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مجلة الدراسات الإستراتيجية للكوارث وإدارة الفرص  
Journal of Strategic Studies  
For Disasters and Opportunity Management



## The Resilience of Spatial Organization in Hospitals

### during the COVID-19 Health Crisis in Tunisia

المرونة في تنظيم المساحات في المستشفيات خلال الأزمة الصحية لكوفيد-19 في تونس

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#### Abstract

During the COVID-19 crisis, hospitals swiftly adapted their spatial organization to meet escalating demands. This study delves into the resilience of hospital spaces, crucial for treating COVID-19 patients. It scrutinizes short-term emergency adjustments and enduring changes for future readiness. The research, employing a descriptive methodology, extensively gathers data from diverse sources, emphasizing the Tunisian context. International models of spatial reorganization are analyzed, including segregated COVID-19 zones, optimized ICU usage, and enhanced communication technologies. Tunisian hospitals' unique spatial strategies are explored, showcasing challenges faced and innovative solutions. The study showcases how designers revamped hospital spaces, focusing on methods and key principles, to effectively address urgent healthcare needs during the crisis.

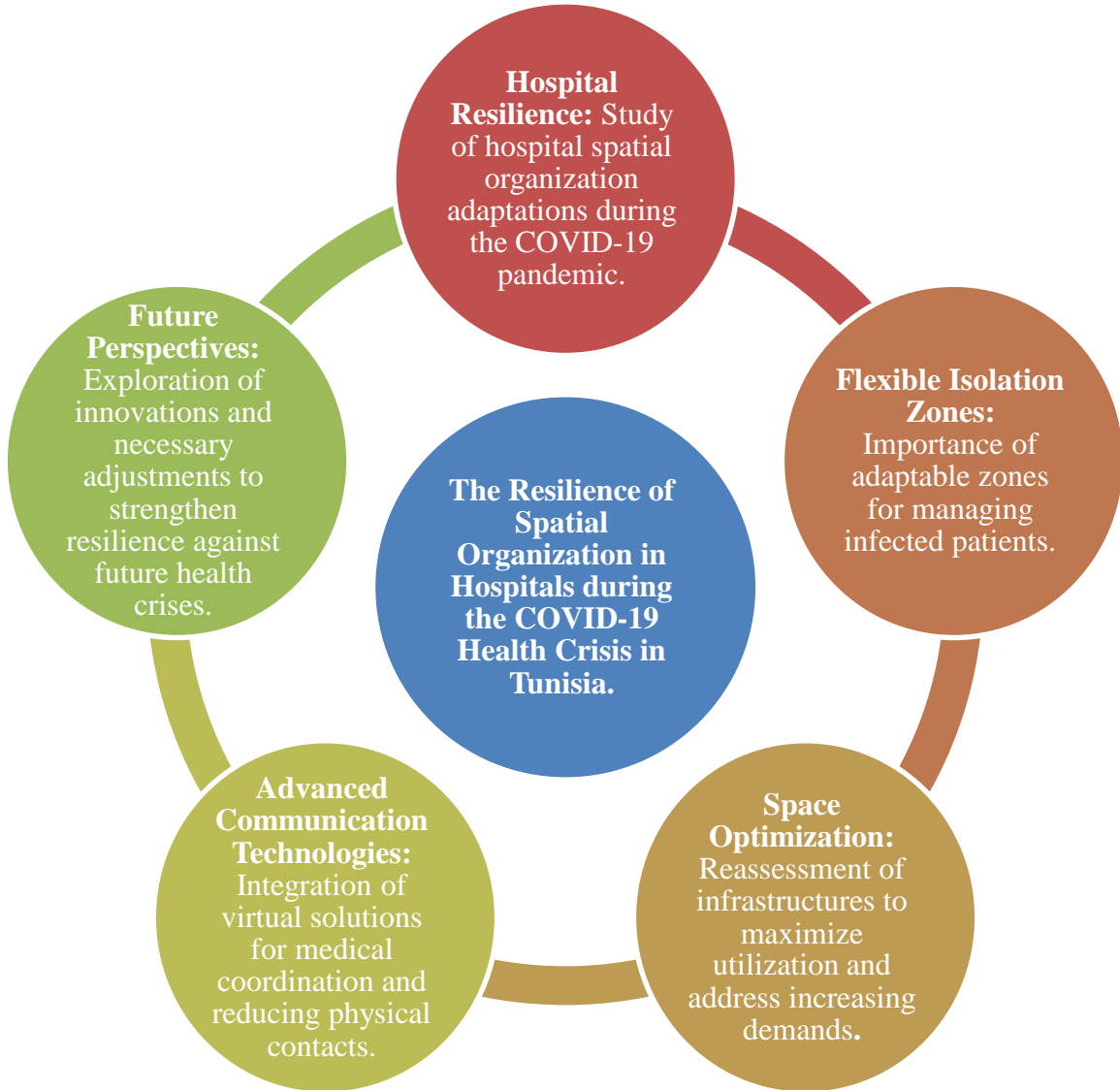
**Keywords:** Hospital space, Spatial organization, Resilience, Covid-19 Health crisis.

#### المستخلص

خلال أزمة كوفيد-19، قامت المستشفيات بإعادة تنظيم تنظيمها المكاني بسرعة لتلبية الطلبات المتزايدة. يقوم هذا الدراسة بالتحقيق في قدرة مساحات المستشفيات على التكيف، والتي تعتبر حاسمة لعلاج مرضى كوفيد-19. تحليل التعديلات الطارئة القصيرة المدى والتغييرات المستدامة للتخصيص للمستقبل. تعتمد البحث على منهج وصفي، مع جمع بيانات شامل من مصادر متنوعة، مع التركيز على السياق التونسي. يتم تحليل النماذج الدولية لإعادة تنظيم المساحات، بما في ذلك مناطق كوفيد-19 المعزولة، وتحسين استخدام وحدات العناية المركزة، وتعزيز تقنيات الاتصال. تُستكشف استراتيجيات المساحات الفريدة للمستشفيات التونسية، مع عرض التحديات التي تواجهها والحلول المبتكرة. تُظهر الدراسة كيف قام المصممون بتحديث مساحات المستشفيات، مع التركيز على الطرق والمبادئ الرئيسية، لمواجهة الاحتياجات الصحية العاجلة بفعالية خلال الأزمة.

