 1810") and younger brother Rufus ("born December the 4th, 1820"). Note: the early family Bible years of birth: 1805, 1810, 1815, 1820 may be said by skeptics to resemble "age heaping", but the exact months and dates of birth (Oct 8 1805; Mar 22 1810; May 4 1815; Dec 4 1820) don't fit "age-heaped" expectations. Neither do the birth years of 1824, 1827, 1833, and 1835 for the younger relatives listed.

Did longevity run in Delina's family? Her father, William Ecker, died in 1879, age 96/97 (William Ecker died either the day before or four days after turning 97–sources differ by five days on his date of birth), and her brother, Rufus Ecker, died in 1914 at age 93. A grandson, Earl, lived to age 94. I could not find anyone other than Delina age 100+ in the family. One thing to note is that Delina's mother, Susanna, born Nov 21 1787, gave birth to her last child, William M., in October 1833, age 45 (David F., born October 15/16, 1835, although listed as her child in the 1850 census, is apparently her grandchild, as per the 1855 New York state census). Births to natural mothers older than 37 often correlate with exceptional longevity. Yet, it's also clear that environmental impacts played a role in shortening the lives of others: for example, Delina's brother William M. Eckler appears to have died in the US Civil War, age just 31.

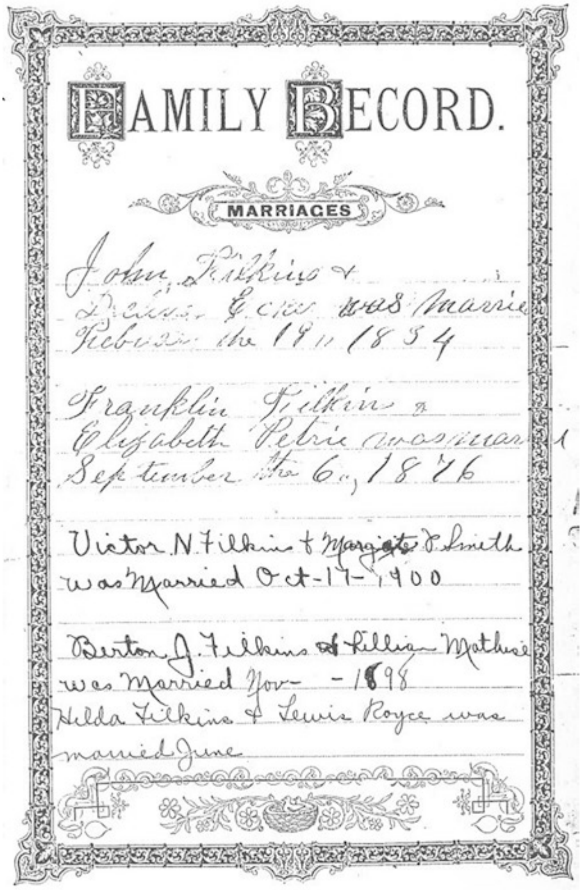


Fig. 17.3 1834 Delina Filkins marriage to John Filkins in the Family Bible

It's also clear that infant and child mortality was a typical problem even for this "long-lived" family in the 1800s: Eleanor and Evelyn apparently died as infants or children. Experts, in reviewing family tree records, look for potential cases of "sibling switching", whereby the birth of an older sibling is conflated with the death of a younger, as in the case of Damiana and Diminia Sette of Italy (Poulain 2010). Searching the Filkins case, the context clues do not support a "sibling-switching" scenario. First and foremost, there are no known candidates for a potential younger sibling to switch with (Sally and Eleanor are far too young to be candidates for this). The family Bible has no later marks indicating potential later additions. Delina's age at marriage, 18, is already relatively young, making it less likely that she was "even younger". Perhaps the strongest clue is that the 1830 census "age range" is for a female aged 15–20: 1830–1815 = age 15. Had Delina been born in 1816 or later, she would not have fit in the age range. And while the 1830 census hints at an older female in the "20–30" age range, if this were Delina, she would have been older than 118 … not at all likely. It possibly could be a wife of older brother Daniel, who was then 25 years old.

What's remarkable about the above set of documents is its depth (20 or more documents for an age validation) and consistency: all documents support Delina being born in 1815, with the possible exception of the (April) 1910 census having her as "95 in April 1910", which would technically support a birth in 1814, but more likely Delina's age was rounded off. Note, also, that the 1850 census lists Delina's son, Joseph, as age "14", suggesting that the "35"-year-old Delina gave birth at age 21, circa 1835–1936 (and about a year after her 1834 marriage to John Filkins). Indeed, the 1840 census indicates that Delina's oldest child was age 5–9. In short, every record check done on this case either supports or accords with the conclusion that Delina Filkins was at least 113 years of age.

The number of documents (20) in support of Delina Filkins being 113 in 1928 would be sufficient to meet the standards of most researchers regarding whether this case is "validated". Proof of death was more than sufficient (including the New York Death Index and multiple news reports) and proof of identity through the life course of this remarkable woman was well more than sufficient. The only weak area is that the earliest certainly dated document is from 1850 (listing Delina as "35"); the 1840, 1830, and 1820 censuses give an "age range", and the marriage and birth records, though placed solidly in the context of a longstanding family Bible heirloom, with older and younger relatives in proper order, does not give a date of recording. Due to these issues, the Filkins case would not attain the highest standards of age validation, an "original proof of birth only" standard that would exclude not just the Filkins case but also notable cases such as Sarah Knauss (Young 2010).

However, if we are to accept Knauss based on the proxy proof of birth method using the 20-year rule, we may also conclude that there is sufficient evidence to deem the Delina Filkins case "validated" according to similar standards. A woman who married in 1834 and gave birth in 1835/1836 fits well with a birth year of "1815", and the claim to birth in 1815, recorded in the family Bible and certainly confirmed by the 1850 census, far predates any potential later motivations which in many instances lead to age inflation, including pension fraud claims, seeking attention, local village elder, et cetera (Young et al., 2010).

17.4 Conclusion

Of all early (pre-1950) claims to age 113, the Filkins case represents the only validated case. Unlike the claim of Pierre Joubert to age 113 in 1814 (debunked by Charbonneau in 1990), the Filkins case appears to be genuine. Being socially well-known for many years helps to minimize identity fraud, sibling switching, and the like. That Filkins's age never deviated before her extreme old age (or at all) rules out pension fraud, attention seeking, or age misreporting due to faulty memory.

Nevertheless, there are some concerns about this case. There is no original proof of birth or baptism (only a family Bible entry—See Fig. 17.2). The marriage record is a recording in a Bible, not an official document (see Fig. 17.3). And while the death record likely exists, it has not been publicly located (however, I have located

Delina Filkins in the New York Death Index … name, date of death, and place of death are given, though not age). Also, the lack of a “date of recording” of the family Bible entries leads to questions as to just when this material was added.

Since the introduction of the rules for the concept of the age validation of centenarians in the 1870s by William Thoms, there has been a heavy divide between the emphasis among skeptics for the importance of age validation and checking and the tendency for longevity mythology to be accepted by the mainstream media (and sometimes non-demographic scientists), often without sufficient proof of age. Twenty documents available for Delina Filkins, the context of family-tree information, and the fact that the documents tightly fit together all support the age claim of Delina Filkins to be 113 in 1928. This case meets most modern standards of age validation used by authorities such as the International Database on Longevity (IDL) and the Gerontology Research Group (GRG). The fact that the oldest document currently known was a family Bible entry written close to the time of birth, and that even the marriage entry for when Delina was 18, makes her case similar to the Sarah Knauss case, who also is missing original proof of birth, but for whom the concept of a “20-year-rule” for proxy census substitution was proposed in 1998 by Jean-Marie Robine (Vaupel and Robine 2002) and subsequently accepted and instituted by the Gerontology Research Group, the International Database on Longevity, and the US Social Security Administration study of supercentenarians. Using the test methods in place for the Sarah Knauss case, the Delina Filkins case passes the same standards.

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Thanks also to former GRG correspondent Jimmy Lindberg for the helpful re-assembly of some census reports for this case.

Finally, I dedicate this book chapter to the late Dr. A. Ross Eckler, Jr. (1927–2016), whose work on this seminal case in demographic history began over 40 years ago, and who provided copies of the family Bible birth and marriage records.

Appendix

Figures 17.2 and 17.3, copies of the original Filkins family Bible, were supplied by Dr. Eckler.

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Chapter 18
Emma Morano – 117 Years and 137 Days

Bernard Jeune and Michel Poulain

The Italian woman Emma Martina Luigia Morano was the last long-living woman who was born in the 1800s. She was the longest living person in the world when Susannah Mushatt Jones died in New York on 12 May 2016 at age 116. Emma Morano lived in a little apartment in Pallanza in the municipality of Verbania on Lake Maggiore, about 100 km north of Milano, where we visited her twice (on 13 October 2015 and on 17 May 2016).

The following history is based on documents from the archives of the communes of Civiasco, Santhia, Verbania, Verrone, and Villadòssola; information provided by Emma Morano herself, her relatives, and her family doctor; as well as interviews with her and articles about her published in local, national, and international newspapers (see Note 1).

As was mentioned on her birth certificate (Fig. 18.1), Emma was born on 29 November 1899 in the mountain village of Civiasco (in the province of Vercelli, about 50 km west of Pallanza). She was the daughter of Giovanni Morano aged 22, minatore (miner); and his wife who was living with him, Mathilde Bresciani, aged 24, tessitrice (weaver).

Emma's parents married in 1897 in Santhia (in the province of Vercelli between Milano and Torino). Her father Giovanni Battista Morano was born on 15 May 1878 in Santhia and died in Intra (in the municipality of Verbania) on 15 April 1950 at the age of 71. Her mother Matilde Bresciani was born on 28 October 1875 in Mendrisio (Switzerland) and died in Pallanza (Verbania) on 24 April 1969 at the age

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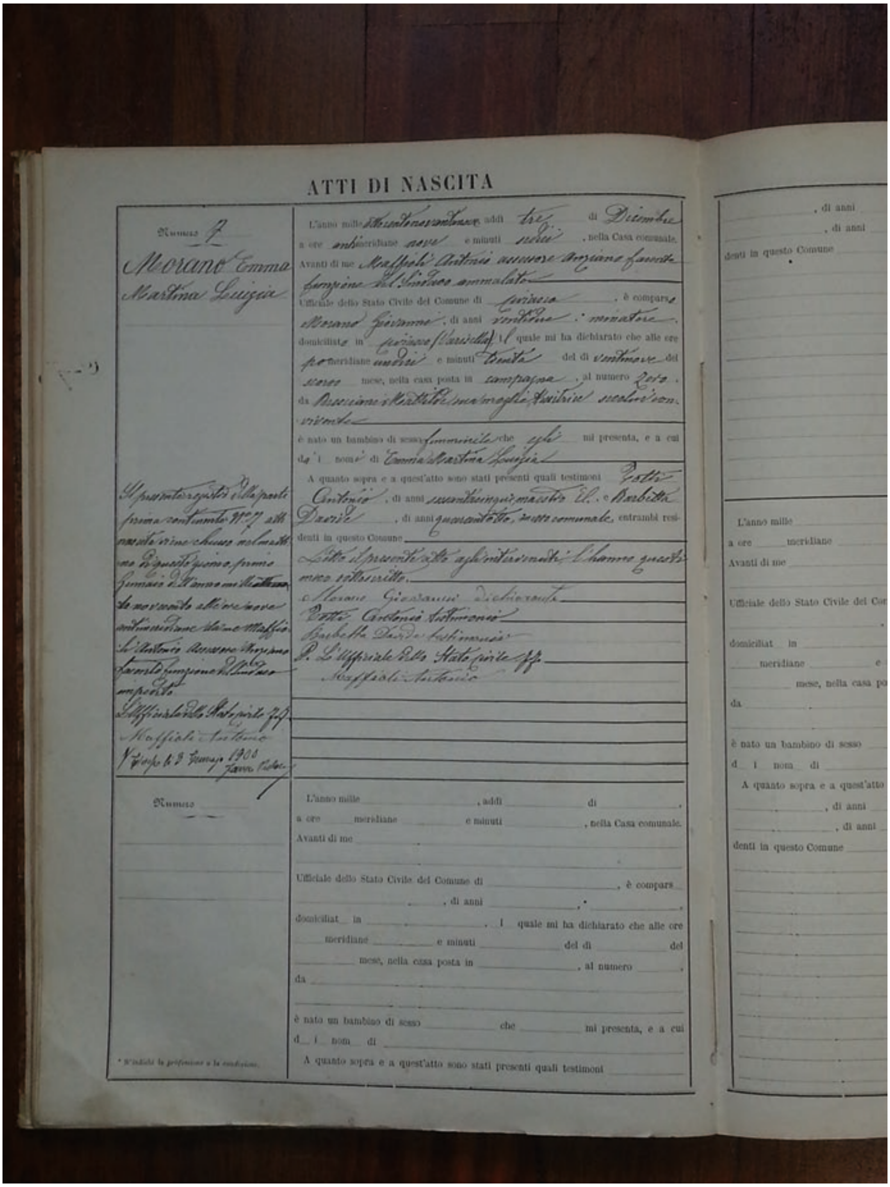

ATTI DI NASCITA

Numero 7

Morano Emma Martina Luigia

Fig. 18.1 Emma Morano's birth certificate

of 93. We obtained copies of the death certificates of both parents in the archive of Verbania.

Emma was the first child born to the family. She was the only child who was born in Civiasco, where her parents moved shortly after they married. At that time, her father was employed in the building of the railway in Civiasco. It appears that less than 2 years after her birth her family moved to Verrone Biellesse (between Civiasco

Table 18.1 The family composition of Emma Morano

Parents:	Born	Died	Age at death
Giovanni	15 May 1878	15 Apr 1950	71
Matilde	28 Oct 1875	29 Apr 1969	93
Children:	**Born**	**Died**	**Age at death**
1. Emma	29 Nov 1899	15 Apr 2017	117
2. Edouardo	13 Jan 1901	23 May 1932	31
3. Quinta	22 Jun 1903	16 Jun 2000	94
4. Lucia	27 Dec 1904	24 Feb 2003	98
5. Carmen	26 Oct 1906	11 Feb 1994	87
6. Angela	16 Dec 1908	03 Jan 2011	102
7. Luigi	20 Jan 1911	4 Oct 1995	84
8. Ottavio	19 May 1913	20 Sep 1979	66

and Santhia) where their second child, Edouardo, was born in 1901. But shortly thereafter, the small family settled in Villadóssola, an industrial city about 50 km north-west of Pallanza where her father started working in a foundry.

Emma's birth was followed by the births of seven siblings, four sisters and three brothers, all of whom she survived. Five of them were born in Villadóssola. We have obtained copies of the birth certificates for all of her siblings. We found no younger children with the name Emma, which could have been the case if the first-born Emma had died as a child. As the births of her younger siblings were spaced about 2 years apart (max. 2 years and 4 months), it is impossible for her mother to have had other children between the births of the abovementioned siblings. As is shown in Table 18.1, most of Emma's siblings reached high ages, like their mother.

The siblings are all shown on the following Photo (Fig.18.2) of her family. Emma is seen in the back row as the second from the left beside her brother Edouardo in the middle. Hence, Emma Morano had a big family living nearby, including 11 nieces and eight nephews, most of whom spent their childhood in Verbania.

18.1 A Short Summary of Emma Morano's Life Course

In the 1920s, her family moved to Pallanza (Verbania) because the climate in Villadòssola was considered unhealthy. However, it is possible that Emma did not accompany her parents at that time. We found evidence that she moved to Pallanza on 1 January 1925 from Tecate (in the province of Novara, west of Milano). It appears that her mother moved first to Pallanza after her parents separated, but was later joined by her father in spite of the separation. Emma Morano probably joined her mother in 1925, and lived all of her remaining life in Pallanza.

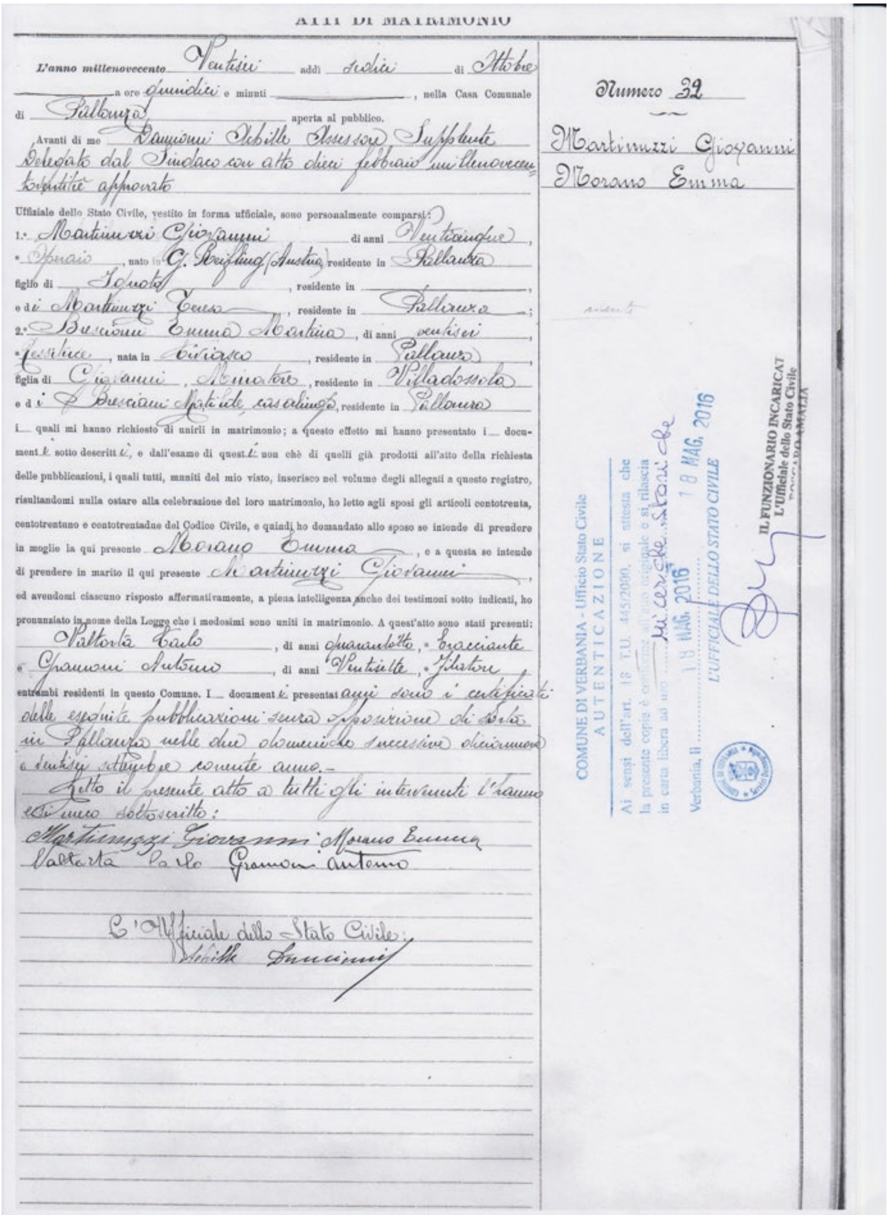
On 16 October 1926, Emma Morano married Giovanni Martinuzzi (1901–1978). As recorded in the marriage certificate (Fig. 18.3), Emma was aged 26; a tessitrice (weaver); and the daughter of Giovanni, a minatore (miner) living in Villadòssola, and of Mathilde Bresciani, a casalingua (housewife) living in Pallanza. Emma's

Fig. 18.2 Emma as a young woman with her parents and siblings

family name was erroneously written on the certificate as Bresciani, her mother's name; but her family name was correctly mentioned in the margin.

The marriage record confirms that Emma's parents were living separately when she moved to Pallanza in 1925 and married there in 1926. According to her niece Maria, Emma's mother forced Emma to marry her husband. Emma told us that her future husband had threatened her to get her to marry him. The marriage was unhappy. That may have been the reason why she did not have a child with him until 28 January 1937, when Leo Angelo Martinuzzi (Fig. 18.4) was born. Leo died on 8 August 1937, when he was only 6 months old. Shortly thereafter, in 1938, she separated from her husband. She later told a journalist from the New York Times that she had plenty of suitors after that, but never chose another partner: "I didn't want to be dominated by anyone".

For more than 30 years (until 1954), she worked for Maioni Industry (in a building that is today the library of Pallanza), a jute factory where she sewed potato sacks. At that time, she lived in one of the factory's apartments. She then worked for about 20 years in the kitchen of the Collegio Santa Maria, a Marianist boarding school in the hills of Palenza, until she retired at the age of 75. According to the magazine Qui of the local journal ECORisveglio, she liked to work and never complained of fatigue. At that time, she lived in an apartment close to the San Giuseppe church belonging to the boarding school. After retirement, she moved to a small two-room apartment close to the San Leonardo church belonging to the parish.



ATTI DI MATRIMONIO

L'anno millenovecento Ventisei addì sedici di Ottobre a ore quindici e minuti ___, nella Casa Comunale di Pallanza aperta al pubblico.

Avanti di me Damioni Achille Assessore Supplente Delegato dal Sindaco con atto dieci febbraio millenovecento ventitre approvato

Uffiziale dello Stato Civile, vestito in forma ufficiale, sono personalmente comparsi:

1.° Martinuzzi Giovanni di anni Venticinque, Operaio, nato in G. Preifling (Austria) residente in Pallanza

figlio di Ignoto, residente in ___,

e di Martinuzzi Teresa, residente in Pallanza;

2.° Bresciani Emma Martina, di anni ventisei, Tessitrice, nata in Civiasco, residente in Pallanza,

figlia di Giovanni, Minatore, residente in Villadossola

e di Bresciani Matilde, casalinga, residente in Pallanza

i quali mi hanno richiesto di unirli in matrimonio; a questo effetto mi hanno presentato i documenti sotto descritti, e dall'esame di questi non chè di quelli già prodotti all'atto della richiesta delle pubblicazioni, i quali tutti, muniti del mio visto, inserisco nel volume degli allegati a questo registro, risultandomi nulla ostare alla celebrazione del loro matrimonio, ho letto agli sposi gli articoli centotrenta, centotrentuno e centotrentadue del Codice Civile, e quindi ho domandato allo sposo se intende di prendere in moglie la qui presente Morano Emma, e a questa se intende di prendere in marito il qui presente Martinuzzi Giovanni, ed avendomi ciascuno risposto affermativamente, a piena intelligenza anche dei testimoni sotto indicati, ho pronunziato in nome della Legge che i medesimi sono uniti in matrimonio. A quest'atto sono stati presenti:

Vattorta Carlo, di anni quarantotto, bracciante

e Grammoni Antonio, di anni Ventisette, filatore

entrambi residenti in questo Comune. I documenti presentati sono i certificati delle eseguite pubblicazioni senza opposizione di sorta in Pallanza nelle due domeniche successive dicianove e ventisei settembre corrente anno.—

Letto il presente atto a tutti gli intervenuti l'hanno con me sottoscritto:

Martinuzzi Giovanni Morano Emma

Vattorta Carlo Grammoni Antonio

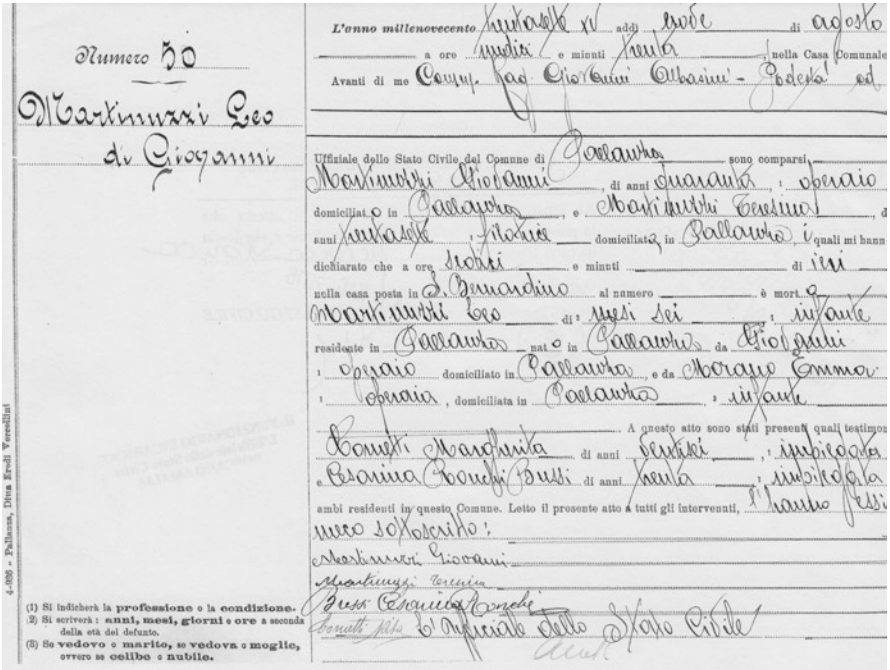
L'Ufficiale dello Stato Civile:
Achille Damioni

Numero 32

Martinuzzi Giovanni
Morano Emma

COMUNE DI VERBANIA - Ufficio Stato Civile
AUTENTICAZIONE
Ai sensi dell'art. 18 T.U. 445/2000, si attesta che la presente copia è conforme all'originale e si rilascia in carta libera ad uso ricerche storiche
Verbania, lì 18 MAG. 2016
L'UFFICIALE DELLO STATO CIVILE
IL FUNZIONARIO INCARICATO
L'Ufficiale dello Stato Civile

Fig. 18.3 Emma Morano's marriage certificate



Numero 50
Martinuzzi Leo di Giovanni

L'anno millenovecento trentasette addì tredici di agosto a ore undici e minuti trenta nella Casa Comunale Avanti di me Comm. Rag. Giovanni Albasini - Podestà ed Ufficiale dello Stato Civile del Comune di Pallanza sono comparsi Martinuzzi Giovanni, di anni quaranta, operaio domiciliato in Pallanza, e Martinuzzi Teresina, di anni trentasette, filatrice domiciliata in Pallanza, i quali mi hanno dichiarato che a ore sedici e minuti ... di ieri nella casa posta in S. Bernardino al numero ... è morto Martinuzzi Leo di mesi sei, infante residente in Pallanza nato in Pallanza da Giovanni operaio domiciliato in Pallanza, e da Morano Emma operaia, domiciliata in Pallanza, infante. A questo atto sono stati presenti quali testimoni Bonetti Margherita di anni sessanta, impiegata e Brovina Bianchi Bussi di anni trenta, impiegata ambi residenti in questo Comune. Letto il presente atto a tutti gli intervenuti, l'hanno meco sottoscritto.
Martinuzzi Giovanni
Martinuzzi Teresina
Bussi Brovina Bianchi
Bonetti ...
L'Ufficiale dello Stato Civile

(1) Si indicherà la professione o la condizione.
(2) Si scriverà: anni, mesi, giorni o ore a seconda della età del defunto.
(3) Se vedovo o marito, se vedova o moglie, ovvero se celibe o nubile.

