

Separating covid from non-covid: spatial adaptations in existing hospital buildings



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Abstract

The early phases of the Covid-19 pandemic challenged healthcare organisations to rethink how to provide care and deal with their infrastructure differently. Hospitals were forced to amend the use and organisation of their buildings at very short notice in order to separate Covid from non-Covid patients. Given the urgency of the situation, healthcare professionals and architects or technical staff collaborated to design and implement infrastructural adaptations, mostly ad-hoc and simultaneously. In this paper we aim to explore how hospital buildings in Flanders, Belgium, were adapted during the early phase of the pandemic. This was investigated based on interviews (in July 2020) with representatives responsible for infrastructural adaptations in six general hospitals in Flanders. Interviewees illustrated changes made with building plans, photos, and other supportive material. The analysis identified five separation strategies: (1) adapting the building program, (2) installing temporary infrastructure, (3) placing new walls and screens, (4) directing flows of people through signage, and (5) installing new rules and instructions regarding building use. Often several strategies were combined. Despite efforts to divide Covid and non-Covid zones, borders between both were crossed by people, materials, and air. In-between zones, like exchange zones, elevators, and air shafts, were challenging, and required combining strategies to guarantee a safe environment. At the same time, interventions in these zones brought existing rules such as fire regulations to a head. Conflicting priorities arose between providing optimal clinical care and caring for patients' and staff's mental well-being. Covid-contagion risks resulted in a new distinction between patients (Covid and non-Covid) but also highlighted a need for spaces to guard and support mental well-being for staff. At the same time, wards for specific groups of patients, such as children or psychiatric patients, demanded adaptations of the rules. Overall, the spatial adaptations made during the Covid-19 pandemic foregrounded how connecting professionals with different backgrounds allowed creatively adapting existing hospital buildings without losing sight of specific needs of certain patient and staff groups despite, at first sight, conflicting situations.

Author keywords

Covid-19; Hospital buildings, Separation strategies, Spatial adaptations

Introduction

The early phases of the Covid-19 pandemic challenged healthcare organisations worldwide not only regarding the provision of care but also regarding the built environment (Mass Design Group, 2020). Whereas, in March 2020, the World Health Organisation (WHO) published recommendations on how to establish and manage severe acute respiratory infections treatment centres from scratch (WHO, 2020), the specificities of existing hospital infrastructure required creativity of all parties involved as they called for tailor-made and ad-hoc interventions. To guarantee Covid-safe circumstances for patients and staff, hospitals were forced to rethink the organisation and use of their buildings and intervene in their infrastructure at short notice.

The Covid-19 pandemic highlighted the need for strong collaborations between clinical and non-medical professionals, such as architects and engineers (Ndayishimiye et al., 2022). Our research during the early phase of the pandemic suggests that at that point interventions in hospital environments focused on separating Covid from non-Covid patients. In contrast with former formal (re)design processes of hospital environments, these interventions were initially often steered by healthcare professionals and only later coordinated by architects or technical staff (Jellema et al., 2021). To facilitate their daily tasks and optimally care for patients, healthcare professionals are constantly adapting the physical environment (Duque et al., 2019). When doing so, they are well aware of the need for infection control – from the emergency department to patient rooms (Cheng et al., 2013) – but not always familiar with design features that enhance safety, efficiency, and healing or a holistic understanding of the physical and mental impact of the built environment on health care (Cesario & Stichler, 2009). Despite healthcare professionals' essential role is making adaptations to the physical environment, architects and technical staff often fail to recognise these adaptations as design intervention. They tend to take spatial adaptations made by healthcare professionals for granted and do not always acknowledge their input as relevant for a (re)building process (Water et al., 2018).

Interviews with representatives from six general hospitals in Flanders (Belgium), all responsible for infrastructural adaptations, showed how ad-hoc adaptations made during the pandemic have affected space and which benefits and conflicting priorities arose during the adaption of hospital infrastructure.

Based on the analysis of these interviews we aim to explore how hospital buildings in Flanders were adapted. Insight into these adaptations to separate Covid from non-Covid patients identified the importance of connecting healthcare and architectural professionals (Jellema et al., 2021). The cross-disciplinary collaborations between them allowed realizing useful, physically safe solutions in a short time span without losing sight of patients' and staff's well-being. Especially when caring for specific groups like children or psychiatric or palliative patients, guaranteeing physically safe and mentally supportive environments sometimes required conflicting measures. At the same time, the measures taken allowed providing additional care for staff under harsh circumstances.