**الكلمات المفتاحية:** مساحة المستشفى، التنظيم المكاني، المرونة، أزمة كوفيد-19 الصحية

## Conceptual Abstract:



## The Resilience of Spatial Organization in Hospitals during the COVID-19

This study investigates the resilience of hospital spatial organization during the COVID-19 crisis, focusing on adaptive strategies employed by designers. It aims to highlight effective approaches and principles guiding the reorganization of hospital spaces, with a particular emphasis on the Tunisian context.

This study employs a descriptive approach, combining qualitative and quantitative analysis, collaboration platforms, and literature reviews to investigate hospital spatial reorganization during the COVID-19 crisis.

How have hospital spaces been reorganized in response to the COVID-19 crisis? What are the key challenges faced by designers in ensuring the resilience of spatial organization within hospitals? How effective have these adaptations been in managing patient care and minimizing the risk of infection transmission?

Implementation of flexible isolation zones and optimization of space usage enabled swift adaptation of hospital facilities to meet urgent demands during the COVID-19 crisis, highlighting the critical role of spatial organization resilience.

The most crucial recommendations include establishing flexible isolation zones, optimizing space utilization, integrating advanced communication technologies, and implementing adapted traffic flows to enhance the resilience of hospital spatial organization during health crises like COVID-19.

- Further research into innovative spatial design solutions, such as modular and adaptable hospital structures, enhanced telemedicine capabilities,
- Advanced ai-driven systems for patient monitoring.
- Ongoing evaluation and refinement of planning principles based on emerging healthcare challenges and technological advancements will be essential to ensure the continued resilience of hospital spatial organization in the face of future health crises.

## 1. Introduction

The notion of crisis is a complex and polysemic reality. Etymologically, it encompasses the concepts of "decision and judgment"(Portal, 2009). By definition, a crisis "is a sudden and disruptive situation"(Lagadec, 2019, p. 6). It represents a state of instability where decisions must be made to restore normal functioning. It can also refer to a profound imbalance, significant confusion, or severe disorder, regardless of its nature. Crises with health implications can stem from various origins, including natural phenomena like earthquakes, floods, or storms, health issues like pandemics (such as the coronavirus, H1N1, or the plague), as well as technological, economic, or socio-political crises. Therefore, the notion of crisis finds vast and diverse applications. Patrick LAGADEC (1995), a researcher, and co-director of the National Center for Scientific Research (CNRS) research group on major risks and post-accidental crisis situations, presents the following definition: " *The crisis shakes the core foundations of a system, including the fundamental collective decisions made by the relevant actors*" (Hassid, 2011). He further emphasizes that " *Three elements can intertwine in the concept of a crisis: it is an exceptional event, surpassing our capacity to act, and causing a loss of orientation*" (MARRE, 2010, p. 8). This definition and these elements highlight the significance of considering appropriate responses in the face of a crisis. Therefore, it is widely acknowledged that the notion of a crisis refers to a momentary imbalance, necessitating prompt and suitable decision-making.

Our research mainly focuses on health crises. According to Jean-Marie Fessler(2004, p. 620), a health crisis is defined as follows: "*The crisis is a situation that threatens the priorities of an organization by surprising decision-makers, limiting their reaction time, and generating stress and profound resistance*" (MARRE, 2010, p. 7) . In other words, it is a critical moment when it becomes crucial to make quick, appropriate, and efficient decisions. The consequences of crises are often significant and far-reaching in terms of financial losses, human casualties, and the impact on organizations, particularly hospitals that face a massive influx of patients. In this context, Fabien Fed Up emphasizes that "*health establishments are obviously the primary recourse in managing health crises as they receive the victims, but they can also be a source of crises.*" (MARRE, 2010, p. 11) . Thus, health facilities are confronted with a state of emergency, as pointed out by Alain Bolzinger (1982): "*There is no crisis without experiencing the crisis*".

Therefore, the pandemic situation, despite its difficulties, constitutes an urgent call for governments, doctors, architects, urban planners, and designers to find ways to better understand and consider health disparities to propose solutions. At this stage, the question is no longer limited to strategy but rather to crisis management, which aims to manage the health situation in an organized, attentive, and delicate manner to preserve public health.

In this context, hospitals play an indispensable role in the care of infected individuals. However, the social organization of hospital facilities can have a significant impact on patient outcomes in these situations.

In our research article, our primary focus is on examining the impact of health crises on hospital spaces. We will then discuss the interventions and reorganizations implemented in hospital spaces both internationally and specifically in Tunisia. This exploration aims to gain a comprehensive understanding of the key aspects required to effectively address the pandemic, including the structures, arrangements, and reorganization of hospital spaces.

## **2. Literature Review**

The literature review process utilized a comprehensive approach, encompassing traditional search methods through databases such as Science Direct and Google Scholar, as well as a thorough exploration of academic journals, conference proceedings, relevant books, and web pages. This extensive search strategy ensured the inclusion of diverse and authoritative sources spanning various disciplines and perspectives, thereby enriching the breadth and depth of the literature review.

## **3. Methodology**

This study is based on a descriptive research approach aimed at analyzing the spatial organization of hospital spaces during the COVID-19 health crisis. The methodology adopted encompasses several crucial stages. Firstly, an extensive collection of data was conducted from primary sources, including official reports, health guidelines, case studies, and concrete examples of hospital space redevelopment. Additionally, secondary sources such as research articles and relevant academic publications were utilized to enhance the data collection process.

Then, the collected data underwent a systematic comparative analysis, enabling a comparison of the various approaches adopted by hospitals on an international scale, as well as an examination of the specificities of spatial organization within the Tunisian context. The objective of this analysis was to identify organizational models, adaptations implemented, and planning principles employed. To substantiate these findings, representative case studies have been selected, providing detailed information on the specific changes made, challenges faced, and solutions implemented in the redevelopment of hospital spaces.