4-936 - Pallanza, Ditta Eredi Vercellini

Fig. 18.4 The birth certificate of Emma Morano's son Leo Marinuzzi

18.2 Emma Morano in Recent Years

When we visited her for the first time in October 2015 (Fig. 18.5), Emma was sitting without support on her bed. Her sight was greatly reduced but she could recognise faces. Her hearing was also reduced – we had to speak very loudly. However, she seemed to remember both past events and more recent ones. She remembered that her mother was older than her father, but also who had visited her the day before. However, according to the journalist of the New York Times, "[H]er memory evades entire decades. Ask her about Mussolini, or the world wars or any number of current or past political figures, and she shrugs indifferently. Her recollections are mostly intimate". She recalled that "my sisters and I loved to dance and we'd run away to the dance hall and then our mother would come looking for us with a birch stick".

She appeared more frail and smaller than on pictures taken just 1 year earlier (Fig. 18.6). After half an hour she became tired and wanted to lie down, apparently because she had just been treated with antibiotics for a urinary infection. Since September 2015 she had been receiving home help provided by the municipality.

The wife of her nephew, Rosi Santoni, who was her caregiver and prepared her meals, told us that on a typical day, Emma ate one raw egg in the morning at 8 a.m. together with a "biscotta" and some milk. At 11 a.m., she ate soup ("minestra") and raw beef (about 120 g) together with another raw egg. In the afternoon, she had

Fig. 18.5 Emma Morano on 13 October 2015 with Bernard Jeune and Michel Poulain

some fruit (mostly bananas and raisins) and a “biscotta”. At 6 p.m., she again ate soup, but this time the soup consisted of small pieces of pasta, a bouillon cube, and a little olive oil. Previously she had also eaten a boiled egg at dinner. After dinner, she sometimes ate chocolate and drank a glass of brandy. According to La Stampa, she had eaten raw eggs and raw beef since she was 20 years old because her doctor had prescribed these foods as a diet to prevent anaemia.

Our colleague Waclaw Jan Kroczek sent us the following account of his second visit with Emma Morano on her 116th birthday on 29 November 2016: “Mrs. Morano’s mind remains lucid. Her answers to our questions were explicit and comprehensible. Her voice is strong. Moreover, Mrs. Morano has an exceptional nimbleness in her hands. Her appetite is great. We witnessed her eating breakfast which consisted of milk soup with cereals, a plate filled with small sliced pieces of meat, two bunches of grapes and banana. She ate all the meals one after another completely unassisted. The milk soup she ate using a spoon. The pieces of meat she ate with her bare hands. Then, she ate all the grapes (big ones) after peeling each. Mrs. Morano is weaker than she was in December 2014, when I visited her previously. However, the decline between the ages 115 and 116 has not been very significant in Mrs. Morano’s case. It has been noticeable, but not manifest”.

Her doctor, Carlo Bava, who had been visiting her once a month since she was 90, wrote to us after his visit with Emma Morano on her 116th birthday that she had

Fig. 18.6 Emma Morano in her apartment on her 115th birthday (29 November 2014)

"a good appetite" and ate "un piatto di minestra", raw beef, and a boiled apple while he was visiting her. According to the Agence France Presse, "she marked her 116th birthday by offering to sing her favourite song for visiting well-wishers: 'You know I have a beautiful voice, if you like I can sing Parlami d'amore, Mariù'".

The priest Don Giuseppe Masseroni from the San Leonardo church, who had recently turned 90 himself, visited her every Friday. He told the magazine Qui that she had a strong and capable character ("un carattere tenace and caparbio"); that she could defend herself and would never surrender. She prayed very frequently using her rosary and reciting prayers to the local saints Giulio and Giuliano who protect against wolves, serpents, and other dangerous creatures. Her niece told us that the family members called her "Generale" (the general), a name that underlined her will to command.

When we visited her a second time on 17 May 2016 together with her family doctor, Dr. Bava, she was in better shape than when we visited her the first time in October 2015. She spoke fluently with her doctor and sang some local songs he asked her to sing. She was taking no medication for heart problems or high pressure, and was rarely using other drugs except for some occasional laxatives. She had never been hospitalised, as she had always refused to go to the hospital. Ten years previously she had experienced some gastrointestinal bleeding. Her doctor managed to give her a transfusion at home because she refused to be hospitalised. Although she had fallen several times at home, she had never had a fracture. We think her doctor played an important role in her survival to such a high age.

In December 2011, she was awarded the honour of Knight of Order of Merit for the Italian Republic by President Giorgio Napolitano. On her 114th birthday she gave a TV interview on RAI. She received Pope Francis' congratulations on her 116th birthday.

We think that the documents that we have found, together with the information we have obtained from family members and from her doctor, are enough evidence to be certain that Emma Morano reached the age of 117 years.

Note 1

The above history comes from the following sources: oral information from Emma Morano herself; information from Rosi Mariella (Rosamari) Santoni (born in 1943), the wife of Emma's sister Angela's second son Antonio Sala (born in 1937); information from her niece, Angela's daughter Maria Antonietta Sala in Intra (Verbania) (born 14 February 1945); and information from Dr. Carlo Bava.

Additional information came from articles in magazines and newspapers, especially articles that appeared around her 116th year birthday; and when she became the world's oldest person on 12 May 2016, the date when Susannah Mushat Jones from the U.S. died ('Qui. Magazine di ECOrisveglio', Supplemento no. 129, 2 December 2011, 'New York Times', 14 February 2015 'La Stampa', 29 de Novembre 2015, 'Agence France Presse', also used in 'La Parisienne' and 'The Guardian', 30 November 2015, 'ECOrisveglio' 18 Maggio 2016, 'El Pais' 18 de Mayo de 2016, 'La Stampa', 15 de Aprile 2017, 'The Washington Post', 15 April 2017, 'The New York Times', 15 April 2017, etc.).

In October 2015, we also visited her sister Angela's daughter, Maria Antonietta Sala. With her help we went through the genealogy of the Morano family. Maria had collected a large amount of information, which she had made into a nice book. Michel Poulain took photos of the most important pages.

In the Municipio of Civiasco (about 50 km west of Palenza), we obtained a copy of her birth registration.

On 17 May 2016, we visited her again to learn more about her family and to get an authorisation to obtain copies of documents in the archives of the municipalities of Verbania, Villadòssola, and Santhia. In the days that followed, we visited the archives of these municipalities, where we obtained copies of her parents' death certificates, the birth certificates of all of their children, Emma's marriage certificate, and the birth and death certificates of Emma's son.

Chapter 19
A Life Cycle of Extreme Survival Spanning Three Stages: Ana Vela Rubio (1901–2017)

Rosa Gómez-Redondo and Ramón Domènech

19.1 Introduction[1]

The life trajectory of Ana Vela Rubio (hereinafter AVR) condensed the sociodemographic changes that took place in Spain during the twentieth century. This Andalusian woman, born in Puente Genil (Cordoba), lived through the changes that played a large part in our society's metamorphosis and modernisation, and in the well-recognised epidemiological and health transitions. AVR was born in 1901 to Andalusian parents in a humble home and in the bosom of rural society, in which gender-divided work was characteristic of the time – her certificates euphemistically code her mother's occupation as "her sex". Fertility rates were high – the Total Fertility Rate (TFR) was constantly higher than 4 in the pre-1920s (Delgado 2009), as was infant mortality – the Infant Mortality Rate (IMR) was never lower than 100 deaths per 1000 live births (Gómez-Redondo 1992) in the same period. These figures are reflected in our case in the death of four of AVR's six siblings during early childhood due to infections that were rife in the pre-transitional stage.

However, in the course of AVR's life, Spain underwent major sociodemographic mutations and became a country with one of the highest life expectancies in the world. Furthermore, during the middle decades of the twentieth century, a rural exodus took place, with successive waves of massive movements of people from the countryside to the cities. AVR was a case in point. From Puente Genil, she first migrated to Malaga, a medium-sized city on the south coast of Spain, where she formed a family and brought up her children. Later, she uprooted again, this time to

[1] This study was financed by Project CSO2104-54669-R, granted under National Plan I + D + i 2014–2017 of the Spanish Ministry of Economy, Industry and Competitiveness.

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Barcelona, a hot spot for immigrants from all corners of Spain, and particularly from Andalusia and Murcia. This immigration process occurred mainly during the 1950s and 60s. In parallel, fertility and mortality rates started to tail off, with the TRF (4.7 in 1900) falling to 2.5 children per woman in the 50s, and the IMR (172 per 1000 live births at the start of the century) standing at about 50 in Spain when AVR's first grandchildren were born.

After our supercentenarian arrived in Barcelona, the processes mentioned above became more intense: migration acquired an international dimension (as shown in the experience of AVR's own children), while fertility rates continued to fall until they reached an all-time low by 1975. Longevity figures showed the opposite trend, as Spain became one of the highest ranked countries worldwide in terms of survival and extreme longevity, leading to an exponential rise in the centenarian population starting in the 80s. As we will explain below in greater detail, AVR's long life is a privileged example of more than a century of social and demographic changes in the life of a country.

19.2 An Example of In-Depth Verification

AVR's case is of particular interest because of her extreme longevity compared with the majority of European supercentenarians. Notably, at the time of writing she is one of the 20 longest-living persons in the history of humankind and the longest-living person in Spain. Moreover, before her recent death on 15 December 2017, she was the oldest living person in Europe and the third oldest living person in the world. For this reason, the work undertaken to verify AVR's age followed not only the protocol established by the International Database on Longevity (IDL), completed in May 2017 (Gómez-Redondo et al. 2017), but also a more in-depth verification using the different types of sources described below:

(a) Official documents. These are the cornerstone of every age validation process. In this case, we corroborated birth certificates (AVR, parents and siblings), death certificates (parents, and of her six siblings, four who died in childhood), her parents' marriage certificate, and also the national identity cards of AVR and of three of her children.
(b) Parish documents. Historically, parishes have been responsible for recording the religious ceremonies and rites of their parishioners. Most documents refer to life events such as birth (baptism), marriage (and its Catholic ceremony) and death (and its corresponding religious ceremony). We referred to these documents in addition to the official records to rule out incongruities and fill in any information gaps. Although parish registries have become less reliable lately compared to official civil sources, in historical demography they are a traditional source of inestimable value, especially in view of the inaccuracies and gaps in the incipient Spanish Civil Registry (created in 1870) at the turn of the twentieth century, which could have affected our case.

(c) Witness accounts by relatives and other persons in close contact with AVR. Beyond the data recorded in official and religious documents, we reconstructed AVR's life trajectory through a total of nine personal interviews and telephone calls, as well as various minor consultations. During our verification work, we visited "La Verneda" care home in Barcelona four times. The staff reported on AVR's state of health and her quality of life, as well as any changes and limitations in her daily activities at the home.
(d) Graphical materials. Through the visits and interviews mentioned above, we collected various photographs of recent events as well of AVR's whole life trajectory and the changes in her place of residence. These photographs complemented the validation process reported here. AVR's daughter and two grandchildren (Antonio and Ana) provided most of the photographs from the past and we also collected others in the course of our investigation through the interviews and visits.

In short, to conduct this validation process, we visited Puente Genil twice, including an interview on one occasion, where we obtained AVR's parents' marriage certificate, birth certificates (and death certificates where applicable) of AVR and her siblings, as well as the parish records of these life events. We also made other trips to interview relatives (conducting various telephone interviews beforehand) and collect photographs in Malaga, Torremolinos, and Barcelona, as mentioned above. In 2017, we exchanged many emails with the principal informants and also with staff from registry institutions.

19.3 Three Stages, Two Centuries and 116 Years. An Extensive Validation of the Life Cycle of Ana Vela Rubio (1901–2017)

Ana Vela Rubio celebrated her 116th birthday in October 2017, shortly before her death. Hers was a unique case of extreme longevity in an unfavourable physical and sociodemographic setting for survival. Cordoba province at the start of the twentieth century, a family history fractured by the moral values of the times, and the harsh conditions of AVR's socioeconomic origin, meant she faced periods of poverty and high mortality during her childhood and early youth. Her life cycle was especially complex to follow in her life trajectory as a supercentenarian because she formed a family with a partner with whom she held neither a religious nor civil union – a status that was stigmatised in interwar Spain and for many decades to come. However, a positive factor that made our research feasible was the Vela-Rubio family's ability to surmount social and economic obstacles, adapting to their changing environment as a result of their migrations within Spain and beyond its borders, to Europe. Above all, we were supported by AVR's closest relatives and their interest to recover their family history and to understand and respect the purpose of our scientific investigation, undertaken from a sociodemographic perspective.

We have divided AVR's life trajectory into three stages, corresponding to her three different places of residence. The first starts with her birth in Puente Genil and ends when she moved to Malaga as a young woman starting her adult life. From this first period, AVR's descendants knew incomplete, disjointed stories from the family history; isolated tales that AVR had told her children, who in turn had passed them on in some cases to their own children, but there were gaps that had to be filled and verified. They were almost unaware of the existence of AVR's siblings. Only AVR's daughter mentioned a vague recollection of one of them, saying that he had drowned as an adult in the river Genil, which gives its name to AVR's place of birth. The order of AVR's siblings has been reconstructed through this investigation by in situ searches of documents held at the civil and parish registries of Puente Genil. We searched and followed up all the births (and deaths, in some cases) of the children born to AVR's parents, from the time that AVR's mother, Carmen Rubio, reached a reproductive age until her death. Thus, through a systematic review of official and religious documents from the period 1890–1917, we drew up a list of all AVR's siblings, in order to be able to rule out the existence of a sister with the same name, which could have given cause for doubts or objections in the international validation of AVR as an exceptional supercentenarian.

The second stage covers AVR's years in Malaga, where she set up her home and had her children, while working as a seamstress in private households. The reconstruction of a large part of this second stage has been possible mainly thanks to the testimony and documentary support contributed by two close relatives: AVR's daughter Ana, the only one of the four children who is still alive, and who has lived much of her life, including old age, with AVR; and AVR's grandson Antonio Vela, whose father, Antonio – firstborn of AVR and Antonio Padrón – had passed on fragments of family history to him during his life. In the course of several interviews in Barcelona, we pieced together significant portions of this family story. It was in fact the complementarity of the two sources that formed the basis of our registry searches. In addition, in Torremolinos (Malaga) we interviewed a second grandchild, Ana – daughter of AVR's youngest son, Juan, who formed a family in Leicester (England) but lived the latter part of his life with his daughter on the coast of Andalusia, where he died at the age of 84.

The third and last stage of AVR's long life takes place in Barcelona, where she worked until retirement and continued to celebrate her birthday, year in, year out, with her loved ones. Again, thanks to AVR's daughter and grandson, who live in the same city, and to the care home staff where AVR spent her last years (and particularly to David González, Raquel Cubero and María Rosa Martín, director, social educator and psychologist, respectively) we have been able to document this stage of active old age that AVR enjoyed until a few years ago, and of total dependence during her last years. From this final stage we have been able to step back into the past to complement all the official data we have collected during the course of our investigation.

19.4 Origins: Puente-Genil (Cordoba), Andalusia. Beginning of the Twentieth Century

A baby girl was born on 29 October 1901 in Calle Tintor 48, in the small town of Puente Genil, municipality of Aguilar de la Frontera (Cordoba). She was baptised (Fig. 19.1) on 10 November of the same year in a church called Iglesia de la Purificación with the Christian name of *María de Santa Ana, de San Simón y San Judas*, shortly after her birth had been entered in the Civil Registry, on 30 October (Fig. 19.2) in the same town. She was the first child born to her parents following their civil marriage on 22 November 1899 and religious ceremony the following day, as recorded in the respective certificates (Fig. 19.3). AVR's mother was Carmen Rubio Becerra, born in Puente Genil, who was motherless and had AVR at the age of 24; AVR's father was Pedro Vela Carrasco,[2] born in Ronda (Malaga), a hat maker by trade and aged 27 when AVR was born. AVR, the firstborn, was followed by three brothers and three sisters: Dolores (born 8-06-1903), María Dolores (06-02-1905, following the death of Dolores, her namesake, 1 year earlier), Francisco (15-02-1908), María del Carmen (02-02-1911), Juan (01-04-1913) and Manuel (31-10-1915) (Fig. 19.4).

The family's health and living conditions were precarious in Puente Genil, a rural town in the Cordoba countryside. AVR survived in a setting where infant mortality was high (which could be a predictor of her biological strength and health preservation in the face of adverse conditions) as seen by the deaths of four of her six siblings: Dolores at 9 months, María Dolores at 5 years, Francisco at 3 years and


de la mañana; hija legítima de Pedro Vela y
de María del Carmen Rubio: Abuelos pater-
nos Francisco Vela y Ana Carrasco y mater-
nos Juan Rubio y María del Carmen Be-
cerra, el padre y abuelos paternos naturales de
Ronda y los demás de esta Villa, y se puso por
nombre María de Santa Ana de San Si-
món y San Judas; fueron sus padrinos

Fig. 19.1 AVR baptism certificate

[2]AVR's maternal grandparents were Juan Rubio Bascón and María del Carmen Becerra Morán, and her paternal grandparents were Francisco Vela Domínguez and Ana Carrasco Matoso.

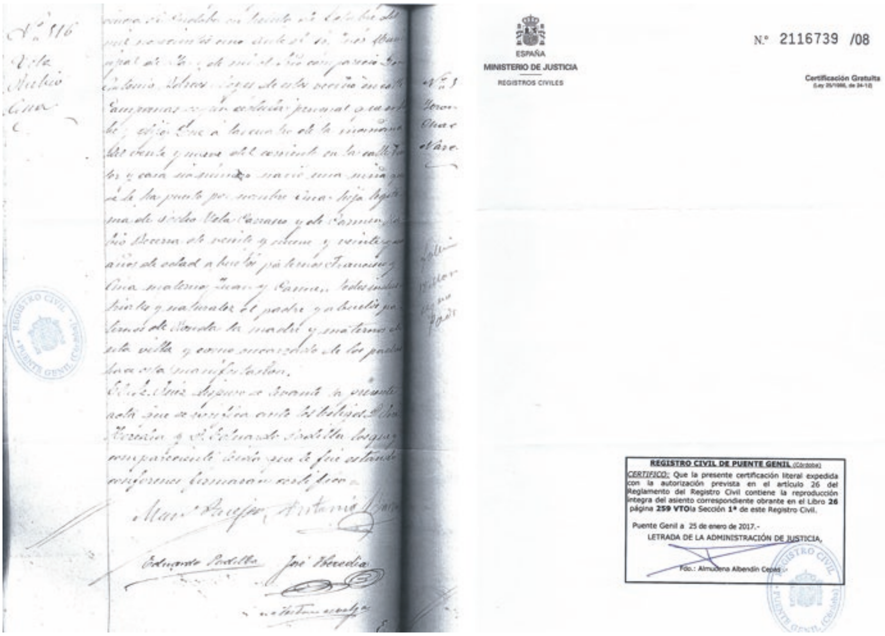

Fig. 19.2 AVR birth certificate

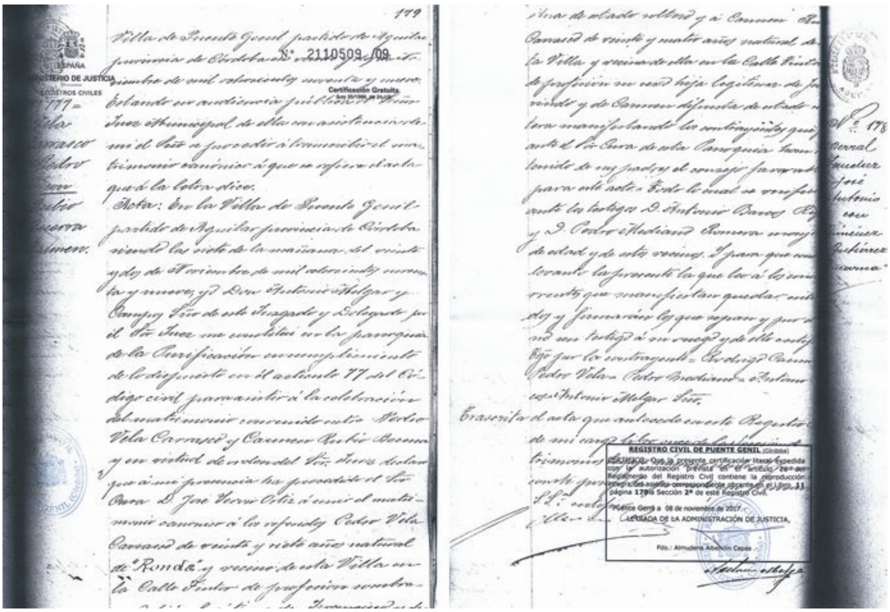

Fig. 19.3 Parents' marriage certificate

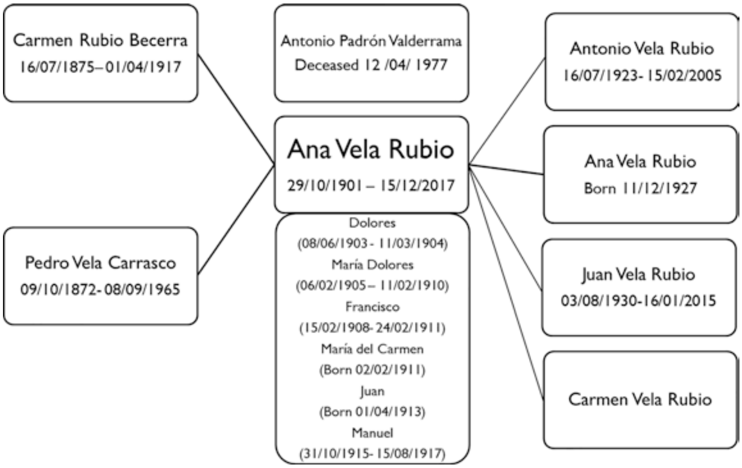

Fig. 19.4 AVR family tree

Manuel at under 2 years, a few months after their mother (Carmen Rubio) died in April 1917.[3]

AVR was the oldest of her siblings and appeared to play an essential role in the home despite her young age, as shown by the baptism records of her younger brothers, Juan and Manuel, in which she was entered as their godmother, as if she were an adult, despite being only 11 and 14 years old, at their respective baptisms. Although the figure of godmother has lost relevance over the years, it is noteworthy because in a fervently religious Spanish society at the beginning of the twentieth century, a godmother held great responsibility in the upbringing of her godchildren, especially if one of the parents died. Proof of this is the following statement in both baptism records:

> his godmother is Ana Vela (…), whom I duly cautioned of the obligation and spiritual relationship that she has herein acquired.

AVR's role as protector, in sole charge of family welfare, was also mentioned by her surviving daughter and grandchildren during the various interviews that we held. Their responses revealed that AVR's household responsibilities and care of her siblings became unsustainable shortly after her mother's death, and was compounded by the fact that her father was blind. The family's accounts were consistent in that, according to AVR, these circumstances led to her departure from Puente Genil to Malaga in the 1920s, to seek a new beginning there.

[3] With regard to AVR's two other siblings, Carmen and Juan, we know they reached adolescence at least, since they were alive in 1924, as corroborated by a margin note in their baptism records, stating that they received Catholic confirmation that year. The family story suggests that these two siblings may have spent their childhood in orphanages outside Puente Genil or even outside Andalusia.

