

Challenges of the next generation hospitals: Rethinking the Emergency Department

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Introduction

The COVID 19 outbreak dramatically highlighted the inadequacy of the Emergency Department (ED) settings in dealing with events that can acutely affect a wide range of population. The immediate urgency to create strictly distinct pathways became also a strategic aspect for reducing possible sources of contagion inside the hospital.¹ This need has often clashed with inadequate structural conditions of the hospital: in fact, the rigidity of many EDs is

due to the hospital typology and its localization (affected by functional program);^{2,3} and it prevents them from being quickly adapted to new needs in the case of maxi-emergencies.⁴ In several recent international projects, the presence of a multifunctional space and/or a buffer area guarantees different scenarios in relation to the healthcare/emergency needs.⁵

Unfortunately, adding more stretchers is too often the only possible response to overcrowding. In addition, there have been calls for years now for emergency rooms to be adapted to the needs of the frailest patients, particularly the elderly, who make up more than 30% of the ED accesses and who need a suitable environment for their physical limitations (reduced walkability, sensory reductions such as sight and hearing) and cognitive limitations (dementia). There is also a frequent lack of spaces to manage the patients with acute behavioral disorders, who need a quiet environment, safe furnishing, and the possibility to be monitored, observed, and treated outside the ED' hard area.⁶

The ED is, as its mission, a dynamic environment that must deal with the expected and the unexpected events. This implies that its organization must be flexible so that teams can always respond appropriately to the changing needs.⁷⁻⁹ A proper support of the architecture, its technologies, and overall facilities is essential to make this possible.

Starting from these assumptions, a group of experts in emergency medicine from the AcEMC (Academy of Emergency Medicine and Care), a team of researchers in healthcare design of the Design & Health Lab (ABC Department) of Politecnico di Milano (Milan Polytechnic University) and other experts in the field gave rise to a collaboration for the definition of the Emergency Department 4.0. In fact, the aim was to develop a proposal for a structural and functional model of the Emergency Department and to identify the best design strategies to implement it for the new construction hospitals and for the renovation of existing facilities. This position paper aims to give rise to a Decalogue that is based on the analysis of the scientific literature and some useful strategies argued between experts in hospital design and practicing health professionals. It aims to become a starting point on this field of interest for the scientific community, with the ambition to continue the studies in the field and to be continued and detailed over time as useful reference for future evidence-based projects.¹⁰

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Decalogue

1. Accesses to the ED and pre-triage area

During the pandemic event, the ED proved crucial in responding to the spread of the virus, especially in the early stages, when EDs risked becoming themselves the epicenter of epidemic out-

breaks. To respond to this and other possible special needs (maxi-emergencies, NBCR emergencies, environmental ones, etc.);¹¹ it is appropriate to guarantee separate and dedicated entrances in addition to the traditional routes for ambulances/vehicles and pedestrian accesses. This could ensure an easier control of the flow of patients and separate accesses to the different functional areas, especially during epidemic periods. In addition, it is necessary to make available multiple cleaning and disinfection points in the ambulance area.

Decontamination outdoor areas should be provided close to the ED, possibly facing the entrance, where temporary and semi-temporary prefabricated volumes (or canopies) can be placed to ensure a confined space with a buffer and pre-triage function.¹²

In conclusion, the atrium and waiting areas should be enough dimensioned to facilitate spacing and convertibility to emergency care spaces (easily implemented oxygen and vacuum dispensing facilities should be provided for this purpose).

2. Triage area

The triage area should be located barycentrically to the entrance(s) for facilitating the rapid flows of priority codes. A dedicated space should be available to allow separating the triage of patients with possible transmissible infections.

There should be easy interaction with administrative staff and clinical areas of the ED. Systems should be provided for audio and/or monitor communication with people in the waiting room.

3. Pre- and post-triage rooms

The COVID-19 pandemic has imposed the need to ensure social distance among users. For the waiting rooms, it is suggested to estimate about 3.14/4 sq m or 9.85 cu m per user to allow safe seating in the worst-case situation, as several international institutions suggested.