As part of this descriptive research, no specific ethical approval was required since all the data used were publicly available. However, it should be noted that this study is based on data available up until the research date, and the practices and examples presented may evolve over time. Lastly, it is important to emphasize that this analysis specifically focuses on the spatial organization of hospital spaces and does not consider other essential aspects such as human resources or medical equipment. Utilizing this descriptive methodology, the aim of this study is to offer a comprehensive understanding of the organization of hospital spaces during the COVID-19 health crisis. The objective is to enhance their resilience and provide guidance for future decisions regarding design and layout in the healthcare field.

## 4. Analyse

### 4.1.The Resilient Hospital Space

To enhance the management and organizational response capabilities of healthcare institutions in the face of any pandemic, it is essential to grasp the nature of the crisis from the outset. Questions arise: How should we manage the crisis? What strategies should be employed? Paradoxically, in pandemics like COVID-19, we are thrust into the situation abruptly and with great intensity. As illustrated by doctors Olivier Babinet and Corinne Isnard Bagnis, (2021) " *like all health crises, that of Covid-19 was sudden, acute and unexpected*". This crisis exposes the weaknesses of healthcare systems worldwide, as Serge Cannasse (2020) said, highlighting two interconnected types of vulnerability: medical and/or socio-economic vulnerability. The factor of time and organization is at the root of this weakness. In other words, there was insufficient time to anticipate and demonstrate the adaptability of hospital spaces in managing the emergency. In this regard, the Covid-19 crisis has brought about multiple and varied organizational changes in hospital spaces.

On the other hand, in any health and socio-political crisis, hospital establishments have specific procedures that the establishment managers must follow, often referred to as the "white plan." Even during this crisis, several healthcare institutions have implemented their white plan to enhance the health situation. The "white plan" "*is a crisis management mechanism that enables hospitals to promptly mobilize their available resources in response to a surge of patients or to address an exceptional healthcare situation*" (Catherine et al., 2022, p. 5). In such circumstances, from the preparation guidelines and the management of emergency health situations to the design of hospital spaces, the white plan emerges as a critical element that aids in crisis management and guides the adaptation of hospital structures and organizations to accommodate the influx of patients.

#### 4.1.1. The Organization of Hospital Spaces in a COVID-19 Unit: Optimizing the Utilization of Existing Space

In this section, our aim is to examine the adapted organization of hospital spaces during crisis situations and identify how their restructuring can be carried out to ensure compliance with physical distancing guidelines.

Covid has brought great changes, spatial and even functional changes in hospital facilities. At the functional level, crisis situations force professionals to get out of everyday life, such as the paths and protocols of care. At the organizational level, in this context, the French archivist and historian HILDESHEIMER Françoise in 1992 indicates, When the plague modifies, "*the hospital institution transforms into a lazaret, (appears) incorporating elements of isolation and surveillance that will have significant impacts on hospital architectural design.*"(STEUDLER-DELAHERCHE, 2000). In other words, health facilities, especially hospital spaces, are undergoing extensive redesign and mandatory transformations due to the health crisis. This has led to significant spatial reconfigurations.

The organization of hospital spaces has been completely rethought to enhance the capacity of the hospital system to cope with this unprecedented challenge.

As a result, they have undergone substantial changes in their organization. During the Covid-19 pandemic, the Sainte-Justine University Hospital in Quebec took proactive measures upon learning about the specificities and modes of transmission of the coronavirus. The hospital team devised an action plan to enhance safety and adapt to the situation. As highlighted by Émilie TREMPE (2020), "*we had never considered physical distancing as a means to minimize transmission risks. This aspect significantly influenced the decisions made regarding space utilization and planning*". In this regard, they have implemented adjustments in caregiving practices to optimize work organization and ensure employee safety. Consequently, the hospitalization units have been divided into three zones (Sainte-Justine, 2022, p. 4) : cold, hot, and lukewarm zones, each separated based on the Covid-19 status of the patients to prevent cross-contamination.

Initially, the cold zone is designated for patients who are known to be Covid-19 negative or asymptomatic. In this area, the infection protection protocols remain the same as those previously in place, with a strong emphasis on hygiene practices. Physical distancing measures are also implemented to ensure safety.

Then, the warm zone is designated for patients whose Covid-19 status is still unknown or who are exhibiting symptoms. This zone serves as a central area in the hospital where patients potentially infected with Covid-19 await their diagnosis. The warm zone functions as a triage area, with the patients' stay being brief before they are redirected to either the hot or cold zone based on their test results. To prevent cross-contamination among patients and staff, healthcare workers are required to wear personal protective equipment (PPE) whenever they enter a patient's room and remove it immediately upon leaving. In the warm zone, corridors and workstations are considered non-infected areas.

Finally, the hot zone is the designated unit where patients with a confirmed positive status for Covid-19 are located. Each room in the hot zone is equipped with a hand disinfection station. The establishment of zones and the implementation of protective measures for staff based on these zones promote the mobility of healthcare personnel while ensuring their own safety as well as that of the patients.

In addition, they have implemented a phased reorganization plan that involves zoning the hospital spaces based on the evolving epidemic situation.



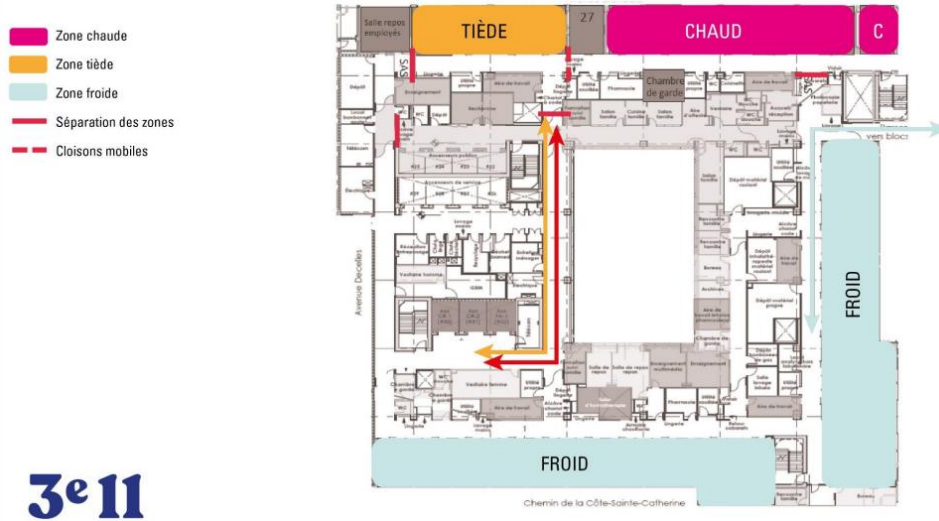


Figure 1: Hospitalization Service Plan: Hot, Warm, and Cold Zones (3E11), CHU Sainte-Justine, Quebec - Phase A. Source: <https://www.chusj.org/CORPO/files/ef/efca0a89-ed39-4023-9afe-796113a6f3ba.pdf>.