19.5 The Birth of Her Children. Second Decade of the Twentieth Century. Malaga (Andalusia)

Carmen Rubio's death was a turning point in the life trajectory of her daughter, AVR. Her "maternal" role as an adolescent, which the family apparently assigned her during the parents' reproductive phase, increased following her mother's death, driving AVR to emigrate at a very young age, without her family, to a nearby city in Andalusia that was prosperous at the time. There, she lived her youth and early adulthood, working as a seamstress in local stores and households of the Malaga bourgeoisie. It was in one of these homes that she met her partner, Antonio Padrón Valderrama, who was to be the father of her four children. However, in view of the circumstances (testimonies from interviewees indicate that Antonio married another woman), they never married through a recognised civil or religious ceremony, and therefore AVR's descendants carry both her surnames, not the first surname of each parent – first the father's and second the mother's – which was mandatory at that time in Spain. But despite this, the couple maintained a stable relationship, according to the testimonies, and apparently for at least the early years when their children were small, the couple enjoyed a degree of tacit recognition from a social point of view among friends and neighbours in Malaga. From a research perspective, these unusual family circumstances made it harder to reconstruct the family tree, demanding highly meticulous protocols and corroboration through complementary sources during the validation process.

To all intents and purposes, AVR was a single mother who brought up her four children at number 32, calle Cuarteles in Malaga. The children, offspring of a single relationship, bore the same surnames, Vela Rubio: Antonio was born on 16 July 1923, Ana on 11 November 1927, Juan on 03 August 1930, and Carmen (Figs. 19.5, 19.6 and 19.7) was the youngest, dying in puberty in the mid 1940s, according to AVR's daughter Ana's testimony. Ana recalls her mother as a very active woman who took care of the household chores and her children's upbringing, as well as doing sewing work at home for clients, and later running a small store. She describes her mother as efficient, with no time for fun and games, but very concerned about educating her children well, a task she carried out conscientiously, if somewhat inflexibly.

The 40s and early 50s were characterised in Spain by social disorganisation and a serious economic crisis, making it hard for many families – including the Vela Rubio family – to survive at an economic level, as we learned from the in-depth interviews conducted. At the end of the Spanish Civil War in 1939, first, hunger, and later, political and economic isolation under the Franco regime, drove families to emigrate to cities that were recovering economically.

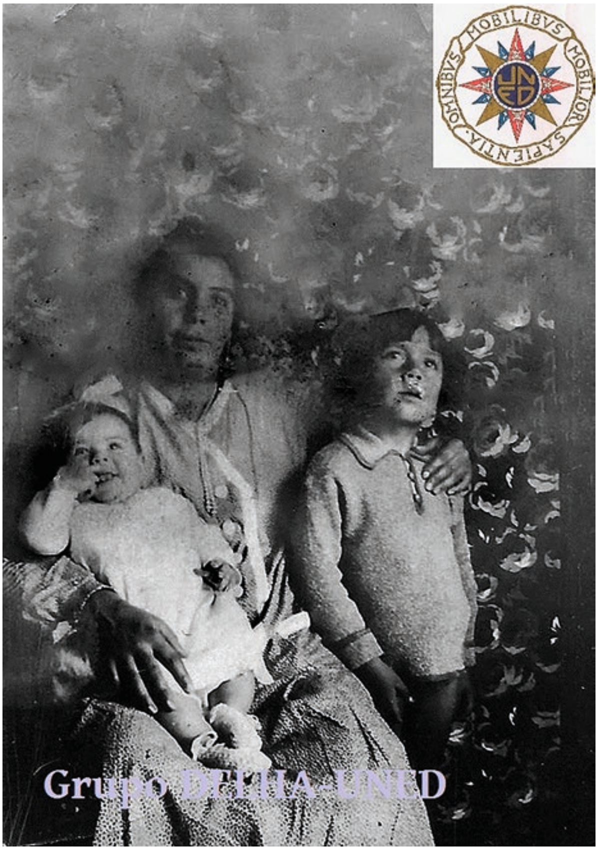

Fig. 19.5 AVR with her children, Antonio and Ana

19.6 Second Half of the Twentieth Century and the Beginning of the 21st. Catalonia and a Split into Two Family Branches: From Barcelona to Leicester (England) – Torremolinos (Malaga)

Internal migratory movements occurred throughout the Iberian peninsula, and intensified over the next two decades. The main target locations, depending on a migrant's place of origin, were Barcelona, Madrid and the Basque Country. In the case of Barcelona, extensive migratory flows came fundamentally from southern Spain. AVR and her family formed part of these Andalusian masses who increased the population in the Barcelona metropolitan area.

Fig. 19.6 AVR with her children, Carmen (bottom), Ana (top) and Juan

At the start of the 50s, Antonio (son) emigrated to Barcelona with his newly wedded wife, where he lived until his death at the age of 82. AVR and her two other children, now adults and of working age, followed her first son's path to Barcelona a few years later. Initially, they lived in various locations on the city outskirts, mainly in Tarrassa, where the former Hospital de Enfermedades del Tórax [Hospital for Chest Diseases] was located, because AVR worked at the hospital as seamstress and also lived on the grounds in the hospital nuns' home until her retirement.

Again, she proved to be a woman of character and initiative, although somewhat shy with strangers. These traits were invariably described by the people close to her throughout her life, even in the final stage of her life cycle, as a centenarian at "La Verneda" care home.

Only in the 70s did AVR and her daughter acquire a property in La Verneda area, an industrial zone of Barcelona, where a working class neighbourhood sprang up to absorb the popular classes and continued to grow throughout the second half of the twentieth century. AVR moved there in 1973, together with her daughter Ana, and lived there after retirement, for more than 30 years of her old age.

During this long period, from her arrival in Barcelona to the present day, two sub-stages can be identified, which in turn include the international migratory movements of her adult children. The first sub-stage covers the second-generation formation of new family nuclei. AVR's grandson, Antonio, son of her firstborn, was born in 1952. Antonio lived in a town near Barcelona, where his father (also Antonio) migrated with his wife a few years before Antonio was born. Antonio (grandson)

Fig. 19.7 Photo of Antonio in 1936, dedicated to his mother, AVR

(Fig. 19.8), our second informant, his children and grandchildren still live in Barcelona. They are an example of a four-generation family's survival, coexisting at the time of AVR's 116th birthday in October 2017. Together, they were able to celebrate her exceptional longevity. With higher education and professional qualifications, this family branch has remained in the autonomous community of Catalonia and has followed the process of marked ascending social mobility in this area, which also characterises and represents the process followed by a large majority of Spanish families in the second half of the twentieth century.

As mentioned earlier, Ana (daughter) has lived much of her life, including her old age, with her mother. For this reason, she has been our principal informant until now, and still is at the age of 90. However, Ana emigrated to Leicester (England) in her youth, where she continued to work as an auxiliary nurse, having started nursing in Barcelona. After this migratory experience, she returned to Barcelona, where she concluded her nursing studies and married in the early 80s. Years later, divorced and

Fig. 19.8 AVR with her grandson Antonio (1960s)

childless, Ana returned to her maternal home at number 179, calle Josep Pla, formerly General Manso, where she lived until July 2017 when she sustained a hip fracture and finally had to be admitted to the same care home as her mother, benefitting from the right to family reunification, given the circumstances.

In parallel, AVR had a second branch of descendants, the children of Juan, the youngest son, who emigrated in his sister Ana's footsteps to Leicester, and also worked in the English National Health Service. Juan married a woman of German origin and they had three children (Wolfgang, Elmar and Ana María). The youngest of the three, Ana María,[4] has been our third informant. AVR's youngest son, Juan, stayed in Leicester until retirement. The interviewees – both close family members and other more distant relatives from our supercentenarian's extended family who

[4] It should be noted that in her youth, Ana (granddaughter) adopted the double surname, Vela Rubio, of her grandmother and her father, breaking the single surname tradition of the English-speaking world, and thus adding a third generation of women in the family who bear identical first name and surnames.

live in Malaga province – remember Juan as an enterprising man, who retired in England and returned to Andalusia as a widower, where he lived until his death in Torremolinos (Malaga) near his English daughter who married a Spaniard. Following his return from England, Juan re-established and nurtured his relationship with cousins living in the province of Malaga but born in Puente Genil, who put him in touch with relatives and acquaintances from his mother's town. Although their marked English accent have made it hard to identify Juan and his daughter as Spaniards, together they have closed the family trajectory circle through the family branch that has returned to Andalusia.

This English-Andalusian branch has also contributed to AVR's flock of great-grandchildren; some live in Barcelona, some in Torremolinos and some in the United Kingdom. As a whole, there are more than twelve members of this third generation.

Despite its peculiarities, it is remarkable how this family expanded and integrated wherever they moved to, without losing track of their past. Today, Ana (daughter) still retains the soft Andalusian accent of her Cordoba-Malaga birthplace and childhood, recalling her ancestors' origins. AVR's accent was similar, until her cognitive deterioration advanced.

AVR's final stage in Barcelona refers to her period of advanced age, mainly from the time of her admission to "La Verneda" care home (Fig. 19.9). Located in the heart of AVR's neighbourhood, "La Verneda" is a day centre combined with a residential unit, managed by the Fundación Salud y Comunidad [Health and Community Foundation]. This dual-purpose centre allowed AVR to enjoy her long old age in an ideal setting, while adapting to her changing state of health and to the process involving her gradual loss of autonomy, characteristic of her advanced age. AVR attended first the day centre, from the age of 104, while she was independent and in a good state of health and mobility, requiring no more than the aid of a walking stick. Then, on 18 April 2008, at the age of 106, she moved into the residential unit. From her early years at "La Verneda", AVR was recalled as an autonomous, very active, independent person, with initiative, as characterised by her ready participation in activities, dances, parties and other events. She was cooperative and willing to help others, as far as her incipient age-related dementia would allow. She remained in this state until she had a fall and broke her leg (a femoral fracture), which drastically limited her mobility. According to the staff, this triggered a progressive deterioration in her health and autonomy and, in turn, an increasing need for care. Although she looked younger than her chronological age, AVR was wheelchair bound in her later years. Despite not having any illness requiring the polypharmacy that is commonly found in older people – except for medication to alleviate the consequences of her forced sedentary lifestyle – she was in a state of high dependence from the age of about 110, with very advanced cognitive deterioration, responding less and less to external stimuli. At our last visits (Fig. 19.10), we observed a response only to two types of stimuli: music rhythm, and above all, to the caresses of her daughter Ana (Fig. 19.11), responding to these stimuli while constantly babbling, with words that sounded like "*mummy…mummy"*, sometimes also accompanied by emotional facial gestures in mother and daughter.

Fig. 19.9 Places where AVR lived: Calle Tintor (Puente Genil), Calle Cuarteles (Malaga), Calle Josep Pla and La Verneda care home (Barcelona)

Fig. 19.10 AVR with her daughter Ana, Rosa Gómez-Redondo and Ramon Domènech. June 2017

Fig. 19.11 AVR on her 116th birthday, with her daughter Ana. October 2017

On 15 December 2017, shortly after finishing this chapter and 6 weeks after celebrating her birthday, Ana died peacefully in her sleep at 3.30 a.m. on a wintry morning in "La Verneda" care home, Barcelona, at the age of 116 years and 47 days, thus relinquishing her privileged position as the oldest living woman in Europe.

19.7 Conclusion

We believe that the longevity of this Spanish supercentenarian is amply validated through the various documents we have obtained from the multiple sources consulted during our investigation, together with the information obtained from the various interviews with family members spanning two generations of AVR's descendants, and also through the technical and multidisciplinary details provided by the staff at the care home where she spent the last 12 years of her life.

Despite being an atypical family with a single legally-responsible parent – which presented some challenges when we started our investigation due to the gaps in the family's account of their history – and given the prevailing values in Spanish society in the period when AVR and her children were brought up, AVR's family later showed keen and recurrent interest to recover their complete family story. The study has been more complex for the above reasons, but this has given us the opportunity to broaden the investigation scene by following the stages in AVR's life cycle, meeting and getting to know her relatives, friends and neighbours, and reconstructing – with their testimonies – an exceptional life cycle of demographic and social survival. This study provides evidence that the three children who survived to adulthood got to know each other better during old age and coexisted with their mother, Ana Vela Rubio: one of the longest-living women in Europe of the twenty-first century.

Acknowledgements We were able to conduct this investigation thanks to the support of various people in different contexts, to whom we are very grateful:

Family context:

– Ana (daughter), family memory and guide. Ana was the first and main informant in this study.
– Antonio (grandson) collaborated with us and understood the scientific interest of our work.
– Ana (granddaughter) helped us enthusiastically to recover her family history.
– Agustina and Carlos provided useful information when we were searching for the last testimonies in Puente Genil.

Professional context:

– David González, director of "La Verneda" care home, and his team, whose professional skills aided our investigation.
– The staff at the Civil Registry Office of Puente Genil. In particular, Iván Jesús Ruiz (Judge), Leo Vigildo Marto, (Civil Registry head clerk) and Almudena Albendín (court secretary).
– José Manuel Gordillo (priest of the Iglesia de la Purificación) in Puente Genil.
– Noelia Cámara, member of Spanish supercentenarian data verification team for the IDL.
– Staff at the National Statistics Institute, and in particular Carmen Salaices, Head of the Area of Natural Population Movement.

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Chapter 20
Validation of 113-Year Old Israel Kristal as the World's Oldest Man

Wacław Jan Kroczek and Robert Young

20.1 Biography

Mr. Kristal's life story is remarkable, as being a Holocaust survivor was only the worst of many hardships he had to face. Israel Kristal was born as Izrael Icek Krysztal to Mojżesz Dawid Krysztal and Brucha Krysztal (nee Rojt) in the village of Malenie (then part of the Russian Empire; now located in Łódź Voivodeship, Poland) on Sept. 15, 1903. His mother died just 10 years later, in 1913.

As his father was drafted during World War I, Kristal was forced to work hard on a farm to earn his living as a teenager. In 1920, he was reunited with his father and siblings in Łódź, where the family opened a confectionary. Israel Kristal became a candy maker, which would remain his lifelong profession; in articles written about him later, his candy making career would prompt reporters worldwide to refer to his "bittersweet long life.". In 1928, at the age of 25, Israel Kristal married Chaja Fajga Frucht in Węgleszyn, Poland. The couple had two children. The Kristal family ran a local chocolate and candy business until the outbreak of World War II, when Łódź was occupied by Nazi Germany. The Nazis forced the Jewish population of Łódź, including the Kristal family, to move to a district called the "Litzmannstadt Ghetto." Israel Kristal lived there for 4 years, until he was deported to Auschwitz in August 1944, where he remained for another 3 months. Subsequently, he was a prisoner in the labor camps of Wuestegiersdorf, Doernau, and Schottenwerk. He regained his freedom in May 1945, when the Allied forces liberated the Schottenwerk camp. Although his wife and children had been killed in the Holocaust, Israel Kristal did not lose his will to live after this devastating loss. Instead, he returned to Łódź, where he restarted his confectionary business and married his second wife, Szejwa (nee Chuda). Together, they had a son: Chaim Dawid. In 1950, Mr. Kristal and his family decided to leave Poland to settle in Haifa, Israel, where he lived until his

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death. In September 2016, Israel Kristal turned 113 years of age, and the family celebrated his Bar Mitzvah. This coming of age ritual is traditionally held at the time of a Jewish boy's 13th birthday, but Israel Kristal was unable to celebrate his Bar Mitzvah 100 years previously because when he turned 13, World War I was raging and his family was separated. He died at his home in Haifa on Aug. 11, 2017, at the age of 113 years and 330 days (Stephenson 2017).

20.2 Research

The research performed to validate Mr. Kristal's age turned out to be very challenging. The investigation lasted a total of 2 years, and can be broken down into four phases.

Phase I (May 2014 – July 2014)

Reports that Mr. Israel Kristal was the oldest living Holocaust survivor first appeared upon the passing of Alice Herz-Sommer in the spring of 2014 (even though he was already older than she was). This marked the beginning of the validation effort. Some early reports mistakenly named his place of birth as Tarnów (instead of Żarnów), a city located in Lesser Poland Voivodeship. Thus, an attempt to obtain a record of his birth from the Tarnów registry office was unsuccessful. The focus of the investigation shifted to confirming that Mr. Kristal had lived in the Jewish ghetto in the occupied city of Łódź. With the assistance of GRG-Germany correspondent Stefan Jamin, we obtained several registration lists from the Litzmannstadt Ghetto dated from 1940 to 1942, which provided middle-life evidence of Mr. Kristal's age. We then suspended our research because of the lack of sufficient information.

Phase II (August 2014–October 2014)

The second phase of the research started when reports on Mr. Kristal's upcoming 111th birthday appeared in August 2014. At that time, more detailed information about Mr. Kristal's place of birth was disclosed, which indicated that Mr. Kristal had been born in Żarnów, not Tarnów. Further research was therefore performed at the local archive unit in Piotrków Trybunalski and at the registry office of Żarnów. The Jewish registry books from both places were checked, but the requested birth record was not found. There were two gaps in the documentation. The books of births for the years 1905 and 1907 for Żarnów synagogue district were reported as missing, and no entry for Mr. Kristal's birth could be found in the Żarnów birth registry books for the years 1903, 1904, 1906, 1908, or 1909. Independently, the registry office of Żarnów checked the Jewish community's birth records until 1945, but could find no mention of the name Kristal. At that time, it was common practice among Jewish families in Poland to report the births of several of their children in a single year. Hence, it was possible that the children of Moszek-Dawid Kristal, Israel's father, were reported in one of the missing years. We continued our research in the Łódź archive in the hopes of discovering a registration list that included Israel Kristal's name. Meanwhile, we filed a request with the Kielce archive to grant us permission to research the population lists for Żarnów. Unfortunately, neither the research in Łódź nor in Żarnów proved fruitful. Researchers at the Łódź archive combed through the collections of the Łódź Jewish religious community, electoral lists of the Jewish religious community in Łódź, alphabetical lists of taxpayers of the school and synagogue in Łódź, city acts of Łódź, and records of the resident population of Łódź for the years 1903–1931. Still, the name of Israel Kristal was nowhere to be found. By October 2014, it appeared that the research on Mr. Kristal had hit a dead end.

Phase III (July 2015–December 2015)

The third phase began when we established contact with Mr. Oren Kristal, Israel Kristal's grandson. Oren Kristal provided us with more detailed information about his grandfather's place of birth than had previously been reported: namely, that Israel had been born in a village with a name that could be translated into English as "Little nothing" (Polish: małe nic). After looking at the map of the region, found two villages that might fit this account: Malenie and Maleniec, both of which were within the Żarnów synagogue district. Meanwhile, Mr. Kristal provided us with additional materials, including middle life evidence dated to 1949 and 1955. Oren Kristal also gave us information on the exact place of Mr. Israel Kristal's first marriage, which he referred to as "Wingelsin." After a thorough examination of the maps of the region, we found the village of Węgleszyn, which lies 60 km south of Żarnów. Currently, Węgleszyn is located in Oksa Commune, Świętokrzyskie Voivodeship. When contacted, the registry office in Oksa said they did not have the record, and advised us to contact the state archive in Kielce. Another request was sent to the archive to investigate the population lists for the village of Malenie. The response to this inquiry, which arrived in October, was negative. However, it came to our attention that at the time of Mr. Kristal's marriage, Węgleszyn belonged to the Małogoszcz Commune and not the Oksa Commune, as was previously thought. When we called the Małogoszcz registry office in December, we finally made our long-awaited breakthrough. The record of Israel Kristal's first marriage to Chaja Feige Frucht from 1928 was discovered. Although the document was not issued within the first 20 years of the claimant's life, and thus does not meet modern early-life evidence standards, the chances that Mr. Kristal's reported age was authentic increased substantially with this discovery. Under a law enacted by the Second Polish Republic, all Polish brides and grooms, including all Jewish couples, were required to present a valid document verifying their reported date of birth, such as an extract of a birth record, if they wished to marry in another synagogue district. As Israel Kristal had been born in the Żarnów synagogue district but was marrying in Węgleszyn, he would have been required to present such a document. Due to some bureaucratic issues, we had difficulties obtaining that particular document. Although we also asked for permission to research the population lists of the other, similar sounding village of Maleniec and the village of Węgleszyn, we were unable to obtain any new information from these lists due to the lack of surviving documentation. Oren Kristal confirmed reports that the Kristal family was impoverished at the time Mr. Kristal's father was called to serve in the army, and that his mother had died young. As we pieced this story together, it became clear that young Israel's family was in such dire straits by the time he reached age 13 that he was unable to follow the Jewish tradition of celebrating his Bar Mitzvah. Because Mr. Kristal had no Bar Mitzvah celebration, there was no document providing evidence of his age for that period of time.

Phase IV (January 2016–February 2016)

Mr. Yasutaro Koide of Japan, the GWR- and GRG-recognized World's Oldest Man, passed away on Jan. 19, 2016, at the grand age of 112, leaving Israel Kristal as a leading candidate for the Guinness World Records' title of World's Oldest Man. The research into Mr. Kristal's case entered the decisive phase soon thereafter. Also around that time, Mr. Kristal's life became a topic of interest for Haaretz journalists. We contacted Stanley Diamond and Michael Tobias of Jewish Records Indexing-Poland, an organization specializing in the field of Jewish genealogy. They had contributed to the important discovery of the 1918 Łódź Registration Card for the Kristal family, on which Izrael Icek's name had been added when he reunited with his family in 1920. This evidence of his arrival in Łódź in order to work in the family's confectionery business was consistent with the reports and stories of the Kristal family. After the war, Mojżesz-Dawid Kristal settled in Łódź with his surviving family members. Young Israel was not present in Łódź at the time the record was made, but he joined his family 2 years later. This timeline explains why his name was added to the entry for the Kristal family in the 1918 Łódź census, and why a corresponding notification was added in the margin. At that point, a piece of early-life evidence that meets modern validation standards had finally been discovered. Shortly thereafter, Oren Kristal provided us with late-life evidence in the form of an ID card issued in 2013, which was translated from Hebrew.

20.3 Validation

The age of Israel Kristal is confirmed by the following documents:

I. Łódź census (1918) – This bilingual document, written in German and Polish, mentions a Kristal family residing in the city of Łódź as of 1918. The document was created before the end of World War I, when Łódź, along with part of the Congress Poland, which was still a de-jure part of the Russian Empire, was administered by the German Empire. In the document, Kristal, or the German form of the family name, was used instead of Kryształ, the Polish version of the name. We were therefore able to confirm that the document was created before Nov. 11, 1918, which marks the end of WWI and the independence of Poland. The document mentions Mojżesz Dawid (given names in

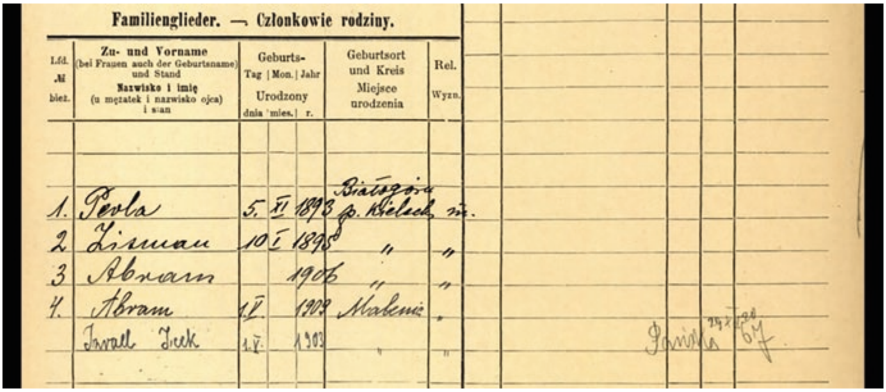

Fig. 20.1 Israel Kristal's entry in the 1918 Łódź census

Polish), head of the family, who came to Łódź from Maleniec on Apr. 15, 1918. His profession was recorded as glazier, which is in line with news reports and family stories. His religion was listed as Jewish and his nationality as Polish. Several other household members were also recorded: Perla, Zirman, Abram, Abram, and – importantly for the purposes of our study – "Izrael Icek", born in Malenie, on "1 V 1903" (see Fig. 20.1). It is notable that Izrael Icek was added to the list later, just as the 1920 paragraph says. This event accords with reports and family stories that claim that Israel Kristal, aged 17, arrived in Łódź in 1920 to work in the family confectionary business. He lived with his family at 27 Średnia Street, District V. The paragraph next to the addition of Izrael Icek's name was written on Oct. 29, 1920. Oren Kristal confirmed that the information on the document corresponds to a family story in which it was claimed that Israel's father did not know that his son was alive. According to this story, Israel, who had been on his own since the beginning of the war, was 16 years old when he left the farm where he had been working after the war ended, and walked barefoot until, a year later, he finally reunited with his father. This document is of crucial importance. It is the only piece of early-life evidence that supports the claim that Israel Kristal was born in 1903. Thus, the requirement of modern age validation standards that evidence from the first 20 years of life is provided has been met (Poulain, 2010).