When possible, waiting rooms should be in proximity of, or have direct contact with the outdoors; this could ensure greater user safety through natural air recirculation and more seating space, at least in the spring and summer seasons.

Waiting areas and intermediate buffer zones within the ED and

with adequate engineering plants (oxygen, vacuum, electricity, etc.) allow the separation of flows and, in case of need, enable the safe parking of stretchers as is already the case in many national and international case studies.

4. Flexibility, internal layouts, and dimensioning

The recent pandemic has highlighted the need for adaptable, flexible, and resilient architectures, an issue previously argued by several international researchers.⁷ Specifically, it is strategic to arrange, also within the clinical area of the ED, multipurpose buffer areas, which can be quickly set up or reconverted in case of need.

The organization of the internal layouts - for what is consented by the construction features of the building- should ensure a series of compartments/core units that: i) in the ordinary scenario, they are differentiated based on priority coding (white/green/light blue/orange/red) or the intensity of care (low, medium or high ones); ii) in maxi-emergencies can be divided into independent nuclei for the treatment of different casualties (*i.e.*, infectious/non-infectious areas).¹³

About these needs, the presence of a nurses' station and the duplication of support rooms for each compartment is strategic to ensure managerial and organizational flexibility.¹³

The present ED sizing in general needs to be increased (by 10% or more) with special attention to:¹⁴ i) the atrium and waiting areas to facilitate spacing and convertibility to emergency care space; ii) the inclusion of smaller and more numerous waiting spaces close to the treatment areas; iii) the increase of storage areas for healthcare materials, equipment, and dirty and clean storages; iv) the inclusion of isolated treatment stations, dedicated to infectious patients but also useful during the ordinary daily activities; v) the possible increase of the corridors' sizing and elevators to encourage the social distance.

In general, starting from the possibility to sub-divided the areas, the presence of two corridors, playing the role of a double "backbone" could ensure the coexistence of internal paths for ordinary activities along with differentiated flows in the case of infectious maxi-events.



Figure 1. Schematic layout of the Emergency room, starting from the contents decalogue. Sketch by M. Gola, S. Mangili, Y. Yu and S. Capolongo.

In addition, the settings should be supported by the presence of a wayfinding system that is easy to understand and allows flexibility in case of a change in the organization of flows and compartmentalization of the areas.

Finally, since ventilation systems play a strategic role in the design of ED spaces, as several experiences have shown, it is suggested that as many rooms as possible should be created with an external view to ensure air exchange by opening windows.¹⁵

5. Specific treatment areas

ED often proves inadequate for the management of specific categories of users. Dedicated and adequately equipped pathways and clinical examination areas should be provided for the following: i) elderly patients: spaces for evaluating reduced cognitive, motor, and sensory capacity. Consider designing spaces with adequate lighting and soundproofing, walking aids, presence of family members is necessary;¹⁶ ii) children and adolescents: it is requested, if present, to guarantee separate areas for the pediatric areas, except for emergencies, and it is necessary to offer dedicated waiting areas and spaces for parents;¹⁷ iii) patients with mental and behavioral disorders: here it is necessary to offer spaces for interviews and treatment area, to be designed with safety criteria for patients and healthcare staff. If possible, a dedicated area should be available to physically restrain agitated and violent individuals. The psychiatric observation unit, when present, should be located away from the chamber area of the ED; iv) victims of sexual abuse or domestic violence: a special attention to safety and privacy should be dedicated with specific and protected areas; v) patients with infectious disease: it is necessary to guarantee dedicated negative pressure rooms. The presence of isolated ED areas and/or buffer spaces of varying sizes in case of an emergency can be useful;¹⁸ vi) immunocompromised patients: one or two positive-pressure rooms are required; vii) contaminated patients by chemical, biological and/or radiological agents: NBCR area with direct access from outside, showers, wastewater collection, audio video system for control and communication from outside are necessary; viii) patients in custody: dedicated room with security criteria doors, windows, and furniture, if necessary, should be guaranteed.

In addition, a counseling area is required for bad news communication and/or bereavement management; the dedicated area should be designed with armchairs, ordinary furniture, and toilets.