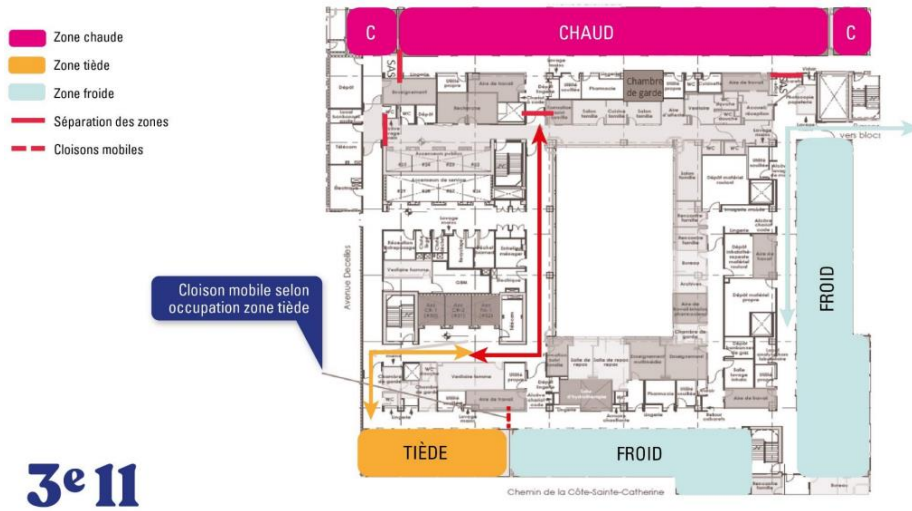


Figure 2: Hospitalization Service Plan: Hot, Warm, and Cold Zones (3E11), CHU Sainte-Justine, Quebec - Phase B. Source: <https://www.chusj.org/CORPO/files/ef/efca0a89-ed39-4023-9afe-796113a6f3ba.pdf>.

La Figure 1 and Figure 2 depict two floor plans of the Hospitalization Department at Sainte-Justine University Hospital. In response to the increased influx of COVID-positive patients, they have restructured phase A to be more suitable, incorporating separation and movable partitions. They have expanded the hot zone while reducing the size of the cold zone. In essence, the spatial configuration and layout have been modified based on the requirements and circumstances, ensuring that "The necessary arrangements in the different areas have been dictated by the principles of infection prevention. The zones must be flexible" (Emilie, 2020).

#### 4.1.2. The Resilience of Hospital Spaces: Adapting Space to the State of Crisis

This pandemic has posed a threat to health systems worldwide, including Italy, which is among the countries most affected by the coronavirus. To enhance the capacity for accommodating infected patients, the Maggiore Della Carità Hospital in Novara, the second largest tertiary hospital in Italy, has implemented a strategy to address this situation,

particularly focusing on organizational and structural aspects. This aims to ensure a prompt response to the increasing demand for beds, particularly those required for invasive mechanical ventilation<sup>1</sup>.

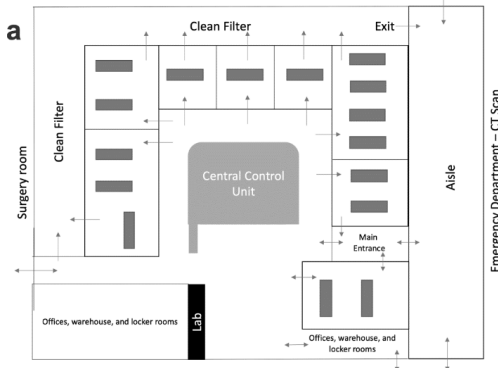


Figure 3: (a) The Normal State of the Intensive Care Unit. Source : [www.ncbi.nlm.nih.gov/pmc/articles/PMC8393636/#!po=90.0000](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC8393636/#!po=90.0000)

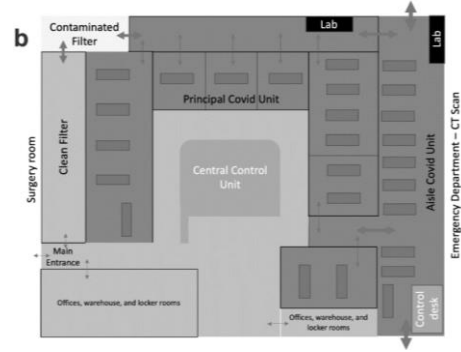


Figure 4: (b) Agreement of the Intensive Care Unit in the COVID-19 Unit. Source : [www.ncbi.nlm.nih.gov/pmc/articles/PMC8393636/#!po=90.0000](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC8393636/#!po=90.0000)

The hospital space represents an Intensive Care Unit (ICU), as depicted in Figure 3, which illustrates the general configuration of this unit during normal circumstances. The ICU comprises "14ICU stations and a shock room with two dedicated positions for in-and out-of-hospital emergencies are all placed around a central unit for visual control and telemetry monitoring" (Cammarota et al., 2020, p. 432). However, the ICU has undergone gradual conversion and reorganization into specialized units and cohorts for COVID-19-positive patients who require invasive mechanical ventilation. Therefore, an emergency plan was designed and implemented under the supervision of building engineers to address unforeseen needs. As depicted in Figure 4, "as shown in Figure 1b, an aisle was transformed in to an additional critical care area and connected to the principal ICU COVID-19 due to its proximity to the emergency department and the computer tomography scanner"(Cammarota et al., 2020, p. 433).