II. Delayed birth record (1927) – This document was attached as an allegate to the marriage record found in the Małogoszcz registry office. The document mentions Izrael Icek Krysztal (the Polish version of his name), a son of Moszek Dawid [Kryształ] and Brucha Rojt. In this document, the entries on his year of birth (1903) and his place of birth: (Zarnow) are consistent with his claims. The delayed birth record of his wife, Haja Feigla Frucht, who was born in Wegleszyn on Nov. 12, 1909, was also attached.

III. Marriage record (1928) – The document mentions the marriage between Izrael Icek Kryształ, aged 25, and Haja Fajgla Frucht, aged 19. The document was issued in Małogoszcz on Apr. 22, 1928. Israel Kristal was mentioned as having been a resident of Węgleszyn at that time. The names of his parents (Moszek Dawid and Brucha Rojt) and the place of birth (Żarnów, Opoczno County) entered in the document are consistent with information in previous records. The years of birth listed for both Israel and Haja (1903 and 1909) are in line with those recorded in the Litzmannstadt Ghetto documentation from the 1940s.

IV. Application for the ID card (1931) – The details on this card are consistent with those of previous records. The document contains the earliest known picture of Mr. Kristal, who was then a young man in his late twenties.

V. Litzmannstadt Ghetto documentation (1940–1944) – This collection of documents consistently mentions Izrael Icek Kryształ as living in the ghetto together with his wife in residences on the following streets: Veit Stoss, Cranach, and Muehlgasse.

VI. Relocation documentation (1944) – The documentation mentions the exact date of Israel Kristal's birth: "Sept. 15, 1903," as well as the correct names of his parents. It also mentions his former places of residence. The documentation indicates that Israel Kristal lived in Litzmannstadt (German name of Łódź) until the liquidation of the ghetto in August 1944. On Aug. 23, 1944 he was deported to the Auschwitz-Birkenau concentration camp, where he remained until October 1944. He was then transferred to the Wuestegiersdorf, Schottenwerk camp in October 1944; to the Doernau camp in November 1944; and again to the Schottenwerk camp in February 1945. He was freed on May 11, 1945, when the Allied forces liberated the Schottenwerk camp. Chaja Feige Krysztal and their two children did not survive.

VII. Confirmation of Polish citizenship (1949) – This document mentions Izrael Icek Kryształ (again using his Polish name) living in Łódź after World War II. The unique identifiers are consistent with those in the earlier documentation: birth on Sept. 15, 1903, in Żarnów; parents Moszek Dawid and Brucha Rojt. It also includes details on his second wife, whom he married after the war: Szejwa nee Chuda, born in Łódź on Apr. 24, 1923. The couple had one son, Chaim Dawid, born in Łódź on Feb. 24, 1948. The document was issued on Apr. 12, 1949. This is the earliest document that was in Oren Kristal's possession.

VIII. ID card (2013) – This is the piece of late-life evidence that confirms Israel Kristal's identity. It mentions his birth place and year as Poland in 1903, the names of his parents as Moshe and Brucha, and his current residence as Haifa (Table 20.1).

It should be noted that the name of Mr. Kristal's father appears in three different versions throughout the documentation. Which version was used varied depending on which country's administration was operating in the region at the time each record was made. The region was part of the Russian Empire until 1918, when it

Table 20.1 Examination of unique identifiers for Israel Kristal

Year	Given name	Spouse	Father	Mother	Family name	Residence
1913	Not stated	–	Moszek Dawid	Brucha Rojt	Kryształ	Żarnów
1920	Izrael Icek	–	Moszek Dawid	Brucha Rojt	Kryształ	Łódź
1928	Izrael Icek	Haja Fajgla Frucht	Moszek Dawid	Brucha Rojt	Kryształ	Węgleszyn
1931	Izrael Icek	–	Moszek Dawid	Brucha Rojt	Kryształ	Łódź
1940	Izrael Icek	Chaja Fajga	–	–	Kryształ	Łódź (Litzmannstadt)
1940	Izrael	–	Moszek	Brucha	Kryształ	Łódź (Litzmannstadt)
1941	Izrael	–	Moszek	Brucha	Kryształ	Łódź (Litzmannstadt)
1942	Izrael	–	Moszek	Brucha	Kryształ	Łódź (Litzmannstadt)
1942	Izrael	–	Moszek	Brucha	Kryształ	Łódź (Litzmannstadt)
1942	Izrael Icek	–	Moszek	Brucha	Kryształ	Łódź (Litzmannstadt)
1942	Izrael Icek	–	Moszek	Brucha	Kryształ	Łódź (Litzmannstadt)
1942	Izrael Icek	Chaja Fajga			Kryształ	Łódź (Litzmannstadt)
1942	Izrael Icek	Chaja Fajga			Kryształ	Łódź (Litzmannstadt)
1944	Israel	–	–	–	Kristall	Auschwitz-Birkenau
1945	Israel		Mosche David	Bracha Rojth	Krystal	Łódź
1945	Israel	Chaja Feigel	Mosche David	Bracha Rojth	Krystal	Łódź
1949	Izrael Icek	Szejwa Chuda	Moszek Dawid	Brucha Rojt	Kryształ	Łódź
2013	Israel		Moshe	Bracha	Kristal	Haifa, Israel

became part of Poland. Between 1915–1918 and 1939–1945, the region was occupied by Germany. Mojżesz and Moszek are two Polish versions of the same name, while Mosche is the German version. The family name was also variously recorded as Kryształ, the Polish version; or as Kristal, the German and Yiddish version. Similarly, there were two versions of his mother's name: Brucha Rojt in Polish and Bracha Rojth in German and Yiddish. Litzmannstadt is the German name of the city of Łódź. According to his family's reports, which were confirmed by the 1918 Łódź census, the exact place of Mr. Kristal's birth was Malenie, a little village that

Table 20.2 Israel Kristal's age validation

Time	Sort of document	Documented age/date of birth
Dec. 1913	Mother's death record	–
1918 (de facto Oct. 29, 1920)	Łódź census	"1 V 1903" – May 1, 1903
Nov. 10, 1927	Delayed birth record	1903
Apr. 1928	Marriage announcement	25 (accords with Sept. 15, 1903 -age possibly rounded)
May 8, 1931	Application for ID card	1903
May 24, 1940	Litzmannstadt Ghetto registration card	1903
Dec. 3, 1941	Litzmannstadt Ghetto registration card	1903
June 19, 1942	Litzmannstadt Ghetto registration card	1903
June 21, 1942	Litzmannstadt Ghetto registration card	1903
Oct. 4, 1942	Litzmannstadt Ghetto registration card	1903
Oct. 5, 1942	Litzmannstadt Ghetto registration card	1903
1940	Litzmannstadt Ghetto residents' list	1903
1942	Litzmannstadt Ghetto residents' list	1903
1942	Litzmannstadt Ghetto residents' list	1903
1944	Deportation record	Sept. 15, 1903
1945	Vad Yashem card	Sept. 15, 1903
1945	Relocation record	Sept. 15, 1903
Apr. 12, 1949	Citizenship confirmation	Sept. 15, 1903
Jan. 1, 2013	ID card	1903

currently has fewer than 30 inhabitants. The village belonged to the Żarnów synagogue district and to the greater region of Łódź (Łódź Voivodeship between 1918 and 1939). Given these unique identifiers, it has been proven beyond a reasonable doubt that the gathered documentation concerns one and the same person: Izrael Icek Kryształ, who later became known as Israel Kristal (Table 20.2).

The gathered documentation confirms Mr. Kristal's claim that he was born on Sept. 15, 1903. Indeed, the earliest document mentions an earlier date, May 1, 1903, which suggests that Mr. Kristal might have been even older than he claimed, and thus reached age 114. However, no other piece of evidence supports that date. All of the other documents either mention a birth date of Sept. 15, 1903, or are otherwise in line with this date. It is important to note that the date of Sept. 15, 1903, appears in the documentation for the first time in 1945. In the earlier documentation, with the exception of the Łódź census, only the year of birth (1903) is mentioned. Yet this information still corresponds to the reported birth date of Sept. 15, 1903. There is a considerable amount of middle-life evidence and early-life evidence from the first 20 years of life that supports the claim that Israel Kristal was born in 1903. Thus, there is sufficient evidence that meets modern age validation standards. In sum, we contend that while the case of Mr. Kristal was extremely difficult to confirm, there is strong reason to believe that Israel Kristal was born on Sept. 15, 1903, as Izrael Icek Krysztal in Malenie, Russian Empire (now Poland), and died in Israel, on Aug. 11, 2017, at 113 years of age.

20.4 Conclusion

The authors confirmed the authenticity of Israel Kristal's age on the basis of the gathered documentation, which includes early-, middle-, and late-life evidence. The biggest concern that arose in the case of Israel Kristal was the lack of a birth record. Given that the census records are often a reflection of the respondents' memories, both May 1, 1903, and Sept. 15, 1903, may have been manufactured dates of birth. It is worth noting that one of Izrael Icek's brothers, Abram, was recorded as having the same date and month of birth. Hence, it is possible that the census enumerator wrote the same details twice, or that the younger Abram was an adopted child, as there were many war orphans at that time, and giving the same name to two children in a row was not common practice. The theory that the younger Abram was adopted is strengthened by the mother's death record from 1913, which mentions that she was survived by three children. The oldest of those children, Perla, would have been 20 at the time of the mother's death, so it is possible that she was no longer counted as a child. Based on our experiences in researching cases of extreme longevity and supercentenarians in Poland, we believe that reports of the ages of people born in the territory of present-day Poland are reliable, because in the early twentieth century, Poland had a well-developed system of birth registration. Moreover, cases of age exaggeration are rare in Poland, and the few cases that have occurred were mainly among the population of repatriates who may have misreported their age when they needed to produce new documents after moving from the territory of one country to the territory of another. Whether Israel Kristal had the need to recreate documents at any point in his life in Poland is unknown. It is peculiar that his delayed birth certificate, which he presented at the office where he married Chaja Frucht a few months after, listed the year (1903) but not the day and month of his birth, whereas his future wife was able to present a delayed birth certificate on which her full date of birth was recorded.

Israel Kristal's case represents an important intermediate step in the expansion of the worldwide IDL and GRG databases into Poland and Israel. Mr. Kristal's age is significant, as it is one of the 10 oldest ages ever validated for men. Mr. Kristal is also the oldest Polish-born person on record, the oldest Jewish man on record, and the Guinness "World's Oldest Man" titleholder for over a year and a half (January 2016–August 2017). There is consistent documentation of Mr. Kristal's age from

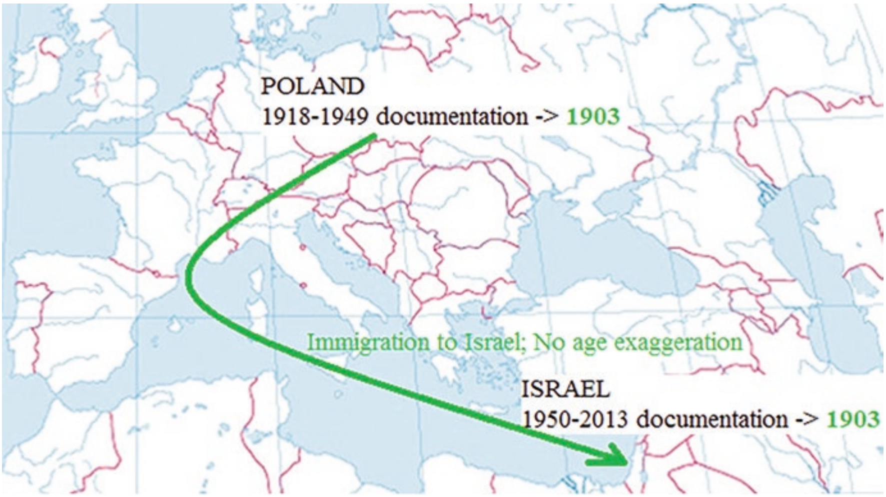

Fig. 20.2 Israel Kristal's claim was unaffected by the migration between countries

both of his countries of his residence: first Poland, and then Israel. His reported year of birth is consistently supported by all of the gathered evidence, including one document issued within his first 20 years of life. Thus, there is evidence that meets the early-life evidence requirements of modern validation standards. Given that Mr. Kristal was born in the area of present-day Poland, and not outside its modern eastern border, he is not among the population of emigrant supercentenarian claimants who have been suspected of age exaggeration. While some Polish individuals who claimed to be supercentenarians were found to have exaggerated their age, this exaggeration occurred while they were migrating between countries in the World War II era. It has been proven that Israel Kristal did not exaggerate his age either during the war or upon his migration from Poland to Israel (see Fig. 20.2; confirmed by the located evidence). The risk of age misreporting was therefore low in this case. As Poulain (2010) has pointed out, age validation is never definitive, and may always be reconsidered if a new piece of evidence that seems incompatible with the previous conclusion is discovered. In sum, given that the documents that were uncovered in the case of Israel Kristal span nearly a century and contain many unique identifiers that confirm his identity – and that the gathered documentation is consistent with the stories told by the family – we consider this case to be validated at least to the standard of validation by proxy, as an early-life census entry was substituted for the original proof of birth.

In conclusion, based past research of similar cases and the gathered evidence, Guinness World Records and the Gerontology Research Group deemed the case of Israel Kristal validated, with his official date of birth recognized as Sept. 15, 1903.

Acknowledgements The authors would like to express special thanks to Mr. Oren Kristal, the grandson of Mr. Israel Kristal for his cordial cooperation by the validation of the age of his notable grandfather; Messrs. Stanley Diamond and Michael Tobias of Jewish Records Indexing for providing the crucial breakthrough in our research; and Mr. Stefan Jamin, GRG Correspondent for Germany, for his valuable assistance and advice in the research.

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Chapter 21
Age Verification of Three Japanese Supercentenarians Who Reached Age 115

Yasuyuki Gondo, Nobuyoshi Hirose, Saori Yasumoto, Yoshiko Lily Ishioka, Hiroki Inagaki, Yukie Masui, Yasumichi Arai, and Yasuhiko Saito

Compared to other countries, Japan is the world leader in longevity and has the largest proportion of centenarians par total population. According to Japan's Ministry of Health, Labor and Welfare, the number of centenarians living in the country as of September 2017 was 67,824. However, there are only eight known cases in Japan of individuals surviving to age 115 (Table 21.1). This chapter presents the life histories of three Japanese supercentenarians who lived more than 115 years, and provides details of the age verification processes used to confirm their ages. The first case is that of Mr. Jiroemon Kimura (J.K.), who was the longest-lived man in the world. He passed away in June 12, 2013, at the age of 116 years and 54 days. The second case is that of Mrs. Misao Okawa (M.O.), who was the first Japanese person to reach the age of 117 years. She passed away on April 1, 2015, at the age of 117 years and 27 days. The third case is that of Mrs. Chiyo Miyako (C.M.), who was alive at the age of 117 years when We wrote this chapter in June 11, 2018. She was ranked as the oldest living person in the world after Mrs. Nabi Tajima (117 years and 260 days

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Table 21.1 List of Japanese supercentenarians who reached age 115 years (as of July 23, 2018)

Number	Name	Born	Died	Years	Days
1.	Tane Ikai	January 18, 1879	July 12, 1995	116	175
2.	Chiyono Hasegawa	November 20, 1896	December 2, 2011	115	12
3.	Jiroemon Kimura	April 19, 1897	June 12, 2013	116	54
4.	Koto Okubo	December 24, 1897	January 12, 2013	115	19
5.	Misao Okawa	March 5, 1898	April 1, 2015	117	27
6.	Nabi Tajima	August 4, 1900	April 21, 2018	117	260
7.	Chiyo Miyako	May 2, 1901	July 22, 2018	117	81
8.	N.A. (anonymous)	March 15, 1900	September 27, 2015	115	196

old), who considered the longest-lived Japanese person. Regretfully, we were unable to contact Mrs. Tajima.

21.1 Data Sources Available for the Age Verification of the Oldest-Old in Japan

The data sources that can be used in Japan to verify a person's age may be categorized as official administrative data or non-official data. The official data are issued and maintained by governmental authorities. For example, school systems may keep records that refer to their former pupils, while companies may keep records that refer to their former employees. The non-official data sources include stories told by family members and acquaintances, as well as media reports.

21.1.1 Official Data

21.1.1.1 Administrative Data Sources

The **KOSEKI** (the Family Register) and the **JUMIN-KIHON-DAICHO** (the Resident Registry) are the primary sources used for age verification in Japan. The **KOSEKI** is based on the registered residence of the family, whereas the **JUMIN-KIHON-DAICHO** is based on the current place of residence, which is in turn linked to the Family Register. When all of the family members have moved out the family's residence due to marriage or death, the family's **KOSEKI** is relabeled JYOSEKI and is placed in storage. The Japanese system of KOSEKI was first established in 1872. Evaluations of the first few decades of the records have shown that the data are unreliable. With regard to the ages of centenarians, any records issued since 1972 are considered reliable (Wilmoth and Lundstrom 1996). The faulty registration of age is much less likely to occur among newborns than among people who are reporting their age while in their sixties or seventies. However, even though this system is relatively reliable, centenarians were misidentified using the data from these registers in 2010 (Saito et al. 2012). This occurred mainly because deaths recorded in the Resident Registry were not transferred to the Family Register. There were even some cases in which family members intentionally avoided reporting the deaths of centenarians in order to receive pension money from the government. Local governments finally discovered these cases by conducting face-to-face interviews with registered centenarians.

The **ZENKOKU KOUREISHA MEIBO** (the list of oldest-old survivors in Japan) was published for a short period of time only (until 2003) by Japan's Ministry of Health, Labor and Welfare. The list was compiled based on the **JUMIN-KIHON-DAICHO** for the purpose of identifying centenarians for sending award of celebrating longevity by the Japanese prime minster. As the lists had been semi-open to the public, we used them to identify centenarians.

21.1.1.2 Data Sources Related to Education and Employment

Documents Related to Education are also useful sources for verifying age. Because almost 100% of Japanese children were enrolled in primary school in 1905, the likelihood of being able to find the name of a particular graduate in the graduation lists is high. In addition, some elementary schools have published a book celebrating the 100-year anniversary of the school's founding in which the names of past graduates are published.

Employment Records can include information on the work-related records of former employees. If an organization that employed a centenarian still exists today, the employment records of the individual may be available for age verification.

21.1.2 Non-official Data Sources

Among the non-official data sources that can be used in the age validation process are the centenarian's personal memories, the testimonies of his/her relatives, a diary or an autobiography written by the centenarian, and media reports. As the reliability of these data is lower than that of data from official sources, the accuracy of the information extracted from non-official data sources must be double-checked using a third source, such as the records of historical events. Checking whether stories that have been told/written by/about the centenarian are consistent with historical records can help us avoid misidentifying a person.

21.2 Age Verification of Three Supercentenarians

As participants in the Tokyo centenarian study and Japanese semi-supercentenarian study (Arai et al. 2014), the first (Y.G.), second (N.H.), fourth (H.I.), and fifth authors (Y.M.) of this article have conducted face-to-face interviews with the three supercentenarians when they were centenarians, and with their family members. In the following sections, we describe the life histories of the three supercentenarians along with the sources we used to verify the person's age in each case.

21.2.1 CASE 1: Jiroemon Kimura (J.K)

We have previously published an article in which we explained how we verified the age of J.K (Gondo et al. 2017). Thus, in the following, we will provide only a brief summary of the age verification process in his case, and will instead focus on describing his life experiences.

21.2.1.1 Description of the Age Verification Sources

Because J.K. lived in the same village most of his life, we were able to draw from a variety of sources to verify his age. The official records consist of the JYOSEKI of the original family (Fig. 21.1), the KOSEKI of the family he married into (Fig. 21.2), the JUMIN-KIHON-DAICHO (Fig. 21.3), the original graduation list of the local elementary school (refer to Gondo et al. 2017), the centenary anniversary history book of the local elementary school (refer to Gondo et al., 2017), and the official employment record of J.K. from Japan's Ministry of Posts and Telecommunications. The non-official records consist of a booklet about J.K.'s life published when he was 105 years old, a newspaper interview with J.K. about his old friend, and information from an interview of J.K. by the authors (Y.G. and N.H.).

21.2.1.2 The Life History of J.K

J.K. was born on April 19, 1897, in Kami-Ukawa village, Takeno-gun, in the Kyoto prefecture. He was the fifth of eight children of a farming couple, the Miyake family. The structure of his original family could be confirmed by the JYOSEKI (Fig. 21.1). His original name was Kinjiro Miyake. He graduated from higher elementary school on March 31, 1911. While J.K.'s birthday was reported as a date in March in the graduation list, we found that his birthday was reported as a date in April in the official government documents (JYOSEKI, KOSEKI, and KIHON DAICHO). His nephew told us that J.K. believed that his correct date of birth was 1 month earlier than the date reported in the official record. We speculated that his

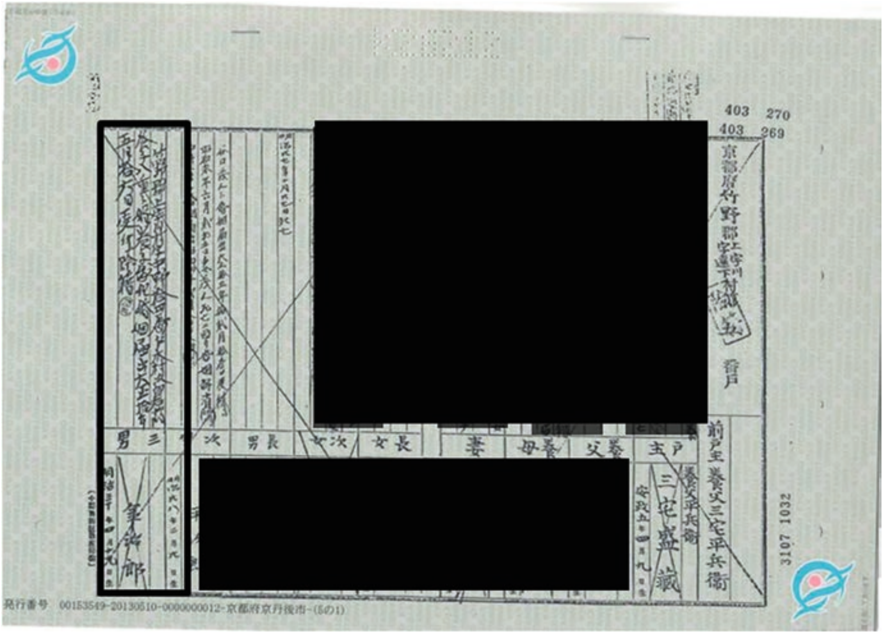


Fig. 21.1 Jyoseki Tohon of the original family (Miyake). J.K.'s old name (Kinjiro) and his history are written in the area surrounded by the black box

parents had wanted him to join the labor force as soon as possible so he could earn money to help the impoverished household, and that they therefore reported a March birth date for J.K. that would allow him to start schooling 1 year earlier. This was a relatively common practice in rural areas in Japan at that time. Thus, we concluded that his correct birthday is April 19, 1897 (Gondo et al. 2017).

After graduation, J.K. took a position as a telegram delivery person. He also held various other post office-related jobs over the course of his career. Except for a short period that he spent as a sake brewer in Nara prefecture, and a period that he spent as a farmer after retirement, his employment history could be confirmed by consulting the official employment records issued by Japan's Ministry of Posts and Telecommunications. He attended a special school in Kyoto city to acquire skills related to mail and telegram delivery from May to November in 1914. He then started working in the local post office (Nakahama post office). On May 31, 1920, he moved to occupied Korea to take care of his sick younger brother for 5 months. During that period, he also worked at the Bureau of Telecommunications in Korea.