Background

Throughout the pandemic, publications on the role of infrastructure in fighting Covid-19 abound – both practice- and research-initiated and -oriented. In the early phase of the pandemic, large architecture firms and architect organisations (e.g. HKS & ARUP, 2021; Mass Design Group, 2020; AIA, 2020) provided reports with specific recommendations to design Covid-safe environments. These recommendations translate general topics such as versatility, flow, clean air, or isolation into actual solutions on various building levels ranging from the campus, over the building and unit to the room and its equipment (HKS & ARUP, 2021). Some even explicitly mention a checklist covering all aspects to consider when designing a Covid-safe hospital, ranging from how to approach cross-disciplinary collaboration between healthcare and design professionals to how to realise environments that facilitate separation of individuals, clean and contaminated circulation paths, and appropriate cleaning procedures (AIA, 2020).

In the meantime, a scoping review on the associations between the Covid-19 pandemic and hospital infrastructure adaptation and planning has identified 106 articles discussing the topic (Ndayishimiye et al., 2022). The majority of these papers reported on studies conducted in high-income countries and were published in the first year of the pandemic. According to this review the main focus worldwide lay on infrastructure capacity. We also identified studies that discuss hospital building typologies focusing on Polish cases (Łukasik & Porębska, 2022) and interventions based on international case studies (Setola et al., 2022). Overall, the aim is to gain insight into designing resilient hospital buildings for the future. To achieve this goal several design strategies are foregrounded as important with respect to infrastructure and management, such as re-configuring existing healthcare facilities, introducing additional temporary structures and re-purposing non-health-related facilities (Setola et al., 2022) or striving for adaptability, convertibility, and scalability (Łukasik & Porębska, 2022). The actual topics to focus on differ depending on the phase of a project, design, or operation. Whereas the studies that aim to deepen knowledge focus on location, configuration, and functionality, those that discuss building types pay more attention to themes such as patient safety, indoor air quality, and materials and furniture (Capolongo et al., 2020). Within the Belgian context, we could identify one study (a master thesis) on the relation between the Covid-19 pandemic and hospital infrastructure, focusing on hospitals in Brussels (Gaaloul, 2022).

Practicing architects (e.g. AIA, 2020) and researchers (e.g. Łukasik & Porębska, 2022, Ndayishimiye et al., 2022) pointed at the importance of involving healthcare professionals and

conducting multidisciplinary research to identify the impact of infrastructure on Covid-safe environments and formulate design recommendations. From an architectural viewpoint such collaboration is sometimes hampered by a limited spatial literacy amongst healthcare professionals (Mass Design Group, 2020). Yet, the Covid-19 pandemic created circumstances under which healthcare professionals had to explicate care processes and take an active role in design processes (Jellema et al., 2021). Studying the outcomes of such collaboration provides insight into what kind of interventions were achieved at short notice when a closer connection is established between people with a background in architecture and healthcare.

Approach

Based on online interviews (in July 2020) with representatives of six general hospitals in Flanders (Belgium) we identified adaptations made during the first months of the pandemic. Interviewees provided architectural plans, photos, and other supportive material to illustrate changes made 'on their watch'. All interviews were audio- and/or video-recorded while the interviewer made detailed notes of the conversation. The hospitals were selected based on convenience such as pre-existing connections between the researchers and the hospital boards. With this small scale and explorative selection, we covered a broad range of hospital types: both urban and suburban, brand-new facilities as well as older ones, both centralized and dispersed organisations. Prior to the interviews participants were sent informed consent forms. Participants completed and returned these forms to the interviewers or gave verbal consent at the start of the interviews.

We analysed the interview notes and recordings according to a grounded-theory based approach (Dierckx de Casterlé et al., 2012).

Spatial adaptations

Based on the conducted interviews we identified five strategies that hospitals adopted to separate Covid from non-Covid patients during the first months of the pandemic (from March until July 2020): (1) adapting the building program, (2) installing temporary infrastructure, (3) placing new walls and screens, (4) directing flows of people through signage, and (5) installing new rules and instructions regarding building use. Often several strategies were combined.