This conversion of space facilitated the creation and swift arrangement of 12 additional care stations, effectively expanding the main COVID-19 Intensive Care Unit to 26 beds, albeit with a slight compromise in ergonomic workspace. Additionally, three beds have been allocated in the operating room to stabilize suspected cases prior to their admission to the main intensive care unit, as only patients with a confirmed laboratory diagnosis of COVID-19 can be admitted to the ICU. In summary, the structural modifications made to the aisle have streamlined the monitoring of clinical activities and enhanced the quality of care, with only a minor reduction in ergonomic workspace.

<sup>1</sup> Invasive mechanical ventilation in medicine is a method of artificial ventilation that involves supporting or assisting spontaneous breathing using an artificial respirator.

### 4.1.3. Principles of Hospital Organization for COVID-19 Units to Promote Resilience

At the beginning of 2020, doctors treating hospitalized patients infected with the COVID-19 virus recognized that the rate of infection with SARS-CoV-2 is higher among healthcare workers and other patients, as indicated by observational studies (Addleman et al., 2021). To mitigate this risk, medical researchers have drawn inspiration from their experiences in the Toronto and Madrid regions, as well as the experiences of their colleagues in Wuhan, China. They propose an approach to the creation of COVID-19 units and care teams that prioritize strict infection control measures and ensure the safety of staff.

This approach to COVID-19 units emphasizes the importance of establishing care protocols for COVID-19 patients and treating them in separate units to optimize care while minimizing virus transmission. In terms of the organization of the COVID-19-unit space, the focus is primarily on zoning the hospital space. Additionally, the organization of the medical team involves restructuring and optimizing the use of personal protective equipment.

#### 4.1.3.1. Optimizing Hospital Space Based on Contamination Risks

The designers have divided the treatment units into circumscribed areas based on the risk of contamination. These areas are clearly demarcated with signage at ground level and posters, as depicted in Figure 5, below.

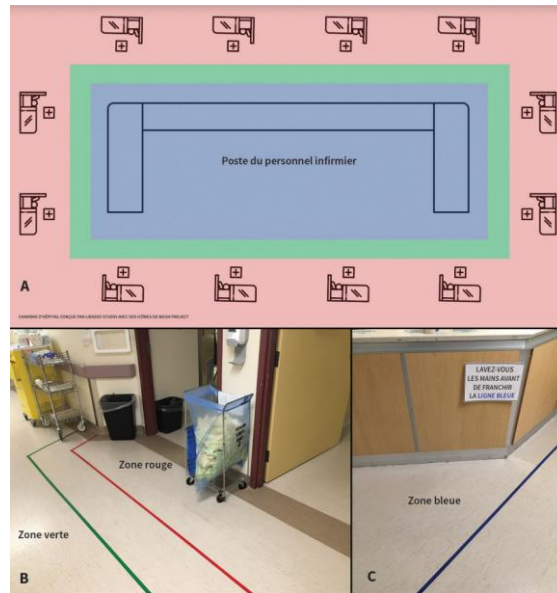


Figure 5: Presentation of the different zones in a COVID-19 unit: A) Zoning layout of a COVID-19 unit (Coronavirus Disease 2019). B) Red and Green areas. C) Blue zone. Source : [https://www.cmaj.ca/content/192/46/E1495?fbclid=IwAR2R4jvdp2Kuc9I\\_xlCuN6LgEza3S35tkN7v9spj2mszM-eE5OqvbFVM0-k](https://www.cmaj.ca/content/192/46/E1495?fbclid=IwAR2R4jvdp2Kuc9I_xlCuN6LgEza3S35tkN7v9spj2mszM-eE5OqvbFVM0-k)

Concentric risk zones are defined around the patient rooms to better manage the different risk levels:

- The Red zone represents a high-risk area, particularly in the corridors.

- The Green zone indicates a moderate risk level.
- The Blue zone signifies a low risk, primarily around the nursing station.

Thus, “one of the guiding principles is to minimize movement between zones and implement visual reminders regarding the use of full personal protective equipment (PPE) in the red zone. Additionally, emphasis is placed on the proper removal of PPE and hand washing before leaving the area” (Frost et al., 2020, p. E1495). Therefore, the isolation of these stations as decontaminated areas is crucial. This spatial organization promotes preventive measures and prioritizes the optimization of patient care, the safety of healthcare professionals, and meticulous infection control.

#### **4.1.3.2. Restructuring of Medical Teams and Optimization of Personal Protective Equipment Usage**

First and foremost, during the formation of medical teams specifically assigned to the management of COVID-19 cases, it is crucial to consider the team's adaptability to changing needs, its capacity to integrate reassigned doctors, and the safety of its members. Additionally, long-term viability and the ability to maintain continuity of care should also be considered. The use of a “twinning system between 2 professionals[...]” meanwhile allows for the separation of tasks and offers related advantages for infection control. For example, the first health professional can perform all the physical examinations and enter the red zones (by putting on and removing the PPE carefully), while the second remains in the green zone, supervises the installation and removal of the PPE, and performs other tasks [...], while being available to offer help or ask for it. With this system, professionals who enter the rooms are less likely to contaminate the working environment. This structure also fosters clinical discussions and collaborative decision-making” (Frost et al., 2020, p. E1497).

Secondly, the utilization of a mobile workstation, models of daily progress notes, and remote printing of notes aim to minimize contacts between health professionals in the red zones. Additionally, the use of portable medical equipment, such as a portable chest ultrasound, can assist in identifying the causes of acute respiratory failure. Additionally, the authors “have designed a remote monitoring system using pulse oximetry, which is usable in patients with an increased risk of clinical deterioration or those receiving supplemental oxygen, as the increase in the frequency of in-person monitoring increases the risk of exposure to the virus”, this eliminates the need to enter the patient's room. Consequently, restructuring healthcare professionals and increasing the utilization of remote medical monitoring equipment serve to decrease the rate of virus contamination and to organize and adjust the workflow among healthcare professionals.