On December 27, 1920, he returned to his home village and married Yae Kimura. On their wedding day, J.K. was 23 years old and Yae was 18 years old. After marrying into the Kimura family, he was recognized as the successor of Jiroemon Kimura the 8th. He had six sons and two daughters. The first child was born in 1922, when he was 25 years old, and the last child was born in 1943, when he was 46 years old. He officially inherited and changed his name from Kinjiro Kimura to Jiroemon

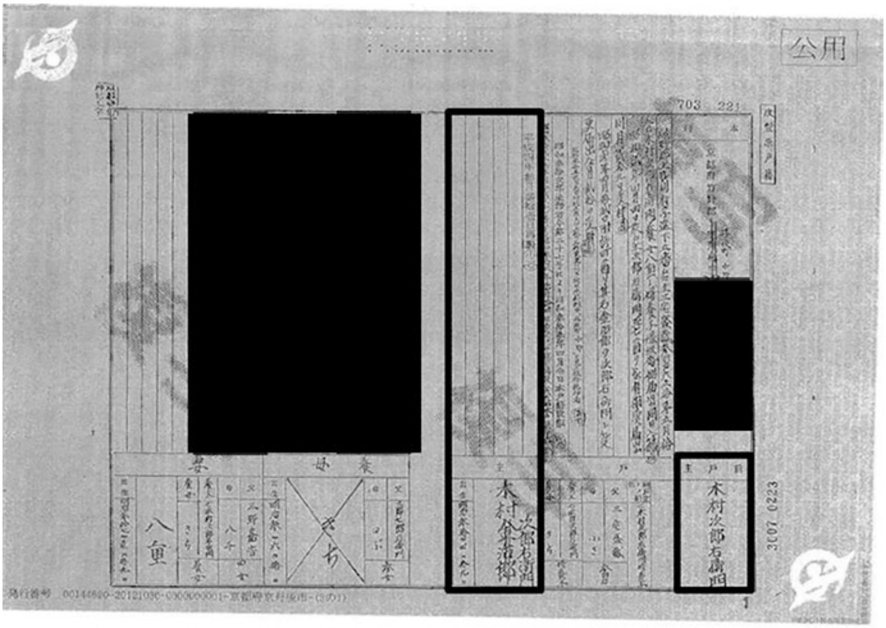


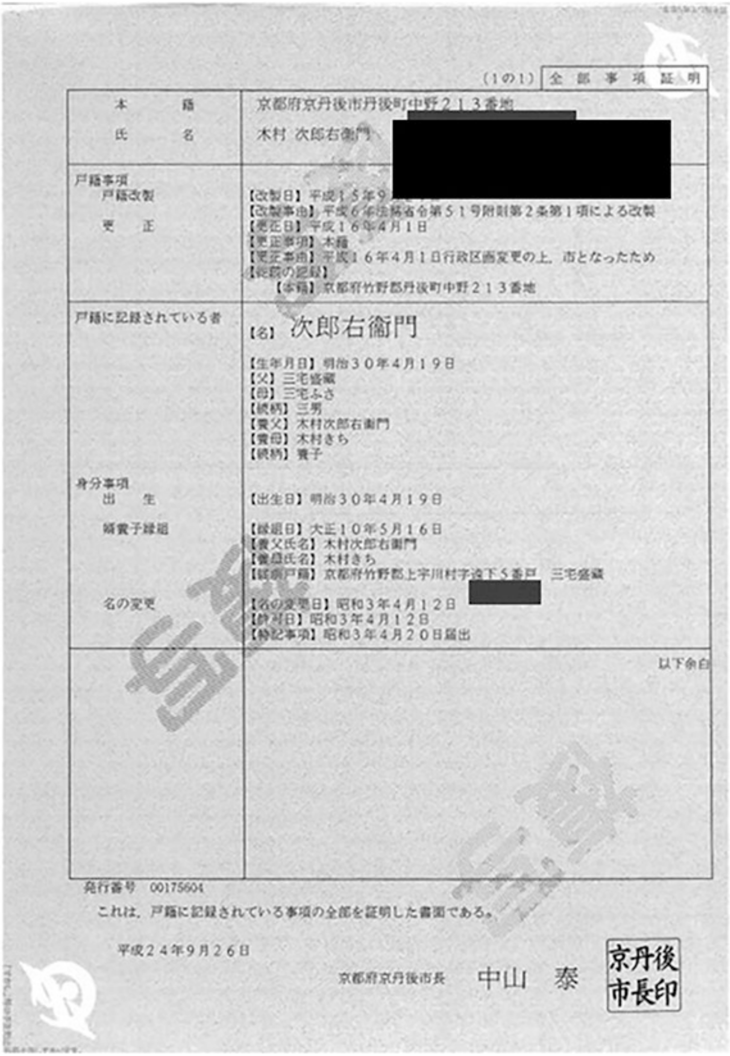
Fig. 21.2 Koseki Tohon of the original family. J.K.'s old name and new name (9th), which is the same as that of the head of the family he married into, is written in parallel (larger box). The same name (8th) is written on the left as a head of the family (small box). The old name is corrected by strike-through (larger box, left name)

Kimura after the death of his father-in-law on April 4, 1927. He started working at the small Hira post office on April 21, 1924, and he remained there until his retirement. According to the job records, he had served as a communication soldier twice for short periods of time in 1919 and 1921.

He retired from the post office on June 30, 1962. In 1963, he built a new house. He was very proud that he was able to build a new house using his retirement bonuses. For the rest of his life, until reached his early one-hundreds, he worked as a part-time farmer helping his son. In 1978, J.K. and his wife started living in the house with their first son's family and their first grandson's family. At its largest, including J.K.'s son's and grandson's family, he lived with nine family members. His wife passed away in 1979 when he was 82 years old.

In 1981, the Kimura family had a family reunion to celebrate 500 years of life, which was the sum of the ages of J.K. and his siblings (Fig. 21.4). On December 11, 1999, a well-known national TV program that covers Japan's local communities and their cultural activities invited J.K. to appear as a guest. Because of this TV appearance, J.K. became popular nationwide. He reported having received hundreds of letters.

J.K.'s first son passed away in 2000 at the age of 76. He expressed his sorrow that his son died before him in the booklet entitled "*Looking back on my happy 105*



（1の1） 全部事項証明

本籍	京都府京丹後市丹後町中野213番地 [redacted]
氏名	木村 次郎右衛門 [redacted]
戸籍事項 戸籍改製 更正	【改製日】平成15年9 [redacted] 【改製事由】平成6年法務省令第51号附則第2条第1項による改製 【更正日】平成16年4月1日 【更正事項】本籍 【更正事由】平成16年4月1日行政区画変更の上、市となったため 【従前の記録】 【本籍】京都府竹野郡丹後町中野213番地
戸籍に記録されている者 身分事項 出生 婿養子縁組 名の変更	【名】次郎右衛門 【生年月日】明治30年4月19日 【父】三宅盛蔵 【母】三宅ふさ 【続柄】三男 【養父】木村次郎右衛門 【養母】木村きち 【続柄】養子 【出生日】明治30年4月19日 【縁組日】大正10年5月16日 【養父氏名】木村次郎右衛門 【養母氏名】木村きち 【従前戸籍】京都府竹野郡上宇川村字遠下5番戸 三宅盛蔵 [redacted] 【名の変更日】昭和3年4月12日 【許可日】昭和3年4月12日 【特記事項】昭和3年4月20日届出
	以下余白

発行番号 00175604

これは、戸籍に記録されている事項の全部を証明した書面である。

平成24年9月26日

京都府京丹後市長 中山 泰 京丹後市長印

Fig. 21.3 Zenbu Kisai Shomei of J.K

years," published in 2002 (Kimura 2002). He also lost his grandson in 2005 at the age of 52. He then lived with his daughter-in-law and granddaughter-in-law.

J.K. participated in our Japanese semi-supercentenarian study in 2008 when he was 111 years old. The authors (Y.G and N.H.) visited him a total of six times between then and his death in 2013. At the first interview, he sat on the tatami floor without using any supportive device for more than an hour and a half, and told his life history clearly and energetically. He reported that he read newspapers every day and was careful with his diet. When we were about to leave his home, J.K. said in English: "Thank you very much. You are a very kind man." He loved to speak

Fig. 21.4 Family picture taken in 1981 that was entitled "The Cerebration of 500 years old." In the first row, the six siblings, including J.K., and their ages are described by authors. The ages noted on the picture use the new Japanese age counting system in which people are counted as zero years old at birth, which means the total age of the siblings was 492 at the time the picture was taken. In the old Japanese age counting system, people were counted as 1 year old at birth. Under this system, the sum of the five siblings' ages is 498. The picture was provided by Miyake Shinji, a nephew of J.K

English because he had learned English while he was studying at the special school for mail and telegram delivery in Kyoto. He recalled the name of the English textbook he used at the time as *National Reader*. Presumably, he was referring to *Barnes' New National Readers*, which has been the most widely used textbook for learning English in Japan since 1883. Because J.K. looked very healthy and fit, one of the authors (Y.G.) strongly doubted his age. We therefore decided to perform a study to verify his age.

J.K. again received attention from the media when he became the oldest living man in Japan at the age of 112 on June 19, 2009. Thereafter, he was introduced in the media as the oldest Japanese man on his birthdays and on Respect for Senior Citizens Day (the third Monday in September). He maintained good health until about 1 year before his death, and was cited as an example of a healthy supercentenarian in a NHK (a national network in Japan) documentary program in 2012. His daughter-in-law passed away in 2013 at the age of 83. In the final phase of his life, he lived with his granddaughter-in-law. We visited him for the last time on May 11, 2013, but we could not talk to him because he had been admitted to the hospital on that day after falling ill. J.K. passed away on June 12, 2013, at the age of 116 and 54 days.

J.K. had had raise a large family: by the time he reached the final phase of his life, he had eight children, 14 grandchildren, 25 great-grandchildren, and 14 great-great-grandchildren. One of the authors (Y.G.) met two of his offspring by chance.

We can say with some confidence that J.K. lived a long and happy life, as he reported in his autobiography booklet.

21.2.2 Case 2: Misao Okawa (M.O)

M.O. is the first Japanese supercentenarian to reach the age of 117. We visited her four times in total from 2013 to 2015 as part of our semi-supercentenarian study and for a newspaper interview. Although her son and the director of the special nursing home where she was living kindly provided us with many resources for verifying her age, we faced difficulties in obtaining some of the official governmental records on her life because of wartime damage and her frequent relocations.

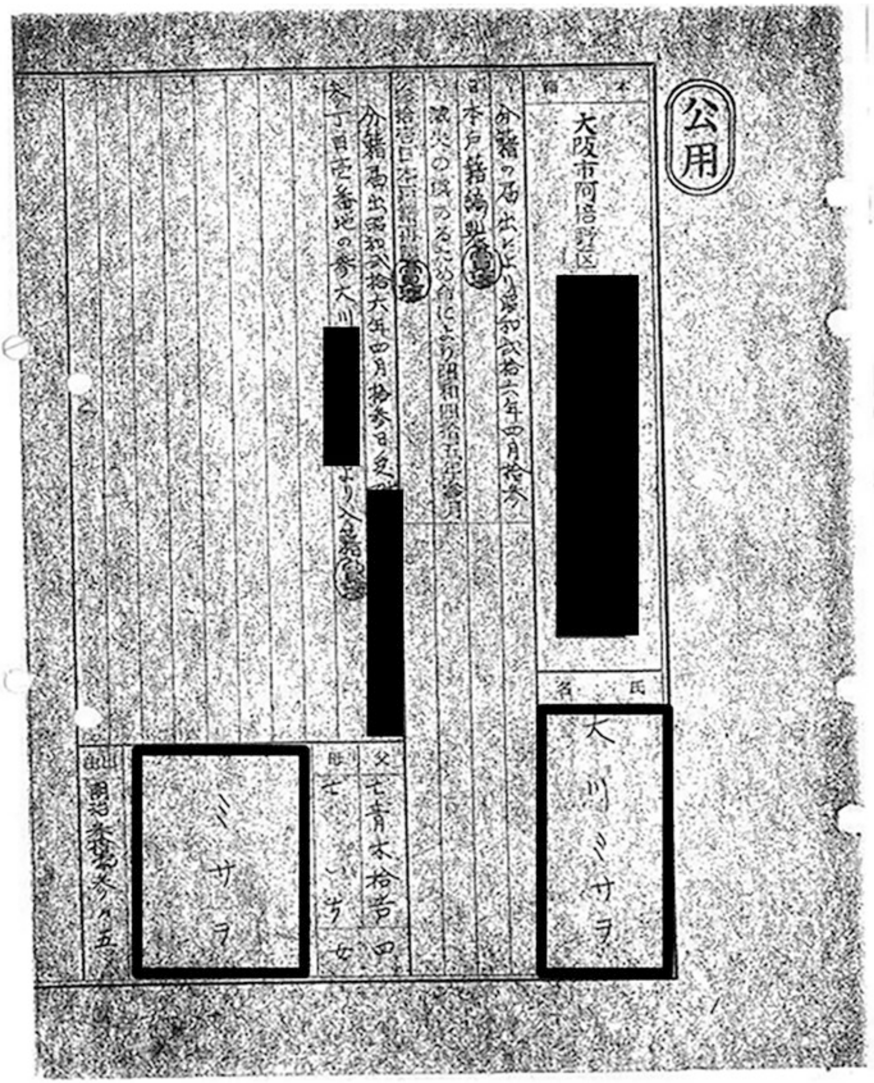
21.2.2.1 Description of Age Verification Sources

Among the official documents we were able to collect for M.O. were her **KOSEKI** (Fig. 21.5) and a mention of her in the **ZENKOKU KOUREISH MEIBO**. Her **KOSEKI** (Fig. 21.5) shows that she became a family head after separating from the **KOSEKI** of her husband's family. Her name was on the **ZENKOKU KOUREISH MEIBO**, which is a list of people living in Japan who became centenarians. We also gathered documents from her nursing home. However, many of the official documents that refer to her life were lost during World War II. In addition, her frequent relocations made it difficult for us to track down the official records of her past. Among the non-official records, we were able to obtain several articles in newspapers and magazines about her and testimonies of her family members and the nursing home staff. We first met M.O. in 2013, but because she was already suffering from dementia, she was unable to provide us with further information.

21.2.2.2 The Life History of M.O.

M.O. was born on March 5, 1898, as the fourth child of the Aoki family. According to her son, M.O. was born in Temma district, which is located in the northern part of Osaka prefecture. Her family moved to Takarazuka city, which is a bedroom community in the Osaka prefecture. As her parents were the successful owners of a kimono fabric business, the family lived in a tri-level house and had a housekeeper. Her parents often took her downtown to buy fashionable clothes.

We tried to find the **KOSEKI** of M.O.'s original family to confirm her birthday, but were unsuccessful. M.O. established her own **KOSEKI** in 1951 (Fig. 21.5), and it is the primary source used to confirm her date of birth. We also attempted to find the graduation records of her elementary school. We contacted the board of education in Takarazuka city, Hyogo prefecture, because her son told us that when the family went to watch the Takarazuka Revue, M.O. took them to the house in


公用

本籍 大阪市阿倍野区 [redacted]

氏名 大川ミサヲ

ミサヲ

Fig. 21.5 Newly established Koseki of the family M.O. became the head of in 1951

Takarazuka city where she grew up. We could find the names of five schools established more than 100 years ago. Two of them, Nishitani and Ryogen elementary schools, have published an anniversary booklet with the list of graduates; however, we could not find her name on the lists. After M.O. graduated from elementary school, she helped her family with the housekeeping and Japanese dressmaking.

In 1919, when she was 21 years old, she married Yukio Okawa, who ran a rubber manufacturing company in Kobe city, Hyogo prefecture. He was successful in his business. They had three children: two daughters who were born in 1921 and 1926, and a son who was born in 1923. Their children's dates of birth were confirmed on the second and third pages of M.O.'s **KOSEKI** (Figure not shown). However, we could not confirm her date of marriage or the date of her husband's death because this information was recorded in the **KOSEKI** of her husband. M.O.'s husband was quite a modern man. He enjoyed drinking a cup of coffee and eating bread on Sundays, which was uncommon in those days. She loved the modern life style, and actively learned how to cook a variety of dishes, such as Chinese dishes and beef-steak. Her son remembers that the family used to go out to Chinatown in Kobe to eat Chinese food, and that his mother often asked the restaurant staff for their Chinese recipes. He also remembers seeing Chinese men with the queue hairstyle working in Chinatown during that period. In 1931, M.O.'s husband died of heart disease. Two years later, she went back to her parents' house in Sumiyoshi ward in Osaka city with her children. M.O. brought them up with help from her older sister, while running the transportation company.

Kansai region, where M.O. lived in the early 1990s, was the birthplace of popular culture in Japan because Osaka, Kobe, and Kyoto functioned as important centers of business and transportation. After the Great Kanto Earthquake of 1923 damaged Tokyo and the surrounding areas, many displaced people moved into Osaka city, making it the largest city in Japan. Private railway networks were established in Osaka in the late 1920s and the early 1930s – before such networks came to Tokyo. We assume that one of the reasons M.O.'s family moved from the center of Osaka city to Takarazuka city was the development of these railway networks. Railway lines connecting Osaka and Takarazuka started providing transportation services in 1897, or 1 year before M.O. was born. Moreover, Takarazuka city was the birthplace of the Takarazuka Revue, a famous act with an all-female cast that was started in 1914, and is still being performed today (http://kageki.hankyu.co.jp/english/index.html). M.O.'s son recalls that she took her children from Kobe to watch the revue. It thus appears that M.O. enjoyed a modern city life as a member of a wealthy family.

We could not obtain information about M.O.s life in her forties, which coincided with WWII. In 1951, when she was 53 years old, M.O. established a new **KOSEKI**, which included her children (Fig. 21.5). According to this document, the registered address was changed from Fukiai ward in Kobe to Abeno ward in Osaka on April 13, 1951. This means that M.O. had been a member of husband's family for about 20 years after he died. We believe that the marriage of her second daughter in 1951 was the reason for the establishment of her new **KOSEKI**. M.O.'s first daughter and her son married in 1953 and 1956, respectively. After her first daughter's marriage, M.O. lived with her son, and later with his wife and children at the same place until she moved to a special nursing home in 1996.

According to her granddaughter, M.O. enjoyed watching professional wrestling, which was very popular on Japanese television in the 1970s. Although she underwent left femoral replacement surgery when she was 83 years old, she could still wear a kimono and walk by herself using a walking stick. Figure 21.6 shows a photo that was taken when M.O. was 98 years old. The occasion was a family reunion marking the renovation of her house in 1996. One year before this photo was taken,

Fig. 21.6 M.O. at the age of 98 years surrounded by her family members at home

M.O. had a fall accident and underwent surgery to repair a femoral fracture. After this photo was taken, she started complaining of unbearable generalized pain and lost her appetite. Soon after, she was hospitalized. “She was on the verge of death,” her son recalled. Miraculously, she was released from the pain through a single injection to her hip at the pain clinic. Although M.O. recovered from this acute condition, the experience led her 74-year-old son and his wife to reconsider taking care of M.O. at home.

On January 1, 1997, at the age of 98, M.O. moved to a special nursing home for older adults, where she stayed until her final days. Although she used a walking stick, she still wore a kimono and walked by herself. She had no major diseases and no symptoms of dementia at that time. Her only complaint was occasional constipation. The basic activities of daily living (BADLs) she was still able to perform were sufficient to allow her to take care of herself as a nursing home resident. At that time, her doctor commented in her care facility record: “I envy her health condition.”

According to reports, M.O. had a strong will and retained her curiosity even after reaching the age of 100. At the age 102, she fractured her femur again when she was dancing at the Bon Festival. After leaving the hospital, she voluntarily underwent rehabilitation and regained her walking ability. She continued to knit until she was around 105 years old. When she was 109 years old, she walked a 70-meter-long corridor 10–20 times per day using a walking stick or pushing a wheelchair by herself.

On August 1, 2013, M.O. became the world's longest-living person. At that point, she started getting media attention. She told reporters that she did not pay special attention to her health, and had not been living a healthy lifestyle. She did not stop smoking until she was about 70 years old. However, she also told the media that having a good appetite and being easygoing are the secrets to longevity. Her hobby was making and designing new styles of kimono. She was cheerful, social, and optimistic. She always responded in interviews with cheerful comments. One of the authors (Y.G.) visited M.O. as she was being interviewed by a newspaper on May 13, 2013. At that time, she was severely demented, and it was difficult to communicate with her. But when Y.G. asked her whether she was happy, she replied "So-so happy." When he asked her, "Will I also become happy if I imitate your lifestyle?" she answered, "It will not go as smoothly as you think." On March 5, 2015, M.O. became the first Japanese person to reach the age of 117. She passed away on April 1, 2015, at the age of 117 and 27 days.

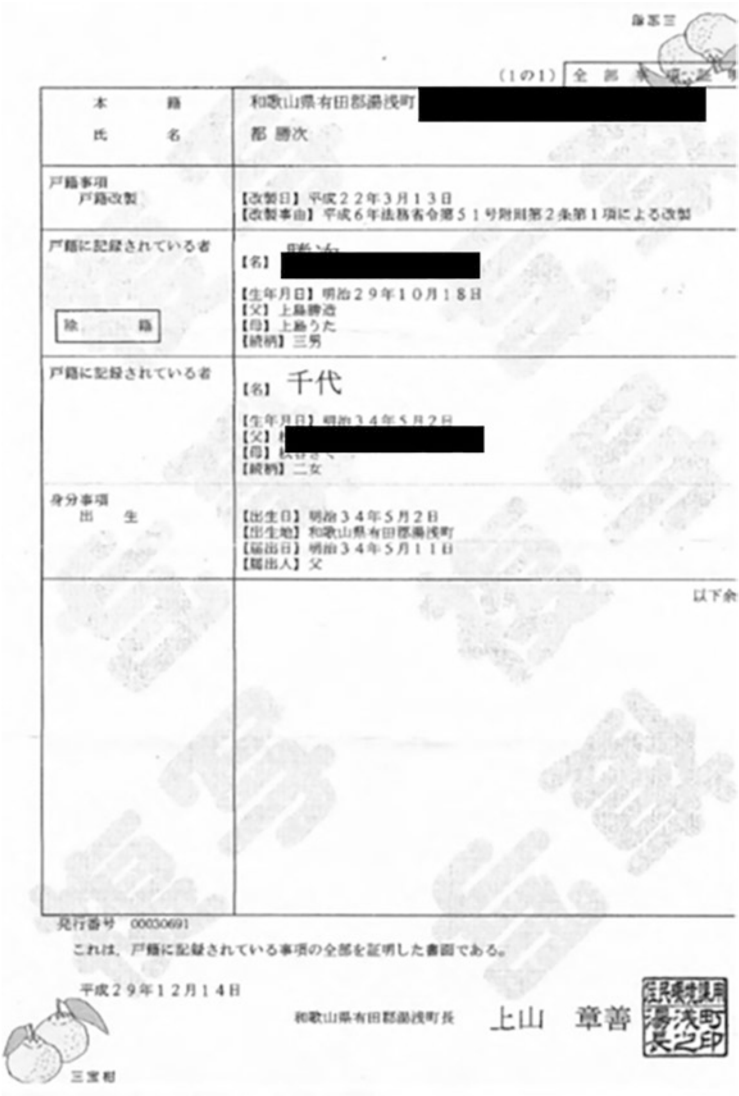
To verify her age, we were only able to obtain a few government registry-related documents (**KOSEKI** and **JYUMIN-KIHON-DAICH** and **ZENKOKU KOUREISHA MEIBO**). However, we found no inconsistencies among the testimonies provided by her relatives or herself. It is important to note that two of her children are still alive. M.O.'s first daughter was 95 years old and her son was 93 years old when she died. Her long-living children may be the best evidence that M.O. had a very long life. Based on the multiple sources of information about M.O.'s life we have described in this article, we can conclude that she was the first Japanese person to reach the age of 117.

21.2.3 CASE 3: Chiyo Miyako (C.M)

As the final case, we introduce C.M., who participated in both the Tokyo centenarian study (Gondo et al. 2006) and the Japanese semi-supercentenarian study (Arai et al. 2014). She is the last survivor among the participants. She became the longest-living person in Japan on April 21, 2018.

21.2.3.1 Description of Age Verification Sources

We collected information on C.M. from her **KOSEKI** (Fig. 21.7), the **JUMIN-KIHON-DAICHO**, and the **ZENKOKU KOUREISHA MEIBO**. Her name was on the residential list Minato ward provided us with when we were preparing invitations to prospective participants in the Tokyo centenarian study in 1999. Moreover, C.M.'s life history was published as a chapter of the centenarian life study book HYAKUSAI HYAKUWA (Centenarian research group, 2003); which in English means "a hundred stories from centenarians." We have checked the consistency and accuracy of her stories by comparing them with actual historical events. She is now living in a nursing home, which her grandson is managing.



謄本三

（1の1） 全部事項証明

本　　籍	和歌山県有田郡湯浅町[redacted]
氏　　名	部 勝次
戸籍事項 戸籍改製	【改製日】平成２２年３月１３日 【改製事由】平成６年法務省令第５１号附則第２条第１項による改製
戸籍に記録されている者 除　籍	【名】[redacted] 【生年月日】明治２９年１０月１８日 【父】上島勝造 【母】上島うた 【続柄】三男
戸籍に記録されている者	【名】千代 【生年月日】明治３４年５月２日 【父】[redacted] 【母】[redacted] 【続柄】二女
身分事項 出　生	【出生日】明治３４年５月２日 【出生地】和歌山県有田郡湯浅町 【届出日】明治３４年５月１１日 【届出人】父
	以下余白

発行番号 00030691

これは，戸籍に記録されている事項の全部を証明した書面である。

平成２９年１２月１４日

和歌山県有田郡湯浅町長 上山 章善 湯浅町長之印

三宝柑

Fig. 21.7 Zenbu Kisai Shomei of C.M. A computerized Koseki

21.2.3.2 The Life History of C.M

C.M. was born on May 2, 1901, in Yuasa town in Wakayama prefecture, which is famous for growing mandarin oranges. Her parents owned a wholesale paper store. She was born as the fourth of five children, but she grew up as a first child of her parents because her older siblings all died at early ages. She had one younger brother. When she was younger, she enjoyed her lessons at school, except for physical education. After finishing elementary school, she attended a school for girls in Wakayama prefecture. After graduating from the girls' school, she pursued further education at the telegraph school in Osaka. While she was studying in Osaka, she met a tall, nice-looking man named Katsuji Miyako in her apartment building. They got along well, and soon fell in love. When C.M. wrote a letter to her suitor, he responded by writing her two or three letters. He had a reputation for being fashionable, and was said to have been as handsome as an American movie star. Mr. Miyako was a student at Kyoto University, which is one of the most prestigious universities in Japan. Because of his status as a student, the couple had a family wedding without publically announcing their marriage. Interestingly, the story of the marriage has changed over time. The abovementioned story was told by C.M. during an interview in 2016 involving one of the authors (N.H.). However, when the author (Y.M.) had interviewed C.M. for the centenarians' story book in 2002, she said that her wedding was arranged by her parents, and that she and her husband were not romantically attracted to each other at the beginning of their marriage. We believe that the couple actually fell in love, but that C.M. had been embarrassed to tell us the real story the first time because a love-based marriage was not common for her generation. A picture taken around the time of their wedding reveals the truth (Fig. 21.8). We should also add that the couple appear to have had a happy

Fig. 21.8 C.M. and her husband in their newly married days

marriage. According to C.M., “It was a good match and we had a wonderful marital life.”