Separation strategies

In light of infection control, especially in the early phase of the pandemic, many hospitals aimed for completely Covid-free building sections. To achieve this, they adapted their building programs and moved entire departments or functions, like secure changing facilities and transit spaces for handing over either clean or dirty supplies. Some initially even aimed to keep (sections of) buildings closed to avoid conflicting situations. Despite the good intentions, these strict separation strategies sometimes rather resulted in such situations. Especially on wards where patients' need for (mental) support exceeded the clinical health benefits of a fully guaranteed Covid-free environment, the taken measures were at least to a certain extent released. On paediatric wards a parent could accompany a child and patients receiving palliative care were often allowed at least one visitor.

New functions, like secure changing facilities and transit spaces on the ward (Table 1) came with new practices for staff.

Nurses needed to don full protective clothing, and logistics, cleaning and technical staff had to be retrained in Covid-safe procedures. In the interest of the mental well-being of staff working on Covid wards, some hospitals installed lounges in adjacent empty rooms.

Especially at entrances of emergency departments, temporary infrastructure was installed to increase capacity and facilitate triage (Figure 1, left). These tents and containers were often ordered and placed overnight without much planning. This sometimes resulted in conflicts in hospitals' internal and external organisation, e.g. illogical spatial connections between emergency department and intensive care unit, or blocked parking spaces and additional traffic in the neighbourhood.



Figure 1. Examples of temporary infrastructure (left) and new walls (right)

To separate Covid from non-Covid zones and introduce transit spaces, new walls were installed, often with building materials readily available (Figure 1, right). The necessity of doors or transparent panels was discussed between healthcare and technical staff in relation to work processes and social effects. While separating spaces, the ad-hoc installation of walls rarely resulted in airtight compartments, possibly giving a false sense of safety. Since regular care was postponed dur-

ing the first months of the pandemic, the number of people in hospitals was relatively limited, which made it easier to keep a distance. Once the hospitals opened again for non-Covid patients, plexi-glass screens were in high demand, especially at receptions and in consultation rooms to deter aerosol spread.

Flows were directed throughout the hospitals (Figure 2, left). Entrances were dedicated to specific groups, either patients or staff members. Signs, posters, stickers, and fences were introduced to direct people to relevant departments, waiting areas and wards, and indicate additional levels of infection risk at entrances.

Finally, new rules and instructions were implemented regarding building use (Figure 2, right). Especially towards visitors and ambulatory patients, the use of mouth masks and hand gel, and the need to maintain safe distance needed to be explicated. This imposed additional tasks for staff, often delegated to volunteers. In waiting areas, only chairs could be used that were 1,5 m apart and consultations had to be planned with enough time in between to avoid patients meeting each other.



Figure 2. Examples of direction of flows (left) and new rules and instructions (right)

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Table 1. Non-exhaustive table illustrating how the five identified strategies were combined to spatially separate Covid from non-Covid patients.

	Installing new rules & instructions (5)	Directing flows of people with the help of signage (4)	Placing new walls & screens (3)	Installing temporary infrastructure (2)
Adapting the building program (1)	Building program could be adapted because (at various lev-els) certain decisions were taken. E.g. regulating who was admitted to the hospital (and interrupting regular care) reduced the number of non-Covid patients, allowing to repurpose empty recovery and pre-operation rooms as ICUs or empty wards as staff lounges.	ICUs and Covid wards need to indicate additional levels of infection risk beyond the Covid/non-Covid division. Patients' rooms were considered high risk compared to other spaces on the ward. These zones were marked with stickers on doors, using colour codes to indicate the protective measures required in a space.	Additional walls and doors were required when wards were repurposed to create dedicated Covid cohorts and facilitate new functions on the ward, e.g. secure changing facilities and transit spaces where either clean or dirty supplies could be transferred.	New functions were housed in tents and containers, in spaces under construction or ready to be refurbished, or by repurposing empty spaces or build-ings.
Installing temporary infrastructure (2)	Hospitals were imposed to maintain a separate Covid and non-Covid emergency department and triage. This demanded the use of temporary infrastructure like tents and containers.	Inside temporary infrastructure signage pointed at the need to follow regulations e.g. wearing mouth masks, disinfecting hands, keeping distance.	Additional walls are placed as part of (new) temporary infrastructure e.g. to create multiple spaces in-side tents and containers. Hospitals also used tents to separate larger spaces like a garage.	--
Placing new walls and screens (3)	New transit spaces required new use-agreements. Walls (and doors) delineated zones where certain measures were taken, clear instructions had to be formulated where walls are allowed (or not) and how they should be constructed (e.g. for fire safety)	New walls were placed to separate Covid from non-Covid flows (e.g. at the emergency department) or to introduce transit spaces and cohort wards The zoning and associated infection risk was often indicated on the doors between them.	--	--

Connections and conflicts

Despite the efforts to maintain a strict division between Covid and non-Covid zones, the borders between both were crossed by people, materials, and air. Staff entered and left the hospital, waste from Covid wards was processed elsewhere, and airflows were not necessarily interrupted by spatial separations such as doors or walls. In-between zones, like transit spaces, and elevator and air shafts challenged consciously conceived separations, resulting in adapted practices like medical waste not being allowed in certain elevators. Especially in the in-between zones combining strategies was key to guaranteeing a safe environment (Table 1).