#### **4.1.4. Organization of the Triage and Screening Area**

It is crucial that every entry to a healthcare facility, regardless of its type, during a health crisis be preceded by a triage area where suspected patients, including healthcare personnel, undergo a COVID-19 screening test. Furthermore, the triage area plays a vital role in a healthcare setting as “the integrated triage for outpatient environments in the context of

COVID-19 is a new decision support tool designed to safely and effectively refer all patients presenting in a clinical setting to appropriate care during the COVID-19 pandemic” (USAID et al., 2022, p. 2). This area aims to prioritize patients and the workload of healthcare staff.

The WHO has proposed two triage options, A and B (Africa, 2020), with the aim of providing guidance on how to quickly establish a triage area within a healthcare facility. Option A involves setting up a basic marshalling yard space that meets the minimum requirements for such installations. This triage option is intended for small healthcare facilities that may have limited resources. Option A fulfils the minimum requirements for yard area installations. The triage area can be set up in a well-ventilated building or in an outdoor tent located at the entry point of the healthcare facility.

Figure 6 depicts a representative diagram illustrating the setup of a basic triage station, specifically Option A. The sorting station is arranged with a designated entrance and a separate exit to ensure an efficient and orderly flow. The triage station consists of a table and two chairs: one chair and the table are designated for the healthcare worker, while an additional chair is specifically assigned for the patient. Both chairs should be positioned at one to two meters from each other. Patients exhibiting symptoms of COVID-19 should be placed in a separate area from those without symptoms. The chairs should be spaced at least one meter apart in this area. Screening forms, thermometers, and personal protective equipment (PPE) should be readily available for healthcare personnel.

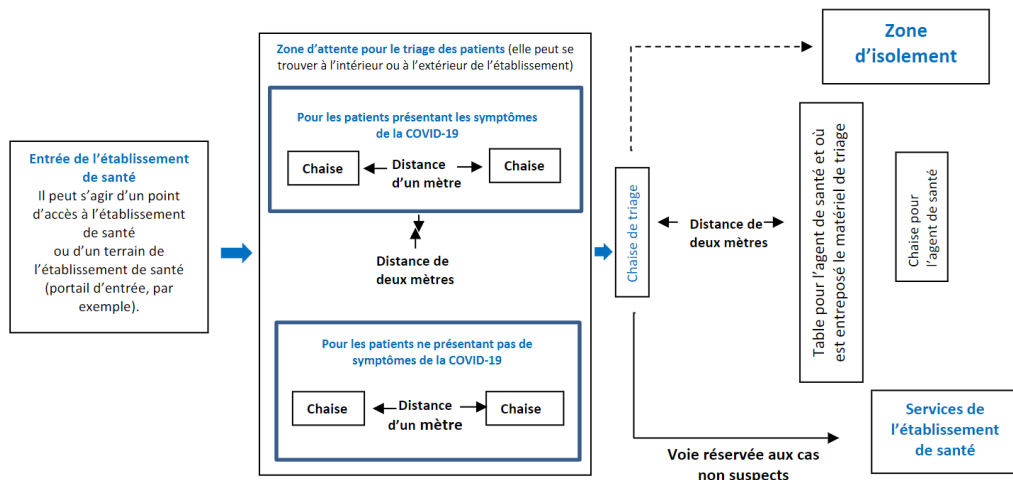


Figure 6: Installation of a Basic Marshalling Yard (Minimum Requirements): Option A. Source : [www.afro.who.int/sites/default/files/Covid-19/Technical%20documents/Installation%20de%20postes%20de%20trriage%20des%20patients%20atteints%20de%20la%20COVID-19%20dans%20les%20C3%A9tablissements%20de%20sant%C3%A9.pdf](http://www.afro.who.int/sites/default/files/Covid-19/Technical%20documents/Installation%20de%20postes%20de%20trriage%20des%20patients%20atteints%20de%20la%20COVID-19%20dans%20les%20C3%A9tablissements%20de%20sant%C3%A9.pdf)

Near the triage station, and ideally in proximity to the triage area, an isolation space should be established to separate suspected COVID-19 cases exhibiting mild to moderate symptoms from others. If it is not possible to create this isolation space near the triage area, a designated room within the health facility should be allocated for isolation purposes. Option A should include two access points: one lane designated for cases requiring isolation should directly lead to the isolation area, while the second lane should provide access to specific services within the health facility based on the patients' needs.

On the other hand, Option B is a more advanced triage station designed for larger health facilities that are equipped to provide emergency care procedures as well. This Option B (refer to Figure 7) combines triage and emergency care in a single space, specifically for individuals in critical condition, while maintaining a minimum distance of one meter between healthcare workers and patients. Handwashing stations should be placed at the entrance of the facility. The triage structure of this triage and emergency care center should be open and well-ventilated. Additionally, the entrance to the health facility should have a single point of entry, and traffic should flow in one direction.