After marrying, C.M. started working as an operator at the Central Telecommunications Bureau located in Osaka. In those days, not many women participated in the labor force. In fact, she was the only female employee in her branch. Meanwhile, her husband was employed by the Ministry of Railways, and had to undertake many overseas business trips to perform inspections. The longest separation the couple experienced was when Mr. Miyako was overseas for 2 years as part of his education. Soon after he returned to Japan, the couple started having children: a son was born in 1922, and a daughter was born in 1927. Because of Mr. Miyako’s job, the family relocated a few times. For C.M., Beijing was the most memorable place. One year after moving to Beijing, World War II ended, and C.M. and her family had to leave the city immediately. Although they had only a small amount of baggage, it was stolen, and they lost all of their belongings, including their clothes, their jewelry, and their family photos. Her husband, who was fluent in English and Chinese, succeeded in negotiating for the family passage on a ship going back to Japan. Recalling this trip, C.M. said, “I was so afraid that I would not return to Japan until I saw the land of Japan.” She also remembered that on the ship “the food was dried cod and water. That was it. … Soon after we landed in Japan, we had a bowl of rice, miso soup and pickles. It was delicious. I still remember that taste.” Because of this experience, she has lost all of the photos and other important forms of evidence that could confirm her earlier life events (Fig. 21.9).

The family started their new life in Tokyo. The housing provided by the Ministry of Railways had vegetable gardens. C.M. and other residents of the housing estate cultivated vegetables, such as potatoes and eggplants, to supplement their food supplies. However, people outside of the estate often stole these vegetables because people were struggling to survive under severe food shortages.

C.M.’s husband passed away in 1951 at the age of 55. C.M. and her children then moved into her parents’ home. Her son went to Tokyo University, and later received his Ph.D. from the University of Michigan. He became a professor at Toyo University, but passed away at the age of 52 in 1974. We found a book about civil engineering technology that he had published in 1975. C.M.’s daughter’s life was also shorter than expected. She died in 1984 at the age of 57.

After the loss of her two beloved children, C.M. lived with one of her grandchildren. She eventually decided to move into a nursing facility, but then came home after failing to adapt to the environment. At the age of 97, she moved to a nursing home again. She participated in the Tokyo centenarian study on July 8th, 2001, when she was 100 years old. At our first visit, she did not need care from others, despite living in a nursing home. Able to move around well with a cane, C.M. was very active, and enjoyed writing haiku poetry and doing calligraphy. She also participated in an intelligence assessment (Fig. 21.8) (Inagaki and Gondo 2003). Compared to other 100-year-old participants, her score was very high, especially for the fluid dimension of intelligence. She was also careful with her diet. Her everyday routine was to drink two liters of water and a half glass of wine, and to eat a lot of fruit. Speaking of her current life, she said, “I am not lonely at all. I do not know

Fig. 21.9 C.M. was taking an intelligence test on September 23, 2001, at age 100

when I will die, but I am always looking forward to seeing my future." She reported that even as a child she was known for being kind and having a strong will. At the age of 102, she still had a strong will. She said, "I always do the things I want to try. I feel uncomfortable if I do not finish the things I started."

On June 10, 2006, she participated in the Japanese semi-supercentenarian study. At that time, she was living in the same nursing home. Although many residents of her nursing home had developed dementia, she was able to build good relationships with other residents. After her initial participation, we called the nursing home periodically because we would like her to remain involved in our study; however, we lost contact because she relocated. In 2011, we found out that she moved to a nursing home in Yokohama city. We tried to contact her via the Yokohama city government, but we could not reach her.

In the fall of 2015, we found information about C.M. in an article published in Anti-Aging Medicine (Shirasawa 2015). She was interviewed by a famous medical doctor studying longevity. Soon after, on December 5, 2015, she became the second-longest-living person after Nabi Tajima. We again sent her a letter inviting her to participate in our study, and she agreed. At that point we had heard that she was in good health, was having conversations with people, and was doing calligraphy. However, we had to postpone a planned visit after she fell ill.

When one of the authors (N.H.) visited her on May 10, 2016, she was still hospitalized. Her health condition was so serious that we could not communicate with her. He visited her again on October 25, 2016, when she was recovering from a serious condition. At that time, she was wide awake and able to communicate with N.H. He heard that she was experiencing a 3-day cycle in which she was active on the first day, less active on the second day, and asleep for many hours on the third day. Although she had lost both legs because of arteriosclerosis and she was using a gastrostomy-feeding tube, she said that she wanted to go back to the telegraph station to work once she recovered.

21.3 Summary

The aim of this chapter was to present the life histories of three Japanese supercentenarians who reached the age of 115 years, and to explain the methods we used to verify their ages. Three cases were described. We were able to collect a large number of official and non-official documents for J.K., but less information for M.O. and C.M. The availability of documents for the age verification of centenarians depends on three conditions: whether the person moved away from his/her birthplace, whether the person lived in a rural or an urban area, and whether the person is a man or a woman.

As we described above, M.O. and C.M. had moved away from their birthplace, married into their partner's family, relocated several times, and lived in the downtowns of big cities. Frequent changes of status can make tracing the life of an individual difficult, and may cause the records of individuals to be switched (Wilmoth and Lundstrom 1996). In Japan, women tend to move their **KOSEKI** from their original family to their husband's family (C.M. and, presumably, M.O did this for a period of time), or they establish a new **KOSEKI** for some reason (M.O.). After a woman has moved her **KOSEKI** from her original family to her new family, it generally becomes unimportant to her and to her offspring, except if they are involved in a court case to negotiate property succession. Therefore, the woman and her children and grandchildren tend to lose interest in their origins, and gradually disconnect from their original family members. In such cases, the offspring of a woman centenarian may not be able to access the original **KOSEKI** that contains information about the woman's parents and siblings.

As this chapter has shown, these kinds of difficulties have arisen in our survey. In addition, having lived in big cities (C.M. and M.O.) or having been repatriated after WWII (C. M.) increases the risk that a centenarian will have lost important documents needed to prove his/her identity. In these cases, it is difficult to find evidence to verify the person's age. Various kinds of interference can have a negative impact on the age verification process in Japan. The case of J.K. is exceptional for being affected by none of these interfering factors. Although the resources available for age verification differ across cases, the reported ages of the individuals profiled in this chapter were found to be accurate. We could show consistency in their life histories based on the testimonies of the centenarian themselves, their relatives, their care workers, media reports, and official documents.

Finally, we should mention the importance of taking into account changes in the testimonies made by a single individual, and discrepancies in the evidence provided in other testimonies and records. In the case of M.O., two different stories were told about the elementary school she attended: one source (the nursing home record) reported that she went to elementary school in the Temma area where she was born; while another source (testimony by her son) reported that she went to school in Takarazuka city where she grew up. We selected the latter report because M.O. herself mentioned that she attended elementary school in Takarazuka, and because her son recalled that M.O. pointed out the house she used to live in as a child when visting Takarazuka with her family to watch the Takarazuka Revue. In the case of C.M., her account of her marriage changed between interviews that took place 14 years apart. Even in the case of J.K., he said he believed that the earlier date of birth was the correct one.

When verifying the age of an extremely old person, the careful examination of the centenarian's life history by double- or even triple-checking the evidence is essential. Consequently, to verify the age of a supercentenarian, it is necessary to check both face validity, which involves confirming the plausibility of an individual's life history based on official and non-official documents; and concurrent validity, which entails checking the identity of the target individual by cross-referencing life episodes told by the individual with historical or official records (Gondo et.al. 2017).

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Chapter 22
Age 115+ in the USA: An Update

Robert Young and Waclaw Jan Kroczek

22.1 Validated Cases: Updated Since 2010

This section updates the last "Americans 115+" chapter on cases validated since the previous chapter went to publication. For "validated" cases, we begin with the same standards that were used in the first book chapter, and similar to those used in the SSA study: original proof of birth issued within 20 years of the birth event; proof of survival to 115+; and intervening life documents that show that the person in the death record is the same as the person in the original birth record. Note that, going beyond the mere "three-document" check of a case for age 110, for cases 115+, an additional level of scrutiny is performed, locating the person within the context of their family, and finding as many intervening life documents as is practical (Poulain, 2010). For the purposes of this section, in order to make it easier to follow, we will discuss the individual new US validated Gerontology Research Group (hereinafter GRG) cases in chronological order by birth, not the order in which the cases were validated in real time.

22.1.1 Augusta Holtz (1871–1986)

U.S. news reports in the 1980s touted a German-born Missouri woman as possibly the world's oldest person. Ms. Holtz was said to be 114 years old at the time. However, the family could not locate the initial birth record, and so Guinness World Records (hereinafter GWR) at the time gave the title to a younger person aged 112. Many years later, new evidence has emerged that indicates that Augusta Holtz may have been the first person in documented history to have reached age 115.

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Augusta Holtz was born in Germany, Posen province (an area now part of Poland) as Augusta Louise Hoppe, on Aug. 3, 1871. The town of her birth was Czarnikau (now Czarnków). Augusta was the daughter of Michael and Wilhelmine Hoppe (nee Quade). Two years later, the Hoppe family migrated to the United States and settled on a farm near Troy, Illinois. In her later years, Ms. Holtz mentioned her earliest memories being the U.S. Centennial in 1876 and pioneers in ox-drawn covered wagons stopping at her father's farm for water as they travelled westward. On Apr. 17, 1900, Augusta Hoppe married Edward Holtz in Madison, Illinois. Thereafter, the couple moved to Missouri. They had four children: Edward, Hester, Gertrude, and Augustus. Edward Holtz died in 1922. Ms. Holtz moved to St. Sophia Geriatric Center in Florissant, Missouri at age 109. On her 114th birthday, she was reported as still mentally alert but also confined to bed and having failing eyesight and hearing. One year later, she reached her 115th birthday, possibly becoming the first validated person in history to do so (the next validated person after Ms. Holtz to reach this age was Jeanne Calment, who turned 115 in 1990). The Holtz family had initially applied to Guinness World Records, but her original proof of birth was not located then. Having been born in the German Empire in a province that later became part of Poland, finding the original proof of birth was not an easy task[1]. Ms. Holtz died 79 days later, having not attained Guinness World Records recognition at the time. The original proof of birth remained unlocated.

About 15 years later, the Augusta Holtz case was included in the SSA Study "group 2" cases (neither validated nor invalidated), indicating that the original proof of birth had still not been located. But the SSA Study records left mid-life documents as clues, such as the names of her parents from the SS-5 (application for a social security number numident file). An application for a Social Security Number Numident file has unique identifying information for the individual such as birthdate, place of birth, and the names of parents (death dates were often added later as most Social Security applicants in the 1950s were alive at the time of application). Verifying overseas births at the time was more difficult, as many records of birth were not yet computerized.

In this case, we already knew that we had proof of death [the National Death Index (NDI) from the Social Security Administration Supercentenarian Study] and an intervening mid-life document that identified the names of her parents, Michael Hoppe and Wilhelmina Quade. We also knew that this woman's story stayed the same throughout her life course, and the Social Security Record listed her as born Aug. 3, 1871 and dying Oct. 21, 1986. All that was needed, then, was to find the original proof of birth from Germany. This was located in April 2012 by GRG-Germany researcher Stefan Jamin: an 1871 German baptismal record, recording Augusta's birth and matching the parental information in the much-later SSA Study records. Also located by Stefan Jamin was an 1873 immigration document. Gabriel Ainsworth helped finding census matches.

[1] In 1985, the Iron Curtain has not yet fallen, so East German and Polish records were not then accessible to the West.

Table 22.1 Augusta Holtz document summary

Time	Type of document	Documented age/date of birth	Record accords with
Aug. 1871	Birth record	Aug. 3, 1871	
Dec. 1873	Immigration record	11 months[a]	Jan. 1873?[a]
June 1880	US Census	8	Aug. 3, 1871
Apr. 1900	Marriage record	29[b]	Aug. 3, 1870[b]
June 1900	US Census	29[b]; Aug. 1871	Aug. 3, 1871
Apr. 1910	US Census	38	Aug. 3, 1871
Apr. 1920	US Census	48	Aug. 3, 1871
Apr. 1930	US Census	58	Aug. 3, 1871
Apr. 1940	US Census	68	Aug. 3, 1871
Oct. 1986	SSDI	Aug. 3, 1871; died Oct. 21, 1986	

[a]Lower age documented
[b]Higher age documented

Documents supporting the Augusta Holtz case include the 1871 German Christening index; US 1880, 1900, 1910, 1920, 1930, and 1940 censuses; the SS-5 (Numident) file; the SSDI; the newspaper reports; and the gravestone. Only the 1873 immigration record, which recorded her as age "1" (and thus would suggest a birthdate in 1872), clearly disagreed (the 1900 marriage record suggests birth in 1870, but might have been rounded up) (see Table 22.1, Augusta Holtz document summary, below):

With the oldest document written in 1871, it would be virtually impossible for Augusta Holtz to have been younger, unless a hypothetical younger sibling of the exact same name was also born in 1872. But so far, no evidence to support this has been detected. Moreover, additional case research in Poland in 2017 by GRG-Poland correspondent and paper co-author Waclaw Jan Kroczek further narrowed the possibility of identity-switching. Waclaw's research on Augusta Holtz's siblings basically ruled out this scenario: the discovery of the birth records of Augusta Holtz's siblings. It was established that Bertha Marie Hoppe was born on Feb. 24, 1867 and Emma Pauline Hoppe on July 1, 1869 (see Box 22.1). This piece of information is very important as it suggests that Augusta's older sisters' ages in the immigration record were also underestimated; namely, Bertha's age as "5" and Emma's as "2". According to the birth record, their ages should have been recorded as, respectively, "6" and "4" as of December 1873. Likewise, Augusta's age seems to have been underreported as "11 months" instead of "2" years old. Meanwhile, no documents for a potential second sibling of the same name were located. Given the timeframe of just one year open between the 1871 birth (9 months after August 1871 is mid-1872) and the 1873 migration, the document period is short. No infant death record was located for this period, either. Finally, Augusta did have one additional older sibling (Paul died at birth in 1870) and one younger sibling (Louise) but she was born in the USA, after the migration…which already records Augusta. Thus, Louise cannot be Augusta.

Box 22.1 Family Tree[2] of Augusta Holtz Parents (Married Apr. 15, 1866)
Michael HOPPE (Sept. 3, 1838 – Aug. 11, 1918) (79 years old)
Wilhelmina Henrietta QUADE HOPPE (Dec 11, 1831 – Dec 19, 1922) (91 years old)

Siblings

1. Bertha Marie HOPPE BUSSE (Feb. 24, 1867 - June 3, 1948) (81 years old)
2. Emma Pauline HOPPE HEINTZMANN (July 1, 1869 – Oct. 22, 1954) (85 years old)
3. Paul HOPPE (July 9, 1870-July 9, 1870) (0 years old)
4. **Augusta Louise HOPPE HOLTZ (Aug. 3, 1871 – Oct. 21, 1986) (115 years old)**
5. Louise Julia HOPPE (June 16, 1875–1960) (85 years old)

Spouse (married Apr. 17, 1900)
- John Edward HOLTZ (Mar. 6, 1873 – Mar. 6, 1922) (49 years old)

Children

1. Edward J. HOLTZ (Feb. 24, 1901 – July 24, 1984) (83 years old)
2. Hester E. HOLTZ BADER (Sept. 28, 1902 – May 23, 1988) (85 years old)
3. Gertrude O. HOLTZ DICKINSON (Oct. 6, 1905 – Sept. 9, 1992) (86 years old)
4. Augustus M. HOLTZ (May 10, 1908 – Apr. 30, 1968) (59 years old)

The vast majority of the evidence supports 1871 (including the oldest record, from 1871) and this case as "validated". There is only a very small hypothetical window whereby another child of the same name could have been born in this case (1872), and this wasn't located (although absence of proof doesn't completely rule this option out, hypothetically, a checking of the books virtually does). This isn't a case of missing documents or having gaps in the record. We should also note that Augusta was recorded in the June 1900 census as having been born in August 1871. The 1910, 1920, 1930, and 1940 censuses also support this. Augusta Holtz's identified year of birth has been consistent with just one exception, a document whose age reporting has already been shown to be unreliable. Considering the weight of the evidence, and that this case is a proof of birth case, not a validation by proxy case, it seems reasonable, based on the evidence, to conclude that Augusta Holtz reached the age of 115 years in 1986 and was the first validated person to do so, so far known, based on the research currently available.

The Augusta Holtz case changed history. Augusta Holtz became the oldest validated German-born person in history, displacing Charlotte Benkner, 114 (and that

[2] All family tree dates listed are birth/death dates unless otherwise indicated. These family trees were reconstructed with the assistance of genealogy websites and, in some cases, family input. Information in these family trees is meant to provide context for the birth, growth, life, and death of the supercentenarian claimant. Information as provided in these trees varies in reliability depending upon the sources used…with primary documents closer to the birth events being more reliable than later census approximations or mid-to-late life claims.

makes Germany's two oldest persons on record emigrants to the USA).[3] More importantly, Augusta Holtz was the first validated person to reach age 115, displacing Jeanne Calment (who reached age 115 in 1990) and moving back the start of validated 115+ cases four years. Yet, from a larger perspective, Augusta Holtz's case only moves the highest datapoint in the 1980s marginally higher, as age 114 had been achieved already by 1985, according to International Database on Longevity (hereinafter IDL) data.

22.1.2 Edna Parker (1893–2008)

Edna Parker was born as Edna Scott in Morgan, Indiana, on Apr. 20, 1893. She was the daughter of Frank and Mary Eads Scott. In the early 1890s, the family moved to Johnson, Indiana. She grew up on a farm before becoming a schoolteacher. Edna taught in a two-room school in the Shelby County town of Smithland for a short time until she married her childhood friend, James Earl Parker, on Apr. 12, 1913. The marriage took place in Shelby, Indiana. That same year she graduated from Franklin College with a degree in education. But as was the tradition of that era, her teaching career ended with her marriage. She began the arduous life of a farm wife, preparing meals for as many as 12 persons who worked on her husband's farm. She had two sons: Clifford and Earl, Jr. Edna Parker was widowed in 1939. Thereafter, she outlived both her sons. On her 113th birthday, Edna Parker said that the biggest difference between the present times and a century ago was that people had been more friendly then and worked together more.

The Edna Parker case was validated in 2005, and that validation process included locating her in census matches, as well as reviewing documents sent in by the family. The family said that Edna herself was an extraordinary woman: she was said by family to have shoveled snow off her roof at age 100. Having spent her entire life in the same Indiana area, within the family and location context, it was an easy case to verify.

Below, please find Table 22.2, a summary of public documents for this case:

From the above family tree information, there's little room for uncertainty. An older sibling, Opal, was born in 1892; a younger sibling, Harry, was born in 1895 (see Box 22.2). An 1894 birth would be unlikely, although not impossible. The 1900 census clearly identifies Edna as 7 years old, born in April 1893. Later documents are all consistent: Edna was born in April 1893.

Note that, in addition to the public documents, the GRG also has documents from the family, such as a "recent ID". With the strong family connection, the possibility of identity-switching is minimized. What is clear from the evidence trail is that we have a relatively strong proxy proof of birth (the 1900 census was written

[3] Germany's third-oldest person on record, Adelheid Kirschbaum, 113, was also an emigrant to the USA. This migration pattern strongly suggests that Germany's lack of anyone 113+ in Germany itself may have had to do with Germany's twentieth-century history (including WWI, WWII, and the interwar and postwar periods). Persons born in Germany that migrated to the safer haven of the USA achieved age 113+ at least three times, compared to none for Germany itself from that same time frame.

Table 22.2 Edna Parker document summary

Time	Type of document	Documented age/date of birth	Record accords with
June 1900	US Census	7; "Apr. 1893"	Apr. 20, 1893
Apr. 1910	US Census	17	Apr. 20, 1893
Apr. 1913	Marriage record	Apr. 20, 1893	
Jan. 1920	US Census	26	Apr. 20, 1893
Apr. 1, 1930	US Census	36	Apr. 20, 1893
Apr. 1, 1940	US Census	46	Apr. 20, 1893
2012	Death record	Apr. 20, 1893	

[a]Lower age documented
[b]Higher age documented

Box 22.2 Family Tree of Edna Parker
Parents
- Frank SCOTT (Apr. 29, 1872 – May 23, 1944) (72 years old)
Mary EADES SCOTT (June 2, 1872 – July 16, 1925) (53 years old)

Siblings

1. Opal Avilda SCOTT OSBORNE (Jan. 14, 1892 – May 31, 1980) (88 years old)
2. **Edna SCOTT PARKER (Apr. 20, 1893 – Nov. 26, 2008) (115 years old)**
3. Harry Luther SCOTT (Feb. 2, 1895 – Nov. 8, 1974) (79 years old)
4. Georgia Deloris SCOTT FATELEY (June 16, 1907 – July 19, 2006) (99 years old)

Spouse (married Apr. 12, 1913)
- Earl PARKER (Nov. 24, 1884 – Feb. 23, 1939) (54 years old)

Children

1. Clifford Scott PARKER (Nov. 23, 1913 – July 13, 1998) (84 years old)
2. Earl PARKER Jr. (Mar. 14, 1919 – June 11, 1985) (66 years old)

7 years after the birth event), a consistent year of birth[4], and strong evidence (including the marriage certificate) that ties the identity of the person in the 1900 and other census records (the 1930 and 1940 censuses were as of April 1), with the woman who died in 2008, as well as the family records. In short, Edna Parker was validated to be 115 years old, with a large set of consistent documents over her life course, and this case presents little room for doubt.

[4]The 1930 and 1940 censuses were supposed to give Edna's age "as of" April 1, so the ages given were technically correct, preceding her next birthday by 5 days.

22.1.3 *Gertrude Baines (1894–2009)*

Gertrude Baines was born in Shellman, Georgia on Apr. 6, 1894 as the third daughter of Jordan Baines and Amelia Daniel. According to the family stories, she married Sam Conley at a young age and had a daughter named Annabelle, who was said born in 1909. The family moved to Hartford, Connecticut and resided there for some time. Gertrude's daughter died of typhoid fever at the age of 18 and Gertrude and Sam separated thereafter. Gertrude resumed her maiden name Baines. She later relocated to Ohio, where she worked as a dormitory housekeeper at Ohio State University in the 1940s, before retiring and moving to California many years later. She lived on her own until 1999, when she was 105 years old, and later moved to Western Convalescent Home in Jefferson Park, Los Angeles. In the 2008 U.S. presidential election, at age 114, Gertrude Baines voted for Barack Obama, becoming perhaps the oldest person to vote all-time.[5] Gertrude Baines died in Los Angeles, California, on Sept. 11, 2009, aged 115 years and 158 days.

Gertrude Baines was only "discovered" by the media at age 112. Having previously gone unnoticed and appearing to be in remarkably good health, Robert (who met Gertrude Baines in person, twice) was initially skeptical whether her age claim was correct. This was a woman who had no close family with her, and so offered a bit of a mystery when it came to identification. She did have social security records supporting her age claim (which are mid-life to recent documents), but no birth record or early-life document initially. Yet, even at 114, when Robert first met her, she was a still-lucid woman. Her recall of her own past history (including that she had once worked at the dormitory at Ohio State University) helped establish the parameters for the documents check. It should be noted that, at the time, Gertrude was not aware of many of the documents that were later found and that helped to confirm her claimed date of birth of April 6, 1894, including the 1900 census, which listed her as born in April 1894 and confirmed her age. After the 1900 census and accompanying mid-life documents from Ohio from the 1940s surfaced, it was clear that her story checked out. Later, at her 115th birthday party, Ms. Baines offered a wonderful juxtaposition of society: she, at 115, an African American daughter of an ex-slave, was photographed by then-25-year-old celebrity photographer and LGBT rights activist, Adam Bouska.[6] While Ms. Baines's 114th birthday article said that "she made 114 look easy"[7], it was clear that, by age 115, she was starting to fade physically and mentally. She passed away five months later, in Sept. 2009, at the age of 115.[8] Ms. Baines was the last validated person from the year 1894.

Table 22.3 lays out a summary of the documents for this case:

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[5] LA Times video by Sachi Cunningham shows Gertrude Baines, 114, voting for US President in Nov 2008: https://www.youtube.com/watch?v=LMOYHpA3C08 (accessed Sept. 20, 2016).