6. Diagnostic areas and mobile technologies

Currently at the international level, there is no specific requirement at the regulatory level to include or not include a dedicated diagnostic area in the ED, and this choice is strongly conditioned by the healthcare design and healthcare organization of each healthcare facility. However, the COVID-19 emergency highlighted the importance of the presence of dedicated radio-diagnostic spaces in the ED settings, as well as the use of mobile diagnostic technologies that can reduce patient and healthcare personnel displacements, thereby reducing the risk of cross-contamination.¹³

7. Communication technology

In an increasingly integrated healthcare system, characterized by clinical and care interventions provided by a growing number of professionals, the support of contemporary and efficient communication technology is essential for:^{13,19} i) decision support (scores, algorithms, guidelines, protocols, diagnostic and therapeutic pathways); ii) remote consultations (with image transmission), both inside and outside the hospital; iii) direct access to patient records, laboratory tests, diagnostic images, consultations, etc.

8. Relationships with other functional areas of the hospital

The design of sanitary and not-sanitary functions within the hospital should consider the strong correlation between the ED and the surgery block, the intensive care unit (possibly with semi-autonomous access from the outdoor), and the diagnostic areas.¹³ Where possible, it is preferable to place these functions on the same floor to facilitate their attainment with horizontal connections, and to limit as much as possible the transit of infectious patients in the vertical distribution (elevators); alternatively, it is advisable to set up elevators dedicated to infectious patients that allow their immediate vertical transfer.²⁰

9. Well-being of patients and healthcare staff

According to the User-Centered Design and more generally Universal Design approach, special attention must be paid in hospital design to the physical, psychological, and social needs of all users (patients, healthcare staff, and visitors), which may be amplified in emergencies.¹³

In general, as several studies demonstrated, with the absence of specific soft qualities and relationship with the green, healthcare personnel can be affected by higher than normal symptoms of anxiety, depression, insomnia, and stress inside hospital facilities. Therefore the design of the space and of the furniture, as well as the views on green areas, is strategic in these settings, both for the workers and user.²¹

From evidence-based design studies, the presence of spaces (particularly green spaces) to ensure the psychological and physical well-being of all individuals involved, as well as the working efficiency of healthcare staff, is fundamental. In addition, such spaces, in the case of an emergency, could provide environments for users to relax from psychological stress and daily pressures.⁵

10. Safety

The safety of patients and healthcare staff is ensured first and foremost by the separation of pathways (children/adults, emergency/minor emergencies, remand patients/others, patients with behavioral disorders/others).

Also the presence of walking aids (handrails in hallways and bathrooms), adequate lighting, beds and chairs with safety devices, and bells for calling for help, etc. are essential. It is important to provide for the surveillance of walking patients with cognitive impairment, using electronic systems (e.g. beacons or other systems).¹³

In any case, the presence of an area for security officers is necessary inside the ED settings.

Conclusions

As a synthesis, the following schemes merge all the useful design concepts argued in the Decalogue (Figure 1).

This study serves as a starting point to define guidelines and strategies regarding the design and management of ED in healthcare facilities, starting from the recent COVID-19 pandemic. Beginning from this Decalogue, it is necessary to develop some focuses on these results and strategies for improving the knowledge on this field also at the international level.

All these aspects will continue the advancement of knowledge and competences within the field of healthcare design which is critical for supporting interdisciplinary collaboration between healthcare facility managers and clinicians in the future planning, programming, and designing of healthcare settings.²²