At the same time, interventions in these zones brought existing rules such as fire regulations to a head, forcing to balance one type of safety against another. Fire evacuation routes blocked by newly built walls may delay evacuation. As a result, additional doors were placed, which sometimes facilitated unnecessary passage. This illustrates how spatial adaptations challenge and are challenged by building use. Efforts of staff with various backgrounds sometimes collided because they understood the impact of particular measures differently, e.g. medical staff asking to divide a ward in a Covid and non-Covid part, unaware that a single ventilation system served a larger part of the building. A close, cross-disciplinary collaboration between building- and healthcare professionals allowed discussing such issues in due time and create a mutual understanding about what could and could not be realized. How this collaboration took place is discussed elsewhere (Jellema et al., 2021).

Discussion and conclusion

The Covid-19 pandemic confronted hospitals with major infrastructural challenges. To control infection and offer optimal care, the built environment needed to be adapted at short notice. Whereas international research mainly focused in strategies to increase capacity (Ndayishimiye et al., 2022), our research has a slightly different focus namely on strategies followed to separate Covid from non-Covid. It foregrounds what kind of interventions were achieved within a limited time span when healthcare professionals – whether as formal members of a design team, or as everyday designers (Duque et al., 2019) – work together with architects and technical staff.

Our study identified adaptations on various scales, realised ad hoc by healthcare and/or technical staff and planned by the technical department in dialogue with healthcare management. Most of our findings resonate with design recommendations (e.g. regarding flows, air quality and patient isolation cf. HKS & ARUP, 2021; AIA, 2020) and strategies (e.g. re-configuring existing facilities, installing temporary structure and re-purposing existing structures cf. Setola et al., 2022, and Ndayishimiye et al., 2022) put forward by architects and researchers worldwide. In line with these other studies on the impact of Covid-19 on hospital infrastructure, we discussed

contradictions, challenges, or conflicts arising when combining different strategies. Additionally, our research conducted during the early phase of the pandemic shows that both the ad-hoc character of the interventions and the difference in background between healthcare professionals and architects and other technical staff sometimes hampered a sustainable solution while at the same time it benefitted the speed and flexibility of certain solutions. Later international studies (Ndayishimiye et al., 2022), stressed how clinical and non-clinical staff worked as an inseparable team, especially to convert non-medical buildings into medical facilities and to build new structures. It is worth noting that neither of these capacity surging strategies emerged in relation to separation strategies. Through the analysis of adaptations to create Covid-safe circumstances for patients and staff we learned various lessons. Firstly, hygiene and infection risk can be reduced through a combination of strategies. Which strategies to opt for depends on specific circumstances. The adaptations made raised awareness amongst a wider public (from healthcare professionals to patients and relatives) regarding hygiene and infection risk as building qualities, but also created a new distinction between patients (Covid and non-Covid). This resulted in additional challenges faced on wards for specific groups of patients, such as children or psychiatric patients. These challenges raised awareness about the necessity to adapt general rules in particular circumstances to provide a careful and inclusive hospital environment. Secondly, the need for additional (hospital) spaces to guard and support mental well-being for staff invites to reconsider the role of the built environment in healthcare professionals' functioning and general well-being. Finally, guaranteeing Covid-safe circumstances for patients and staff requires spatial literacy (Mass Design Group, 2020), which is increased through close collaboration between technical and healthcare professionals, to understand the complex interaction between how the built environment is designed and used and how this impacts on infection control and safe distancing. Overall, the spatial adaptations made during the Covid-19 pandemic foregrounded how connecting professionals with different backgrounds allowed creatively adapting existing hospital buildings without losing sight of specific needs of certain patient and staff groups despite at first sight conflicting situations. While technical staff took care of spatial interventions that allowed separating Covid from non-Covid zones, healthcare professionals had to take care of people while avoiding unnecessary contact with and between them. As such, both technical and healthcare professionals were continuously resolving conflicts between 'taking care of' and 'avoiding contact'.