[6] Photo by Robert Young shows Adam Bouska, 25, with Gertrude Baines, 115. http://www.bouska.net/?blog_id=267 (accessed Sept. 21, 2016).

[7] http://articles.latimes.com/2008/apr/07/local/me-baines7 (accessed Sept. 21, 2016).

[8] http://www.latimes.com/local/obituaries/la-me-gertrude-baines12-2009sep12-story.html (accessed Sept. 21, 2016).

Table 22.3 Gertrude Baines document summary

Time	Type of document	Documented age/date of birth	Record accords with
June 1900	US census	6; "Apr. 1894"	Apr. 6, 1894
Apr. 1910	US census	20[b]	Apr. 6, 1890[b]
Jan. 1920	US census	22[a]	Apr. 6, 1899[a]
Apr. 1940	US census	39[a]	Apr. 6, 1901[a]
–	USPR	"Apr. 6"	
2009	SSDI	Apr. 6, 1894; died Sept. 11, 2009	

[a]Lower age documented
[b]Higher age documented

In Gertrude's case, the evidence is inconsistent and appears to both overstate and understate Ms. Baines's age. The 1910 census overstated Gertrude's age as "20", as she was 15 (almost 16), married, with an infant child (it was common for young mothers to add a few years when young). Later, in mid-life, Gertrude's census age is understated, at a time when it was culturally acceptable for women in their mid-years to understate their age. However, significantly, both the oldest document (the 1900 census) and the social security records match for the year of birth, month of birth, and the names of the parents. The 1940 census age can be discarded, as "39" would make Gertrude younger than the oldest document. Also, the context of the 1900 census record needs to be considered: we have an age given (6); a year and month of birth given (April 1894); and we have a younger sibling listed as born in May 1895, which would make it very unlikely that Gertrude were born later than 1894. While this case may not pass the strongest possible skepticism (for example, some may claim a remote possibility that the Gertrude who died in Los Angeles in 2009 was not the one who was born in 1894, but was an impostor or younger sibling), the fact that she was able to recall events that only later were checked out and found to be correct makes that very unlikely. Ms. Baines also gave birth to her only child, Annabelle, circa 1910,[9] which would have made her about 15 years old at the time, leaving not much room for age inflation. Also, the names of Ms. Baines's parents were not common (Jordan and Ammie; see Box 22.3), making the census match very likely to be true. Finally, the 1910 census listing for Jordan and "Amy" Baines listed only two children: Ada, "20", and Ister, 13 (Gertrude had already moved out and gotten married). While the ages of the children are again off by a bit (Ada should be "18" and Ister should be "14"), what we can confirm is that no additional children are listed. Had there been a later child listed, it could have raised the possibility of "sibling switching", but by 1910 Jordan and Amy "Ammie" Baines had stopped having children for over a decade. In short, in evaluating the Gertrude Baines case, the early-life 1900 census substitution matches well with the mid-life and late-life data and provides strong evidence (listing Gertrude's year and month

[9]The 1920 census lists Gertrude's daughter Annabelle as age 10 (suggesting birth in January 1910 or 1909). However, the April 1910 census does not list a child living with Gertrude and her husband Sam, suggesting that Annabelle was not born yet. Hence, the most likely approximation of her daughter's age would have her born in mid-1910. (added Apr. 16, 2018).

Box 22.3 Family Tree of Gertrude Baines
Parents:
- Jordan Baines (Apr. 1863)
Ammie Baines (Oct. 1867)

Siblings:

1. Fannie Baines (Mar. 1887)
2. Ada Baines (Nov. 1891)
3. **Gertrude Baines (Apr. 1894 – Sept. 11, 2009) (115 years old)**
4. Ister Baines (May 1895)

Spouse:
- Sam Conley (divorced)

Children:

1. Annabelle Conley (1910–1928)

of birth as well as age), with only a short six-year gap between the birth event and the recording of age. While not the most solidly-validated case, we have original proof of birth, mid-life records including work records from Ohio State, a family tree check, and late-life ID documents. We feel that the evidence is sufficient to conclude that the person who passed away in 2009 was the one who was born in 1894.

22.1.4 Besse Cooper (1896–2012)

Besse Cooper was born as Besse Berry Brown in Sullivan, Tennessee, on Aug. 26, 1896, the third of eight children born to Richard Brown (1861–1932) and Angeline Berry (1866–1927). In 1916, she graduated from the East Tennessee State Normal School. She worked as a teacher in Tennessee before moving to Georgia in 1917. In 1922, Besse Brown married Luther Cooper. The couple had four children: Angie, Luther, Sidney, and Nancy. Luther (the father) died in 1963. Thereafter, Besse Cooper lived alone until 2001, when she moved to a nursing home.

One of us (Robert Young) first met Besse Cooper when she was 111, as part of a Georgia State University (GSU) student oral history project (this helps to establish identity by connecting the person alive at 111 with their memories of the past). At the time, she was in remarkable shape, as can be attested to in her oral history recordings.[10] At 111, Ms. Cooper was able to read books. At her 113th birthday

[10] http://www.100wisdom.com/Super-Centenarians/ (accessed Sept. 21, 2016).

party, Besse tended house like a family matriarch, giving a 30-minute speech before a room of family, friends, and invited guests.

Over the course of five years, Robert had gotten to know Besse Cooper's family, especially her son, Sidney, and grandson, Paul. They assisted in documenting Ms. Cooper's life (she still had a teaching certificate from 1911, when she graduated at 15) and also filling in the stories that Ms. Cooper herself might not have told—such as their saying that she chopped down a tree for Christmas at 86. She lived on her own until 105. But Ms. Cooper herself also reminded people that she sailed down the Tennessee River in 1899 with her dad, at age three. Besse may have been the last living person with firm memories of the 1800s.

Besse Cooper appeared to still be in good shape when she suddenly got caught up in the "worst flu outbreak in Georgia in a decade," while a norovirus outbreak was also occurring. Over 100 nursing home residents were taken ill, including Ms. Cooper's grandson. Besse herself trudged on sick for three days, continuing to stay active. On her last day, she had her hair done and watched a movie before breathing issues led to her death on Dec. 4, 2016.

Regarding Besse Cooper's age, the evidence for her age built up over time. At 109, she was a participant in the Georgia Centenarian Study when she came to Robert's attention. Among the documents located were the 1900 census, listing her as age "3" and born Aug 1896 in June 1900. This document, and the following census and other documents in Table 22.4, support Besse's age also (see below):

Besse had four children between 1929 and 1944…the last at age 48! Having a natural child at age 48 may be a sign that Ms. Cooper was in better health than most—a slower-aging individual. In some instances, a relatively high generation gap can raise suspicions, but we firstly have an explanation (Ms. Cooper delayed child-bearing due to being a teacher early in life) and the documentation and life history for Ms. Cooper is too solid for this to raise any unaddressed concerns. See Box 22.4, below, for family history details.

From the family tree information, a skeptic would also note that there is a large gap between the birth of Besse (the third child) and Edward (the fourth child). One reason for this gap is that the family moved from Tennessee to Georgia in 1899. As Ms. Cooper stated, long before becoming the Guinness "oldest living person", that

Table 22.4 Besse Cooper document summary

Time	Type of document	Documented age/date of birth	Record accords with
June 1900	US census	3; "Aug. 1896"	Aug. 26, 1896
Apr. 1910	US census	13	Aug. 26, 1896
Jan. 1920	US census	23	Aug. 26, 1896
Jan. 1920	US census (II)	23	Aug. 26, 1896
Apr 1922	Marriage record	No age given	N.A.
Apr. 1930	US census	33	Aug. 26, 1896
Apr. 1940	US census	43	Aug. 26, 1896
2006	USPR	Aug. 26, 1896	

[a]Lower age documented
[b]Higher age documented

Box 22.4 Family Tree of Besse Cooper
Parents

- Richard Kitzmiller BROWN (May 16, 1861 – Jan. 20, 1932) (70 years old)

Barsheba Angeline “Angie” BERRY BROWN (Oct. 27, 1866 - Jan. 9, 1927) (50 years old)

Siblings

1. Thomas Cecil BROWN (Nov. 25, 1893 – June 1974) (80 years old)
2. John Ralph BROWN (Feb. 19, 1895 - Oct. 26, 1972) (77 years old)
3. **Besse BROWN COOPER (Aug. 26, 1896 – Dec. 4, 2012) (116 years old)**
4. Edward King BROWN (Apr. 15, 1903 - Sep. 4, 1974) (71 years old)
5. Mary BROWN (Jan. 1, 1905 – June 29, 1996) (91 years old)
6. Urcel BROWN (Jun. 7, 1907 – Oct. 25, 1981) (74 years old)
7. Richard E BROWN (Apr. 6, 1909 – Dec. 17, 1932) (23 years old)

Spouse

- Luther Harris COOPER (Apr. 1, 1895 – Dec. 11, 1963) (68 years old)

Children

1. Angeline COOPER (born 1929)-fl. 2020 at age 91+
2. Luther Jr. COOPER (1932–2019)-87
3. Sidney COOPER (born July 29, 1935)-fl. 2020 at age 85+
4. Nancy COOPER (born 1944)-fl. 2020 at age 76+

she remembered sailing down the Tennessee River in 1899, and for someone to remember indicates that they must have been two or older, Ms. Cooper’s story fits the evidence well. From the census and social security information, we can see that every document supports “1896” (and not one document contradicts 1896, although the marriage record does not state an age); there is strong proof of identity from parental and sibling matches; the marriage record attests to the name change; the recent news reports, SSDI record, and the gravestone records all match. While, hypothetically, one could argue that the 1900 census is a reflected memory and Besse might have been a year younger, there’s no evidence to support a younger age. One of the best-documented US 115+ cases, there’s little reason to doubt that Ms. Cooper was 116 years old when she passed away in 2012. We thus concluded that she was 116.

22.1.5 Dina Manfredini (1897–2012)

Dina Manfredini was born as Dina Guerri, the daughter of Carlo Guerri and Maria Manfredini, in Pievepelago in the Province of Modena in the Italian region of Emilia-Romagna in the northern Apennine Mountains, on Apr. 4, 1897. Dina had two sisters (Lucia and Esterina) and a brother, Angelo. Dina Guerri married Riccardo Manfredini (1885–1965) in Oct. 1920 and came to the USA late in the same year (Dec. 22, 1920), sailing from Le Havre, France to New York City for their transatlantic voyage to the USA. The couple settled in Des Moines, Polk County, Iowa and had four children: Mary Russo (born Aug. 17, 1921), Dante (a WWII veteran) (Nov. 4, 1922–Nov 2016), Rudolph (a WWII veteran) (May 2, 1924–Jan. 15, 1997) and Enes (born May 26, 1928). Riccardo passed away in 1965, age 79. Dina was primarily a mother and homemaker, but later cleaned houses until the age of 90. Dina Manfredini lived independently until the age of 110 and later moved to a nursing home in Johnston, Iowa.

An inspection of the records for this case is essential due in part to Ms. Manfredini being initially reported in the Iowa media as born May 4, 1897, and with Jiroemon Kimura of Japan being born Apr. 19, 1897, a one-month discrepancy would have been enough to deny Dina the Guinness "world's oldest person" title[11]. Yet a closer look at the documents, including the original Italian record of birth, confirms that Dina was, indeed, born Apr. 4, 1897. What quickly became clear was that the "April 4" birthdate was supported by multiple sources, including the original birth registration. The "May 4" birthdate may have been a reporting error by the Iowa department of Elder Affairs. The other documents all supported "April 4, 1897" (Table 22.5).

In this case, Dina Manfredini's age claim to 115+ is not in doubt, with nearly all documents supporting "1897" as the year of birth. Given the earliest document is from

Table 22.5 Dina Manfredini document summary

Time	Type of document	Documented age/date of birth	Record accords with
1897	Civil birth registration (Italy)	Apr. 4, 1897	
Dec. 1920	Immigration record	23	Apr. 4, 1897
Jan. 1925	Iowa census	28	Apr. 4, 1897
Apr. 1930	US census	33	Apr. 4, 1897
Aug. 1930	Naturalization record	Apr. 4, 1897	
Apr. 1940	US census	42	Apr. 4, 1897
2007	USPR	Apr. 4, 1897	
2012	SSDI	Apr. 4, 1897	

[a]Lower age documented
[b]Higher age documented

[11] For the purpose of this chapter, the focus is on the individual case and the investigation by the GRG. Guinness World Records has accepted the following cases reviewed in this chapter as "World's Oldest Person" titleholders: Parker, Baines, Cooper, Manfredini, Weaver, Talley, Jones. Madigan, Rivera, and Hannah were never old enough to be considered, and the Holtz and Miller cases were incomplete at the time the title was awarded.

1897, only the slight possibility of “identity switching” could cast hypothetical doubt on this case. However, the 1920 immigration record precludes the kind of issue seen with the Damiana/Dimina Sette case. Also, the 1930 naturalization record gives detailed information, including the birthdates of Dina’s children. When Dina passed away in 2012, her oldest child, Mary, was 91, and Dante was 90. It’s clear that Dina’s age was well tracked consistently throughout her life, the only error coming at 110+, and that from a local government centenarian list. We thus conclude that the documentary evidence and the family tree together, though missing records on siblings, is enough to validate that Dina Manfredini was indeed 115 in 2012.

22.1.6 Gertrude Weaver (1898–2015)

Gertrude Weaver was born as Gertrude Gaines, the daughter of African American sharecroppers, Charles Gaines and Ophelia Jeffreys, in Lafayette County, Arkansas. She married Gennie Weaver in Arkansas on July 18, 1915. The couple had four children: Cab, Marie, Joe, and Ruby. Her husband died in 1969. At 104, Gertrude Weaver moved to the Silver Oaks Health and Rehabilitation Center in Camden, Arkansas after breaking her hip. After successful rehabilitation, she was able to move back to her home with the help of her granddaughter. At 109, she returned to the nursing home. When interviewed about the secret of her longevity, Gertrude Weaver told that there were three factors that have contributed to it: “Trusting in the Lord, hard work and loving everybody.” Later, she added a fourth factor: “Just do what you can, and if we can’t, we can’t” or, in other words, “Kindness”.

Gertrude’s story is also one of overcoming odds. A woman who was of mixed-race heritage (African-American, Caucasian-American, and Native-American), her case was not even featured in the major media until age 112 (at which point, she looked extraordinary for her age). By December 2012, she was still missing proof of birth. The fact that she married in 1915, however, was compelling evidence of this woman’s extreme age. Yet, initial proof of birth was difficult to come by. A potential 1900 census match had been located, but the name given in the document wasn’t exactly “Gertrude”: it was a nickname: “Tonpon.” It took some additional

Table 22.6 Gertrude Weaver document summary Claimed date of birth: July 4, 1898

Time	Type of document	Documented age/date of birth	Record accords with
June 1900	US census	2; “Apr. 1898”[b]	April–July 4, 1898[b]
Apr. 1910	US census	10[a]	July 4, 1899[a]
July 18, 1915	Marriage record	17	July 4, 1898
Jan. 1920	US census	20[a]	July 4, 1899[a]
Apr. 1930	US census	26[a]	July 4, 1903[a]
Apr. 1940	US census	36[a]	July 4, 1903[a]
–	USPR	July 4, 1904	

[a]Lower age documented
[b]Higher age documented

research to ensure that the woman who was alive in 2014 was the same as the woman who was born in 1898. This included oral-history interviews with her then-93-year-old son, Joe Weaver, in 2014.

In reviewing the documentation available (see Table 22.6, below):

The oldest document (the 1900 census) supports 1898. Given that the census report was so close to the birth event, the chances of Gertrude being even a year younger are slim: most people could tell the difference between a 2-year-old and a 1-year-old. July 1900 is definitely out, as the record itself is older than that. The 1910 census supports 1899/1900, but is a reflected memory a decade later. The 1915 marriage record listing of "17" again supports "1898", but not a specific month (but given that it was recorded in July, it supports that Gertrude was born earlier than July 17, 1898). Mid-life documents understate Gertrude's age, but these documents are much further from the birth event. Gertrude being born in 1903/1904 is also impossible, with the oldest document being from 1900 itself. It was not uncommon in the mid-twentieth century US for women to understate their age, so a pattern of older documents showing an older age is not unusual.

Gertrude Weaver's case is another example of a "fuzzy" validation, although the age discrepancy is one of only three months. Ms. Weaver patriotically claimed to be born July 4, 1898 in her later years, yet the 1900 census lists her as born in April 1898, and the family indicated that they believed she may have been born in April. Taking a look at the family tree information (Box 22.5), since Gertrude was the youngest child, this rules out "sibling switching" with a younger sibling.

Box 22.5 Family Tree of Gertrude Weaver
Parents: (married in 1885)

- Charles GAINES (1861 – July 4, 1928) (67 years old)

Ophelia GAINES (Dec. 1866 - Apr. 2, 1916) (49 years old)

Siblings (as recorded in the 1900 US census):

1. Lemon GAINES (b. Jan. 1886)
2. Martha GAINES (b. Jan. 1890)
3. Mag [Maggie] GAINES (b. May 1893 – May 27, 1991) (98 years old)
4. "Teeto" GAINES (b. Dec. 1894)
5. Burley GAINES (b. May 1896)
6. **"Tonpon" [Gertrude] GAINES WEAVER (b. Apr./July 1898 – Apr. 6, 2015) (116+ years old)**

Spouse:

- Genie WEAVER (1896–1969) (c73 years old)

Children:

1. Cab WEAVER (Mar. 9, 1916 – Aug. 1976) (60 years old)
2. Marie WEAVER BENNETT (July 24, 1918 – Apr. 3, 2006) (87 years old)
3. Joe WEAVER (Apr. 7, 1921 – fl. 2020) (99+ years old)
4. Ruby WEAVER (Oct. 13, 1924 – Nov. 22, 2007) (83 years old)

In summation, Gertrude Weaver's case is one that took years of research to convince skeptics (including myself) that the 1900 census listing, in particular, really was her. My own case investigation, along with the work of local genealogist Carolyn Stratton Cox, is sufficient to convince most skeptics. Whether Gertrude was 116 or 117 is another matter. In the larger picture, Gertrude's validated age of 116 years, 276 days could possibly be upgraded to two months older, should additional material be located to support "April" as the month of birth. Only the 1900 census lists "April", and a single document that is a reflected memory is not enough, in my estimation, to grant her an age upgrade. But if we did, Gertrude could have been as old as just reaching 117. However, that also leaves reasonable uncertainty. We thus decided to go with age 116. In summation, the only issue regarding Gertrude Weaver's age is a matter of months, not years: she was clearly over 116.

22.1.7 Jeralean Talley (1899–2015)

Jeralean Talley was born as Jeralean Kurtz, one of 12 children of Samuel James Kurtz and Amelia Kurtz nèe Jones, in Montrose, Laurens, Georgia, on May 23, 1899. She spent her early years living on a farm picking cotton and peanuts and harvesting sweet potatoes. She grew up in Laurens County before moving with her family to Inkster, Michigan before 1930. Jeralean Kurtz married Alfred Talley (January 30, 1893 – October 17, 1988) in Lucas, Ohio, on Dec. 10, 1936. The couple had one child, a daughter, Thelma Holloway, born in 1937. "Mother Talley", as the New Jerusalem Missionary Baptist Church community she was a member of called her, stayed active in her later life. She bowled until she was 104. Reportedly, Mrs. Talley lived by the Golden Rule: "Treat others the way you want to be treated". She was known in the community for her wisdom and wit. Jeralean advised people to use common sense, saying "I don't have much education but what little sense I got, I try to use it". On her 114th birthday, she received a personalised letter from U.S. President Barack Obama, who wrote that she was "part of an extraordinary generation".

Jeralean Talley was a remarkable woman even before her world recognition: she still lived in her daughter's home (not a nursing home) and even went fishing at age 114 (though with younger relatives assisting)[12]. Jeralean was lucid during her interviews as well. At first glance, one must have wondered if this woman were the age claimed, and how much longer she might live. Let's take a look at Table 22.7, below, which summarizes Jeralean's recorded age in various documents:

For the first issue, there really was little doubt: documents supporting her age included the June 1900 census listing her as born in May 1899, located in 2009, and included matches for her parents. A later, undated family Bible entry did list her as born in June 1899 instead, but the census record is more sure because it is certain when it was written (close to the birth event), not potentially decades later. Social security and other

[12] https://www.huffingtonpost.com/2015/06/18/oldest-person-dies-jeralean-talley_n_7614112.html (accessed Apr. 16, 2018).

Table 22.7 Jeralean Talley document summary

Time	Type of document	Documented age/date of birth	Record accords with
Unknown	Family Bible entry	June 23, 1899	June 23, 1899
June 1900	US census	1; "May 1899"	May 23, 1899
Apr. 1910	US census	10	May 23, 1899
Jan. 1920	US census	19[a]	May 23, 1900[a]
Apr. 1930	US census	20[a]	May 23, 1909[a]
Dec. 1936	Marriage record	May 23, 1899	
Apr. 1940	US census	40	May 23, 1899

[a]Lower age documented

Box 22.6 Family Tree of Jeralean Talley
Parents:

- Samuel James KURTZ (Aug. 17, 1866 – Jan. 30, 1941) (74 years old)

Aurelia Amelia KURTZ (June 4, 1869 – Feb. 24, 1952) (82 years old)

Siblings

1. Malinda KURTZ (born Aug. 1887)
2. Arnetta KURTZ (born Nov. 4, 1888-fl. 1956)
3. Richmond KURTZ (Oct. 29, 1891 – July 1964) (72 years old)
4. Levance KURTZ (Dec. 27, 1893 – Oct. 1970) (76 years old)
5. Ida V KURTZ EDMONDS (Mar. 6, 1897 – June 3, 1995) (98 years old)
6. **Jeralean KURTZ TALLEY (May 23, 1899 – June 17, 2015) (116 years old)**
7. Louverta KURTZ (Apr. 4, 1905-Oct 25, 2003) (98 years old)
8. Sam J KURTZ Jr. (Sept. 5, 1908-Oct. 19, 1991)(83 years old)

Spouse (married Dec. 10, 1936)

- Alfred TALLEY (Jan 30, 1893 - Oct. 17, 1988) (95 years old)

Children

1. Thelma TALLEY HOLLOWAY (born 1937)-fl. 2020 at 83

family records also supported her age claim. A marriage record from 1936 was also located, again supporting the age claim, as well as her identity. While there were some small discrepancies in the census records (the 1900 census is transcribed as "Kuntz", but, due to the cursive writing, it may very well mean "Kurtz"), the numerous matching points (including the names of parents and siblings, and location) made it certain that the woman who was born in 1899 was the same woman who was alive in 2015. One small issue, the one-month discrepancy in the month of birth, does not affect whether she was 115+ or not, although it has bearing on whether Jeralean was 116 (if born June 23, she would have been six days short of her 116th birthday).

A larger potential issue is one of "identity-switching". What happened to younger sister Louverta Kurtz, born in 1905 (see Box 22.6)? One counter-argument is that the names “Jeralean” and “Louverta” are not similar. Also, the family Bible entries indicate a close-knit family that tracked births, at least. Finally, the 1920 census lists both sisters in the same document (one is 19; the other is 13). Thus, Jeralean and Louverta cannot be the same person. The only other younger sibling is male. Sibling-switching seems to be ruled out here. Further family tree research found that Louverta died in 2003, age 98. Together with sister Ida,who also lived to 98, this shows a pattern of sibling longevity.

Despite being in great apparent shape at her 116th birthday celebration in May 2016, just a month later, Ms. Talley had passed away, several days after experiencing heart trouble. Jeralean lived her life to the fullest, staying active until almost the end. This was a woman who was never confined to a nursing home; never confined to bed. She walked, with the assistance of a walker and others, rather than settle for a wheelchair. If we need a poster woman for “plateau aging”, Jeralean Talley is it.

22.1.8 Susannah Mushatt Jones (1899–2016)

Susannah Mushatt Jones was born as Susannah Mushatt, the daughter of Callie and Mary Mushatt, in Lowndes county, Alabama, on July 6, 1899. Her parents were African-American sharecroppers. The family stories said Susannah wanted to escape from the life on a farm and she turned to education as a way to accomplish this goal. She graduated from the Calhoun Boarding High School on Mar. 4, 1922. She wanted to become a teacher and was accepted to Tuskegee Institute’s Teacher’s Program; however, she could not afford tuition and moved to New York in 1923 where she worked for wealthy families taking care of their children. Since 1929, she was married with Henry Jones, but they divorced soon after – in 1933. She supported many of her relatives as they moved to New York. She also helped to establish a college scholarship fund for African-American students at her high school. Susannah Mushatt Jones was blind after her 100th birthday and partially deaf. She used a wheelchair. For breakfast, she always ate four strips of bacon along with scrambled eggs and grits. She resided at Vandalia Senior Center in Brooklyn, New York where she had an open party on each of her consecutive birthdays (Watson, 2014).

Susannah Mushatt Jones was the last American from the 1800s and the next-to-the-last validated supercentenarian from the 1800s. Her case is particularly important. Robert met Ms. Jones in person on April 1, 2016, at the age of 116 years, 270 days. At this point in time, she was still able to eat a banana, but didn’t do much else. When she said things like “I want to go home”, her family took it to mean that she wanted to pass away (“Go see the Lord”). About six weeks later, on May 12, 2016, Susannah passed away at the age of 116 years, 311 days. Her death marked the end of an era: the last American from the 1800s; she was also the last American from 1900 or 1901 as well.