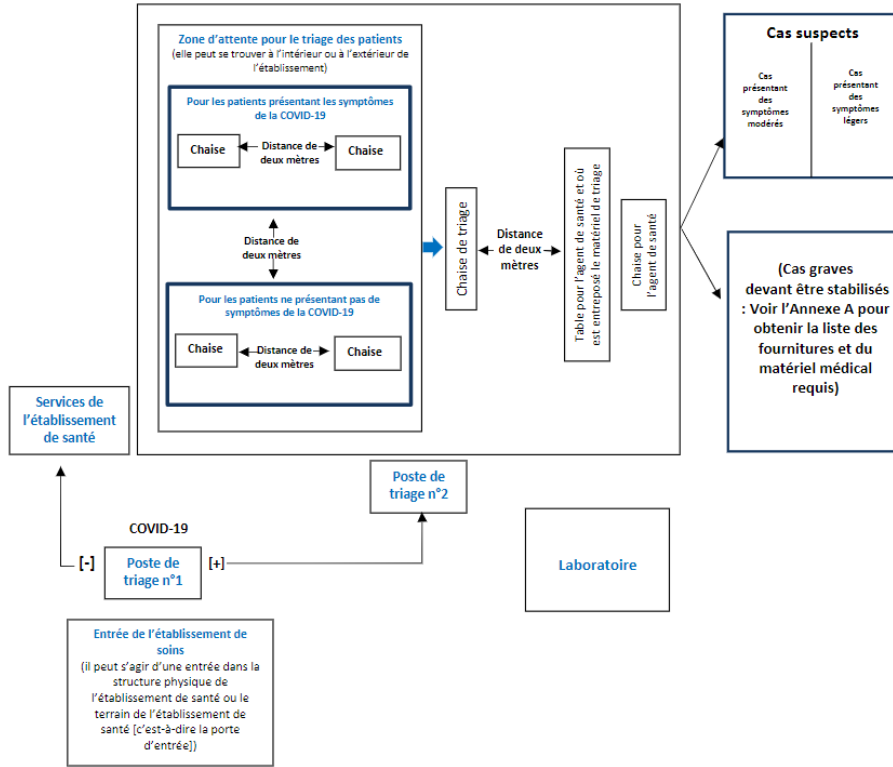


Figure 7: Installation of an Advanced Triage and Emergency Care Center: Option B. Source: [www.afro.who.int/sites/default/files/Covid-19/Technical%20documents/Installation%20de%20postes%20de%20triage%20des%20patients%20atteints%20de%20la%20COVID-19%20dans%20les%20C3%A9tablissements%20de%20sant%C3%A9\\_.pdf](http://www.afro.who.int/sites/default/files/Covid-19/Technical%20documents/Installation%20de%20postes%20de%20triage%20des%20patients%20atteints%20de%20la%20COVID-19%20dans%20les%20C3%A9tablissements%20de%20sant%C3%A9_.pdf)

About the marshaling yard area, two separate marshaling yards should be created. The installation of an initial triage point at the entrance of the health facility, where patients could undergo rapid screening for COVID-19 symptoms, is essential. Additionally, a second triage point should be set up to allow patients to undergo more in-depth clinical examinations immediately after the first point. Adjacent to the second triage area, there should be an isolation area that is divided into two subspaces: one area reserved for emergency and intensive care for severe cases, and the other reserved for suspected cases with mild or moderate symptoms. Lastly, the installation of an advanced triage and emergency care center, Option B, should include a laboratory that is situated outside the isolation zone to facilitate rapid testing of suspected cases with mild or moderate symptoms.

## 4.2.The Hospital Space in Tunisia During the Crisis

Tunisia, like all countries in the world, has experienced epidemic crises throughout its history. According to Tunisian historian ALLAGUI Abdelkrim, (2020, p. 24) "*at the end of the Middle Ages, the geographical area that is now called Tunisia experienced a significant demographic catastrophe: half, or even two-thirds, of the inhabitants were swept away by the disease*". From the Middle Ages until the nineteenth century, Tunisia was consistently plagued by various contagious epidemics, including the plague and cholera.

On the other hand, in the twentieth century, the advancement of science has brought about significant changes. Specifically in Tunisia, Doctor Charles Nicolle(Pasteur, 2023), who was awarded the Nobel Prize in 1928 for his epidemiological work, founded the Pasteur Institute of Tunis in 1893, establishing a legal framework and a healthcare infrastructure. As a result, today, the exponential growth of the healthcare system, including the Basic Health Care Directorate of the Ministry of Health responsible for monitoring diseases with epidemic potential, plays a crucial role in safeguarding the health of the Tunisian population.

Even prior to the health crisis, Tunisian hospitals have been in a catastrophic state in terms of service quality, lack of building maintenance, insufficient available space, poor spatial organization, and an undignified image. All these factors primarily contribute to a negative experience for patients and healthcare personnel within hospital environments. During the health crisis in Tunisia, hospitals exposed their inability to adapt, as well as their infrastructure and patient care deficiencies. As highlighted by Dr. Rim Abdelmalek et al. (2020, p. 604) from the Infectious Diseases Department, "*the COVID crisis has exposed the weaknesses of our healthcare system*". On the other hand, managing the pandemic required both urgency and carefulness. Consequently, despite the collapse of the healthcare system, Tunisia's response to the COVID-19 health crisis has been prudent. Dr.Ben Alaya emphasized during an interview with a Tunisian radio station, "*If we do not unite our efforts, the health disaster will worsen*"(Berthaud-Clair & Favarel, 2021).

### 4.2.1. The Care Pathway and General Structure of COVID Units for Suspected or Infected Patients with COVID-19

Since the emergence of COVID-19 in Tunisia in March 2020, the National Authority for Health Assessment and Accreditation (INEAS) <sup>2</sup> has issued documents and guidelines for institutions and healthcare professionals regarding the organization of care in an interventional medical environment, triage procedures, and the management of suspected or affected patients during the COVID-19 pandemic.

Initially, it is essential to establish a dedicated Covid-19 circuit within each public and private healthcare facility. This patient pathway(INEAS, 2020) (see Figure 8) aims to

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<sup>2</sup> The National Authority for Evaluation and Accreditation in Health is a non-administrative public institution that was established in 2012. This organization possesses legal status and financial independence and operates under the supervision of the Ministry of Health. Its headquarters are located in Tunis, the capital of Tunisia.

streamline the workflow of healthcare professionals, ensure the safety of patients, and prevent the transmission of viruses to other patients and nursing staff. Consequently, it contributes to the effective management of the healthcare situation in Tunisian health institutions.

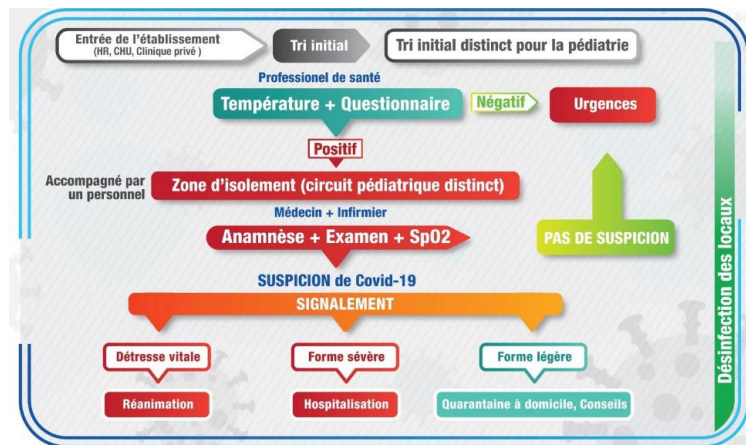


Figure 8: The Path of a Consultation Patient in the Emergency Department of Healthcare Institutions in Tunisia.