Acknowledgments

With thanks to all who made themselves available to participate in this study. This work was supported by the Research Foundation Flanders (FWO, postdoctoral fellowship Margo Annemans) and the KU Leuven Industrial Research Fund.

References

- Capolongo, S., Gola, M., Brambilla, A., Morganti, A., Mosca, E. I., & Barach, P. (2020). COVID-19 and Healthcare Facilities: A Decalogue of Design Strategies for Resilient Hospitals. *Acta Bio Medica Atenei Parmensis*, 91(9-S), 50–60. <https://doi.org/10.23750/abm.v91i9-S.10117>
- Cesario, S. K., & Stichler, J. (2009). Designing Health Care Environments: Part II. Preparing Nurses to Be Design Team Members. *The Journal of Continuing Education in Nursing*, 40(7), 324–328. <https://doi.org/10.3928/00220124-20090623-02>
- Cheng, V. C. C., Chan, J. F. W., To, K. K. W., & Yuen, K. Y. (2013). Clinical management and infection control of SARS: Lessons learned. *Antiviral Research*, 100(2), 407–419. <https://doi.org/10.1016/j.antiviral.2013.08.016>
- Dierckx de Casterlé, B., Gastmans, C., Bryon, E., & Denier, Y. (2012). QUAGOL: A guide for qualitative data analysis. *International Journal of Nursing Studies*, 49(3), 360–371. <https://doi.org/10.1016/j.ijnurstu.2011.09.012>
- Duque, M., Pink, S., Sumartojo, S., & Vaughan, L. (2019). Homeliness in Health Care: The Role of Everyday Designing. *Home Cultures*, 16(3), 213–232. <https://doi.org/10.1080/17406315.2020.1757381>
- Gaaloul, M. (2022). *L'architecture hospitalière à l'épreuve du Covid-19: Quelles leçons pour l'hôpital de demain?* Université Libre de Bruxelles Faculté d'Architecture la Cambre Horta.
- HKS, & ARUP. (2021). The Pandemic-Resilient Hospital: How Design Can Help Facilities Stay Operational and Safe. <https://www.arup.com/perspectives/publications/research/section/pandemic-resilient-hospital>
- Jellema, P., Annemans, M., & Heylighen, A. (2021). Hospitals' decision-making regarding infrastructural adaptations in response to Covid-19. *Design Culture(s) - Proceedings of Cumulus Roma*, 2289–2301.
- Łukasik, M., & Porębska, A. (2022). Responsiveness and Adaptability of Healthcare Facilities in Emergency Scenarios: COVID-19 Experience. *International Journal of Environmental Research and Public Health*, 19(675). <https://doi.org/10.3390/ijerph19020675>
- Mass Design Group. (2020). The Role of Architecture in Fighting COVID-19: Redesigning Hospital Spaces on the Fly to Protect Healthcare Workers. Ariadne Labs and Mass Design Group. <https://massdesigngroup.org/covidresponse>
- Ndayishimiye, C., Sowada, C., Dyjach, P., Stasiak, A., Middleton, J., Lopes, H., & Dubas-Jakóbczyk, K. (2022). Associations between the COVID-19 Pandemic and Hospital Infrastructure Adaptation and Planning—A Scoping Review. *International Journal of Environmental Research and Public Health*, 19(13), 8195. <https://doi.org/10.3390/ijerph19138195>
- Setola, N., Naldi, E., Arnetoli, M. V., Marzi, L., & Bologna, R. (2022). Hospital responses to COVID-19: Evidence from case studies to support future healthcare design research. *Facilities*, 40(1/2), 131–145. <https://doi.org/10.1108/F-03-2021-0023>
- The American Institute of Architects. (2020). COVID-19 Frontline Perspective: Design considerations to reduce risk and support patients and providers in facilities for COVID-19 care. https://content.aia.org/sites/default/files/2020-07/AIA_COVID_Frontline_Perspective.pdf
- Water, T., Wrapson, J., Reay, S., & Ford, K. (2018). Making space work: Staff socio-spatial practices in a paediatric outpatient department. *Health & Place*, 50, 146–153. <https://doi.org/10.1016/j.healthplace.2018.01.007>
- World Health Organisation. (2020). Severe acute respiratory infections treatment centre: Practical manual to set up and manage a SARI treatment centre and SARI screening facility in health care facilities (p. 120). World Health Organisation.