References

1. WHO. Hospital Readiness Checklist for COVID-19. World Health Organization Regional Office for, 2020. Available from: https://www.euro.who.int/__data/assets/pdf_file/0010/430210/Hospital-Readiness-Checklist.pdf
2. Capolongo S, Cocina GG, Gola M, et al. Horizontality and verticality in architectures for health. *Technè* 2019;17:152-60.
3. Bologna R, Emergencies and innovative processes for hospital project. In Williams P (ed), *From Stone to Scalpel. A guide to developing successful hospital in emerging markets*. USA: Global Health Service Network; 2022.
4. Brambilla A, Mangili S, Das M, et al. Analysis of functional layout in Emergency Departments (ED). Shedding light on the Free Standing Emergency Department (FSED) model. *Appl Sci* 2022;12:5099.
5. Brambilla A, Morganti A, Lindahl G, et al. Complex projects assessment. The impact of built environment on healthcare staff wellbeing. In: Gervasi O. et al. (eds) *Computational Science and Its Applications – ICCSA 2020*. ICCSA 2020. Lecture Notes in Computer Science, vol 12253. Springer, Cham; 2020.
6. Bologna R, Setola N, Marzi L, et al. COVID-19: Sparking a new revolution in hospital design? IHF web-site; 2020. Available at <https://www.ihf-fih.org/2020/12/07/covid-19-sparking-a-new-revolution-in-hospital-design/>
7. Astley P, Capolongo S, Gola M, Tartaglia A. Operative and design adaptability in healthcare facilities. *Technè* 2015;9:162-70.
8. Barbash IJ, Kahn JM. Fostering Hospital Resilience—Lessons From COVID-19. *JAMA* 2021;326:693-4.
9. Pilosof NP. Building for change: Comparative case study of hospital architecture. *Health Environ Res Design J* 2021;14:47-60.
10. Jayasekara JHPRU, Siriwardana CSA, Amaratunga D, Haigh R. Redesigning and Repurposing Healthcare Facilities for the New Normal, COVID-19: A Review on New Approaches in Hospital Systems. *Lect Notes Civil Engin* 2022;174:211-34.
11. Polesani L, Cocuzza S, Nachiero D. Earthquakes and health-care. Considerations and proposals for improving seismic safety of hospitals. *Ann Ig* 2012;24:389-96.
12. Ma M, Adeney M, Long H. Functional settings of hospital outdoor spaces and the perceptions from public and hospital occupant during COVID-19. *Healthcare (Switzerland)* 2021;9:1534
13. Capolongo S, Gola M, Brambilla A, et al. COVID-19 and healthcare facilities: A decalogue of design strategies for resilient hospitals. *Acta Biomedica* 2020;91:50-60.
14. Mutti A, Bucci R, Pedrini D. *Area emergenza ospedaliera*. Carocci editore, Roma, 2020.
15. Gola M, Caggiano G, De Giglio O, et al. SARS-CoV-2 indoor contamination: considerations on anti-COVID-19 management of ventilation systems, and finishing materials in healthcare facilities. *Ann Ig* 2021;33:381-92.
16. Shepley MM, Kolakowski H, Ziebarth N, Valenzuela-Mendoza E. How COVID-19 Will Change Health, Hospitality and Senior Facility Design. *Frontiers Built Environ* 2021;7:740903
17. Buffoli M, Bellini E, Dell'Ovo M, et al. Humanisation and soft quality in emergency rooms. *Ann Istituto Superiore Sanità* 2016;52:40-7.
18. Chen TY, Lai HW, Hou IL, et al. Buffer areas in emergency department to handle potential COVID-19 community infection in Taiwan. *Travel Med Infect Dis* 2020;36:101635.
19. Liu L, Zhou H, Lin B, Yu J. Real-time monitoring and controlling strategies of indoor environment in the frontline hospitals during COVID-19 pandemic. *Kexue Tongbao/Chinese Science Bulletin* 2021;66:4324-1.
20. Setola N, Naldi E, Arnetoli MV, et al. Hospital responses to COVID-19: evidence from case studies to support future healthcare design research. *Facilities* 2022;40:131-45.
21. Gola M, Botta M, D'Aniello AL, Capolongo S. Influence of nature at the time of the pandemic: an experience-based survey at the time of SARS-CoV-2 to demonstrate how even a short break in nature can reduce stress for healthcare staff. *Health Environ Res Design J* 2021;14:49-65.
22. Gola M, Brambilla A, Barach P, et al. Educational challenges in healthcare design: training multidisciplinary professionals for future hospitals and healthcare. *Ann Ig* 2020;32:549-66.