But was Ms. Jones the age claimed? Let’s take a look at the documents for this case in Table 22.8.

The June 1900 census alone was almost 116 years older than her month of death (May 2016). The record lists a “Suzy Mudhat” as 11 months old. While this

Table 22.8 Susannah Mushatt Jones document summary

Time	Type of document	Documented age/date of birth	Record accords with
June 1900	US census	11 months; "July 1899"	July 6, 1899
Apr. 1910	US census	10	July 6, 1899
Jan. 1920	US census	20	July 6, 1899
Apr. 1930	US census	28[a]	July 6, 1901[a]
Apr. 1940	US census	40	July 6, 1899
2006	USPR	July 6, 1899	

[a]Lower age documented

Box 22.7 Family Tree of Susannah Mushatt Jones
Parents:

- John Callie MUSHATT (1868 – Apr. 1, 1931) (c62 years old)
Mary Cook MUSHATT (1875 – July 27, 1940) (c65 years old)

Siblings:

1. Elbert MUSHATT (1891–Jan 1937) (c45 years old)
2. Hardy MUSHATT (Mar. 1, 1893 -fl. 1917) (last confirmed alive in WWI registration)
3. **Susannah MUSHATT JONES (July 6, 1899 – May 12, 2016) (116 years old)**
4. Louvilla MUSHATT HAYES (Apr. 12, 1906 -Nov. 8, 1928) (22 years old)
5. Callie MUSHATT (May 22, 1909 -Jan. 15, 2004) (94 years old)
6. Verbena MUSHATT GLOVER (Feb. 10, 1911 – Jan. 26, 1996) (84 years old)
7. Cody MUSHATT (Sept. 18, 1912 – Dec. 1, 1989) (77 years old)
8. George Wesley MUSHATT (Jan. 12, 1915 – Mar. 23, 2003) (88 years old)
9. Eva Mae MUSHATT ROBINSON (May 7, 1918 – Sept. 4, 1991) (83 years old)
10. Lecettie MUSHATT (1919 -Dec. 7, 1938) (19 years old)

particular census-taker didn't record the year of birth, there can be no doubt that June 1900 minus 11 months equals birth firmly in the 1800s. In addition, the April 1910 census lists Ms. Jones as “10” (which accords with a July 1899 birth). Ms. Jones was only briefly married but had no children, but she lived her entire life with her family, as a member of society, including attending school and working as a nanny, making identity-switching unlikely. Her job taking care of the children of others included for some Hollywood stars in the 1940s. A niece, Dr. Lavilla Watson, wrote a 100+ page biography of her aunt (Watson, 2014).

With the June 1900 census so close to the time of birth, the only major issue is whether the woman who died in 2016 was the same as the woman who was born in 1899. Given that the family tree information on siblings (see Box 22.7) shows that all younger siblings are accounted for and the only siblings missing death records are two older brothers, it seems reasonable to us to rule out this issue. While Ms. Jones had no children and was only married briefly, she was connected to society and her age claim was for the most part consistent throughout her life course. We thus conclude that this case is valid: Susannah Mushatt Jones was 116 and possibly the oldest African American on record, excluding the Lucy Hannah case.

22.1.9 Bernice Madigan (1899–2015)

Bernice Madigan was born as Bernice Marina Emerson, the daughter of Harry Emerson and Grace Emerson (nee Bennett) in West Springfield, Hampden, Massachusetts, on July 24, 1899. At the age of six, the family moved to Cheshire, MA. Bernice Emerson graduated from Adams High School in 1918, and thereafter moved to Washington, D.C., where she worked as a secretary for the Veterans Administration, then the Treasury Department. On Sept. 10, 1925, Bernice Emerson married Paul H. Madigan in Washington and later moved to Maryland. They had no children. Paul Madigan died in 1976. Bernice returned to Massachusetts in 2007. A lifelong Republican, she attended the Inauguration of Warren G. Harding in 1921, and cited Dwight D. Eisenhower and Ronald Reagan as her favorite U.S. Presidents. Reportedly, she did not take any medicine nor a daily vitamin. Bernice maintained exceptional mental and physical health to the point she would have an open birthday party each year until aged 114. Bernice Madigan died in her sleep in Cheshire, Berkshire, Massachusetts on Jan. 3, 2015, aged 115 years and 163 days.

Bernice Madigan was an ebullient personality who countered conventional wisdom by eating doughnuts, and yet living to an extreme old age. A career woman, she moved to Washington, D.C. for a typing job. Bernice Madigan, despite living to 115 years of age, never made it to higher than the world's fifth-oldest person (trailing Misao Okawa, Gertrude Weaver, Jeralean Talley, and Susannah Mushatt Jones) in the GRG rankings (despite making it clear in interviews that she coveted the #1 position, it was not to be). Yet despite coming along at a time when age "115" was less rare than it was in the past, this woman's personality fit right up with the best of them. Her birthdays often featured some special local event, such as riding in an antique fire truck. Bernice had a Facebook account which documented her life almost until the last. When she fell in 2014, injuring her hip, her recovery T-shirt said it all: "I intend to live forever. So far, so good." While, in her earlier years, she appeared to be in fairly good health, Bernice's last year or so included being on oxygen as an attempt to keep her going. Her last New Year's celebration on Jan. 1, 2015 was just two days before she passed away and her last photo, on Jan. 2, 2015, included her making toast.[13]

[13] https://www.facebook.com/photo.php?fbid=10206322935171370&set=o.385969844848669&type=3&theater (accessed Sept. 25, 2016).

Bernice's age is well-attested to by documentation (see Table 22.9 and Box 22.8, below).

Bernice's birth in July 1899 was recorded in a December 1899 birth registration. This is backed up with a 1900 census listing (July 1899), as well as census matches in 1910, 1920, 1930, and 1940. There's also a marriage record and a recent ID (not all documents privately sent in will be shared here; only those that are publicly available). The bottom line: this case is one of the best-validated cases; all documents agree. We are confident, based on the records produced, that Bernice (Emerson) Madigan lived to 115 years, 163 days of age.

Table 22.9 Bernice Madigan document summary

Time	Type of document	Documented age/date of birth	Record accords with
Dec. 1899	Birth record	**July 24, 1899**	
June 1900	US Census	**10 months**	**July 24, 1899**
Apr. 1910	US Census	**10 years**	July 24, 1899
Jan. 1920	US Census	20	July 24, 1899
Sept. 1925	Marriage record	26	July 24, 1899
Apr. 1930	US Census	30	July 24, 1899
Apr. 1940	US Census	40	July 24, 1899
2000s	USPR	July 24, 1899	
2015	Obituary	July 24, 1899	

[a]Lower age documented
[b]Higher age documented

Box 22.8 Family Tree of Bernice Madigan

Parents

- Harry G Emerson (Dec. 19, 1876–1927) (50 years old)

Grace E Bennett Emerson (Apr. 19, 1878 – Jan. 1963) (84 years old)

Siblings

1. Muriel Winifred Emerson Andrews (July 13, 1898-fl. 1944)
2. **Bernice Maria Emerson Madigan (July 24, 1899 – Jan. 3, 2015) (115 years old)**
3. Roy Howard Emerson (Jan. 4, 1906 – Aug. 17, 1979) (73 years old)

Spouse

- Paul H Madigan (May 21, 1896 – May 1976) (c80 years old)

22.1.10 Antonia Gerena Rivera (1900–2015)

Antonia Gerena Rivera was born in Loiza, Puerto Rico, a US possession, on May 19, 1900 as the daughter of José Felix Gerena Agosto and Basilia Rivera Diana[14]. At 15, she left her parents' farm and married Jose Solis y Serrano (died 1943). Her first daughter, Isabelle, was born in November 1917, when Antonia was 17. At this time, she had to work on a farm and raise children herself as her husband fought in the First World War. Afterwards, Antonia worked as a teacher in a rural schoolhouse in the Puerto Rican countryside. Overall, Antonia had nine children, two of whom (Carmen and Fermina) survived her. Antonia had two additional husbands in later life. She came to Florida, USA in the 1970s.

Antonia, whose ancestors came to Puerto Rico from the Canary Islands, came from a long-lived family. Her brother Francisco Genera Rivera, a World War I veteran, was born in 1898 and died at 105 in 2003. A sister, Maria (married to a WWI veteran), lived to 103. The ages of the two centenarian siblings have been documented. Antonia's family longevity also extended to her children. Her oldest surviving daughter, Carmen, was 90 as the time of her mother's passing (and is now 95), while her first-born daughter, Isabel, lived to 92. A third daughter, Fermina, is now 91. Less certain are the ages of Antonia's mother (said to have been 95–98) and sister Augustina (said to have lived to 98). The age of Antonia's father is not certain (his death certificate claimed he was 110!) but early census records suggest he was about 87.

Healthwise, Antonia was a remarkable woman. She could walk until age 113. According to granddaughter Jennie Jimenez, she drank brandy every day until she was 110. Mrs. Gerena Rivera herself believed that the key to being successful in life is to be independent as an individual while maintaining close ties to your family. Antonia was in good health at age 111 but a fall at 113 weakened her. Antonia Gerena Rivera died in Kendall, Miami-Dade, Florida, on June 2, 2015 at the age of 115 years and 14 days.

Following Emiliano Mercado Del Toro (1891–2007)[15], Antonia is the second validated Puerto Rico-born 115-year-old. While Puerto Rico is not counted as part of the US population by the US Census Bureau, Puerto Ricans became US citizens in in 1917, and Antonia Gerena Rivera passed away in Florida, on US soil, in 2015, after having lived in the US for many years.

When Robert first met Antonia and her family, she was doing well for 110 ½: still drinking shots of brandy, still able to walk about. However, at age 113 years 11 months, Antonia fell, and was in delicate condition after that. The family even asked Robert for care advice, and the family agreed that Robert's advice helped Antonia do better. She recovered gradually over the next year. When Robert met her again in January 2015, it was clear that this woman of 114+ years of age was no

[14] Alternate spelling: Viana.

[15] http://www.foxnews.com/story/2007/01/24/emiliano-mercado-del-toro-world-oldest-person-dies-at-115.html (accessed July 252,018)

longer the ebullient walker at age 110. Yet, she was still happy to meet and greet. One thing that was clear was that this woman's health depended on the care and attention she received from her loving family. When, in May 2015, the granddaughter (herself age 70) checking up on her was hospitalized, Antonia's care at a local care home floundered. Antonia soon took ill with pneumonia and died a few weeks later, June 2, 2015, just two weeks after her 115th birthday.

But was Antonia the age claimed? Let's review the documents for this case in Table 22.10, below.

Table 22.10 Antonia Gerena Rivera document summary

Time	Type of document	Documented age/date of birth	Record accords with
Mar. 1904	Birth record	**May 19, 1900**	
May 9, 1910	Puerto Rico census	**10**[a]	**May 19, 1900**[a]
Jan. 1920	Puerto Rico census	22[b]	May 19, 1897[b]
Apr. 1930	Puerto Rico census	28[a]	May 19, 1901[a]
Dec. 1935	Puerto Rico census	34[a]	May 19, 1901[a]
1961	Birth record	May 19, 1900	
1978	Birth record	May 19, 1900	
2000s	USPR	May 19, 1900	
2015	Grave	May 19, 1900	

[a]Lower age documented
[b]Higher age documented

Box 22.9 Family Tree of Antonia Gerena Rivera
Parents

- Jose Félix GERENA AGOSTO (1855? – Aug. 5, 1942; Rio Grande, Puerto Rico) (87 years old) (said to be 110 in his death certificate)

Basilia RIVERA VIANA (April 10, 1863? - May 2, 1958; Rio Grande, Puerto Rico) (95 years old)

Siblings

1. Rosario GERENA RIVERA (1881? – June 25, 1912?) (c31)(Typhoid)
2. Bienvenido GERENA RIVERA (Mar. 2, 1884 – July 1975) (91 years old)
3. Brigida GERENA RIVERA (Dec. 21, 1885? – Feb. 21, 1911) (25 years old) (Typhoid)
4. Agustina GERENA RIVERA (May 5, 1887 – Feb. 19, 1986) (98 years old)(old age)
5. Nicodemes GERENA RIVERA (Nov. 5, 1888/1896? – Oct. 14, 1953) (64 years old)(she fell)
6. Andrea GERENA RIVERA (Nov. 30, 1889 – Aug. 16, 1927) (37 years old)(Tuberculosis)
7. Victoria GERENA RIVERA (Mar. 6, 1893 – May 26, 1977) 84 years old
8. Adela GERENA RIVERA (July 13, 1894 -fl. 1940)

(continued)

Box 22.9 (continued)

9. Amelia Gerena Rivera (1895-fl. 1940)
10. Nicolasa (Nicumedia) GERENA RIVERA (Jan. 11, 1897 – June 1, 1898) (1 year old)
11. Francisco GERENA RIVERA (Sept. 9, 1898 – Dec. 16, 2003) 105 years old; WWI veteran
12. **Antonia GERENA RIVERA (May 19, 1900 – June 2, 2015) 115 years old**
13. María GERENA RIVERA (Mar. 15, 1902 – June 5, 2005) (103 years old)
14. Pedro GERENA RIVERA (May 24, 1905 – July 17, 1998) (93 years old)

Children

1. Isabel (Nov. 5, 1917 – Apr. 26, 2010) (92 years old) died Cape Canaveral Florida
2. Daniel (Mar. 11, 1921 – Jan. 17, 1999) (77 years old) San Juan, Puerto Rico (WWII veteran)
3. Catalina (Apr. 30, 1923 – Jan. 17, 1937) (13 years old) died as a child. Buried in San Juan, Puerto Rico
4. Carmen (Apr. 21, 1925 – LIVING 95+)
5. Blanch (Oct. 27, 1926- deceased), Newburgh, New York, cremated.
6. Fermina (July 7, 1929 – LIVING 91+)
7. Abraham (Nov. 29, 1930 – May 21, 1988) (57 years old) Buried in New York, City. Saint Raymond Cemetery
8. Margarita (Feb. 5, 1933 – June 24, 2014) (81 years old) died Las Vegas Nevada
9. Marta (Apr. 30, 1936 – Nov. 28, 2003) (67 years old) Clewiston, Florida, Buried, Miami, Florida

From the family tree records shown in Box 22.9, we can ascertain that Rivera's family tree came from a time of transition. Early-life documents are missing for Antonia's parents and most of her older siblings, but especially for the period from 1898 onward (when Puerto Rico was transferred from Spanish to US control as a consequence of the Spanish-American War), the coverage improves markedly. There are birth records or early-life census matches (all less than 10 years after the birth events) for the last five siblings. Antonia's own birth of May 19, 1900 was established as early as the Mar. 15, 1904 delayed birth record (and two other siblings were also registered at the same time). Moreover, the tightness of the births leaves little margin for differences: only the year 1901 is hypothetically open, but a May 1901 birth would be only 10 months prior to the birth of younger sister Maria, so it is unlikely.

Though there is also some messiness when it comes to records for her husbands and children, the records for the oldest children have been located. That Antonia gave birth in 1917 (also backed by a birth record which records the mother as "Antonia Gerena") is also a testament to this woman's great age.

While the 1920 census overstates her age (probably due to her having a child as a teenager) and the 1930 and 1940 census understate her age, the two earliest documents and those from 1961 onward all accord with a birth in 1900. When Antonia died, her second-oldest daughter was 90 and her granddaughter was 70. The birth of a child in 1917 leaves little room for age inflation. With the delayed birth record being less than four years after the birth event and with the 1910 census supporting, we thus conclude that Antonia Gerena Rivera reached age 115 in 2015.

22.2 Invalidated (False), Exaggerated, and Unvalidated Claims

While the 10 new 115+ American cases researched in section one of this chapter might at first give an impression that "most" claims to 115+ are now correct, such is not the case.[16] Even with the purported age of the oldest American claimant declining from "128" in the 1990s to "125″" in 2007, there is still plenty of age-inflated literature out there for review. Social Security Death Index (SSDI)-generated frequencies of alleged supercentenarians whose deaths were reported between 1980 and 2009 found only five validated cases among 233 claims of age 115+ in the United States, which results in the 2.1% validation rate in this extreme age group (Young et al., 2010). Below, we will review one of the more problematic recent cases, the Lucy Hannah case.

22.2.1 Lucy Hannah (1875/1895?-1993)

The Lucy Hannah case is one of the most-important cases being reviewed in this chapter (the other being Augusta Holtz, the first validated person to reach age 115). The official position of the IDL and GRG since 2003 has been that this case is "validated" and that, at 117 years 248 days, this woman was the third-oldest validated person all-time[17] and the oldest African-American person on record. For the first book chapter on American supercentenarians 115+, this case was not reviewed because there was not enough information publicly available (Young, 2010). However, given additional U.S. records that were released online in 2015, additional

[16] There were other false claims that we researched other than this one, but were not included due to limitations of space. The below case is the only case among them that was considered "validated". Thus, the below invalidation is a retraction, and the most important of the false cases. Thus, the below case was selected for this chapter to be a type case of how a seeming census "match" could be a mismatch, and why more detailed research (such as family-tree reconstruction) is needed for the most extreme age claims (age 115+).

[17] In April 2018, Nabi Tajima of Japan ostensibly passed this apparently false milestone of 117 years, 248 days, but her claim is also under review.

research is presented here which will call the “validation” status of this case into question.

Before we get to that, it would be appropriate to review how this case came to be accepted as “validated”. The GRG backing came from the IDL backing; the IDL backing came from the SSA study backing. So, in order to check further, we need to know how the SSA study came to decide that this case was “valid”. The first thing to know is that Lucy Hannah’s SSDI listed her as “118”. The second thing to know is that the “SSA study” was employed on a “group scale”, not a focus on single cases. More details on the SSA study efforts can be found at their book chapter in the 2010 Supercentenarians book (Kestenbaum and Ferguson, 2010). Having been an SSA study contributor, I summarize the basics here: the study began with claims to age 110+ between Jan. 1, 1980 and Dec. 31, 1999. Efforts were made to verify, firstly, the dates of death to filter out “ghost cases” (persons “alive on paper” but who had died years or decades earlier). The Lucy Hannah case passed this initial test, as her death date was confirmed in the National Death Index (NDI). Second, mid-life ID/proof of name change was generally considered to be the SS-5 (Numident) application, which in most cases includes the names of the SS applicant’s parents, place of birth, etc. With this information, an attempt was made to match the parental information to an early-life census match (Lucy Hannah, being African American and born in Alabama, likely had no birth record). A “match” with an 1880 census record, listing a child named “Lucy” aged 4, was believed to be the “strong proof” that showed that this woman really was “117” years old. Potential census matches were checked for strength/goodness of fit using a formula, and the match came back as solid. This included correct geographic location, correct name, and a close age. That decision was made in 2003, and has stood since then. Even today, not all details of that scoring “match” have been released.

The SSA study methodology probably was effective over 97% of the time (recent GRG re-investigations have found that to be the case). But, as Jean-Marie Robine and other skeptics have stated, extraordinary claims to 115+ should get a further look, including an attempt to fit the case within a family-tree reconstitution, or at least a check to see what further documents may be available. In 2003, relatively few additional documents were available for this case: there were no news reports, no photos, nothing other than the basic SSDI listings, NDI record, and the census matches. No major breakthroughs came until 2015, when the SSA released details of SS application reports, and a marriage record for Lucy Hannah was located. What the newly-released records showed would finally shine additional light upon this case.

The first new document to be located, the 1972 social security application, didn’t shed any new light: it still listed Lucy Hannah’s parents as Sol and Sally Terrell. But this clue was now more easily accessible to the general public, and led to the larger discovery: the 1943 marriage application “bombshell”: In short, the 1943 (second) marriage application suggests that Lucy Hannah was born Aug. 12, 1895, and that her husband, Fred, actually was the one with a “July 16” date of birth. Fred’s 1942 WWII draft card further confirms his date of birth. Had Lucy been born in 1875, she should be 68 years of age here, not 48 years old as listed.

It has been said that just one major piece of evidence could be enough to invalidate a case, but it's possible that this person understated their age in mid-life. In a situation like this, we can look at the larger context: are there multiple lines of evidence to support the earlier birth record and show that the mid-life age statement was an understatement? In this case, the answer is "no". The few additional mid-life census matches returned, such as the 1930 census, cast further doubt that the Lucy Hannah who died in 1993 was born in 1875. Upon further inspection, even the 1880 census "match" appears to be in error: while the right state, it's the wrong county (Marengo) and Lucy "Terrell" is listed with grandparents, not parents. Furthermore, an alternative 1880 census "match" listed Sol and Sally "Terrill" (slightly misspelled) in the correct county (Elmore) with three older siblings…but no Lucy. A check of one of these siblings, Elmore, confirmed from his later-life records that Sol Terrell and Sally Edwards were his parents. And then we located a likely 1930 census record, listing Lucy Brown (her first husband's name), age 36! So, we are left with a weak (not strong) 1880 census assertion, versus a better-fit 1880 census match for Lucy's parents not listing her as born yet.

The lack of a media claim to "117" further speaks against this case, as does the date of birth being transposed from the husband. Taken together, all these clues lead us to the conclusion that this case is one where the ostensible age may have been altered or switched in mid-life. And this raises the issue: how could the 1880 census "match" have been wrong? Problem number one is that the 1880 census "match" shows Lucy Terrell living with "grandparents", not the parents. It is possible that this is another Lucy Terrell, not the one who later became Lucy Brown, then Lucy Hannah. With the parents living a few counties away and with three of Lucy's siblings listed (but not Lucy), we must assume that she was not born yet in 1880 and the census "match" was a case of misidentification. This is a plausible solution to this case's mystery. For a review of findings, please see Table 22.11, below.

There is more to still investigate on this case: indeed, we have not yet located even a single photo, nor interviewed surviving family members for their say on this claim. However, the information that has already come to light is sufficient, in our estimation, to withdraw "validation" support for this case. The concept of validation is for a high degree of certainty (98% or more confident), and a claim of this magnitude must be able to withstand reasonable documentary scrutiny in order to remain as "validation". Yet the only document issued within 20 years of the birth event is

Table 22.11 Lucy Hannah document summary

Time	Type of document	Documented age/date of birth	Record accords with
June 1880[a]	US census[a]	**Not listed**[a]	**Not born yet**[a]
Apr. 1930[a]	US census[a]	36[a]	July 16, 1893[a]
1943[a]	Marriage certificate[a]	48[a]	Aug. 12, 1895[a]
1972[b]	SS-5 Numident file[b]	97[b]	July 16, 1874[b]
1993[b]	SSDI[b]	118[b]	July 16, 1874[b]

[a]Lower age documented
[b]Higher age documented

not incontrovertible, and a mid-life document says that this woman was born Aug. 12, 1895, which would make her only “97” years of age, not “117”, at death. The 1930 census age of “36” suggests birth in 1893 (and thus suggests Lucy was 99). It may not be certain what age Lucy Hannah actually was, and more may be investigated, but already the approximately 20-year discrepancy between the late-life and mid-life year of birth claims is quite concerning, and supplementary investigation has not turned up sufficient evidence that would support retaining validation status for this case. Given the seriousness of the above findings, we recommend the scientific community withdraw support for this case upon the publication of this chapter. It should be noted that this case is more similar to the Shigechiyo Izumi (1865?/1880–1986) case of Japan in that the original case validation remains not fully public, and that the “debunking” of the case is not as clear as with a case such as Pierre Joubert. Yet we must remember that extraordinary cases require extraordinary evidence. And while checking a case such as Sarah Knauss has only turned up more evidence in favor of her being age 119 (recently, a transcription of the 1890 census has been located, adding further support to Sarah Knauss’s case validation), a checking of the Lucy Hannah case did just the opposite.

With the retraction of this case, suddenly the USA has only one validated person 117+ (Sarah Knauss). The new “oldest African American on record” is, however, still fuzzy, with the cases of Gertrude Weaver, Maggie Barnes, and Susannah Mushatt Jones being possibilities. All three are confirmed to be 115+ but when it comes to “fuzzy validations”, there is a margin of error. Susannah Mushatt Jones’s age of 116 years, 311 days is certain and that must stand as the official record, even if the other two might have been older. Note that, in addition, Violet Brown of Jamaica (March 10, 1900-Sept. 15, 2017) likely becomes the oldest officially validated Black person on record, with the retraction of the Lucy Hannah case.

22.3 Conclusion

After this second book chapter on American supercentenarians age 115+, we now have a clearer picture than after the first chapter (Young, 2010) about the American 115+ population. Of the 18 USA cases aged 115+ which have now been validated, only one was male, and this was an immigrant from Europe (Chris Mortensen). Indeed, the USA has gained several cases through immigration: in this chapter, Augusta Holtz from Germany; Dina Manfredini from Italy; and Antonia Gerena Rivera from Puerto Rico. As in Europe and Japan, age 115 is becoming more common over time: one case in the 1980s, four cases in the 1990s, seven cases in the 2000s, and seven cases so far in 2010s. There does not seem to be a halt in the increasing number of those reaching the age of 115 years or more in the USA.

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