Source

[https://www.ineas.tn/sites/default/files//1585254933340\\_situations\\_particulieres\\_25\\_mars.pdf](https://www.ineas.tn/sites/default/files//1585254933340_situations_particulieres_25_mars.pdf)

From the moment of entering the healthcare facility, the process begins with an initial triage area for all patients, where those with suspected COVID-19 are identified. If a patient tests negative for COVID-19 through a rapid diagnostic test and examination by a healthcare professional, they are directed to the regular emergency department without suspicion of COVID-19. However, if the COVID-19 status is still unconfirmed for a patient with suspected symptoms, they are directed to an isolation zone. Following diagnostic tests such as PCR analysis, if the test comes back positive and the patient is in critical condition, they are transferred to the intensive care unit. If the patient's condition is severe but not critical, they are admitted to the hospitalization department. Lastly, if the patient's condition is mild, they are advised to receive care at home.

Therefore, the COVID-19 circuit and the hospital space in healthcare institutions in Tunisia, taking the Tri-COVID circuit of Habib Bourguiba University Hospital in Sfax as an example, are composed of four distinct areas: a screening area, an isolation zone, a hospitalization area, and an intensive care unit.

In the following section, we will conduct a study on the organization and layout of hospital spaces in COVID-19 units in Tunisia. Our focus will be on how the space should be adapted to the COVID-19 crisis.

Moreover, INSEA (2020, pp. 19-22) has also clarified the spatial arrangement of each hospital area. We begin with the sorting area or screening area, where "the Ministry of Health has implemented a strategy for screening Coronavirus cases, which many specialists in the field find inadequate" (manager, 2020). This circuit includes a patient reception area where visual sorting is conducted through questioning, while maintaining a physical distance of one meter for everyone involved.



This pre-triage aims to identify patients exhibiting signs of Covid-19 infection. Once identified, patients are directed to the Covid-19 triage area, known as the patient transit area, through designated corridors. From there, they are directed to specially equipped consultation rooms where they are further assessed to determine the severity of their condition. Based on this assessment, patients may either be allowed to return home, require hospitalization in cases of moderate severity, or need admission to the intensive care unit for severe cases. Additionally, the triage area includes an administrative section for the COVID unit where registration agents are present. Moving on to hospitalization and resuscitation services, INSEA has organized patient rooms with specialized equipment, work desks for professionals, changing rooms, storage areas, as well as transit/corridor spaces and laboratories.

#### **4.2.2. Interventions in Hospital Spaces During the Crisis**

Due to the critical situation in hospitals in Tunisia and the exponential increase in the number of people requiring hospitalization, it is crucial that the main objective for the state and health institutions during the pandemic is to increase the number of intensive care and hospitalization beds to strengthen the healthcare systems. Professor Jalila Ben Khelil, a member of the Covid Commission, emphasizes that "*the number of Covid intensive care beds in the country has increased from 96 to 350*"(France-Press, 2021). To achieve this, various methods and interventions have been implemented to effectively manage the situation and address the crisis circumstances.

##### **4.2.2.1. Reorganization of Hospital Spaces in COVID-19 Units**

Firstly, according to Jawhar MOKNI (2021), the Regional Director of Health, the University Hospitals in Sfax, namely CHU Hedi Chaker and CHU Habib Bourguiba, are fully operational. The health crisis looms large, and as a response, they have established dedicated COVID-19 units by repurposing existing services to accommodate infected patients.



**Figure 9: Collection Unit at Habib Bourguiba University Hospital, 2021**



**Figure 10: COVID-19 Isolation Unit at the Emergency Department, CHU Habib Bourguiba, 2021.**



**Figure 11: COVID-19 Hospitalization Units in Intensive Care at Habib Bourguiba University Hospital, 2021.**

On the one hand, the hospital space in times of crisis at the Habib Bourguiba University Hospital:

Triage Unit: a pre-treatment unit (refer to Figure 9) has been installed at Habib Bourguiba University Hospital for conducting RT-PCR analyses. This measure ensures maximum safety and minimizes the risk of contamination in the emergency department of CHU Habib Bourguiba. Additionally, there is COVID-19 pre-sorting at the hospital entrance, and within the emergency department, a dedicated isolation unit with a capacity of two beds has been established, providing oxygen and/or resuscitation as needed.

COVID-19 Hospitalization Units in Intensive Care: There are two COVID-19 resuscitation hospitalization units at Habib Bourguiba University Hospital (refer to Figure 11). The first unit is situated in the surgical resuscitation department, with a maximum capacity of eight beds. The second unit is in the medical resuscitation department and can accommodate a maximum of nine beds. Thus, the total maximum capacity for intensive care hospitalization is 17 beds. Turning our attention to the hospital space at CHU Hedi Chaker during the COVID-19 health crisis, it comprises:

Triage Unit: To ensure optimal management of suspected and confirmed COVID-19 patients, a COVID-19 triage unit was established on September 16, 2020.



**Figure 12: Tri-Covid Circuit: Hedi Chaker, Sfax, 2021. Source: [www.facebook.com/DirectionRegionaleSanteSfax/photos/pcb.829763951084594/829751551085834](https://www.facebook.com/DirectionRegionaleSanteSfax/photos/pcb.829763951084594/829751551085834)**

This unit was installed in CHU Hedi Chaker and consists of five cabins: a medical examination cabin (1), a sampling cabin (2), two medical observation cabins (3), and a rest cabin for the health team (4).

The oxygenated COVID-19 hospitalization units have operated five units. The first and second units are located on the first and second floor of the pulmonology department, with a maximum capacity of 64 beds. The third unit is in the infectious diseases department, with a maximum capacity of 31 beds. The fourth and fifth units are in the gastro department and have a combined capacity of 45 beds (20 beds started operations on January 05, 2021, and 25 beds started operations on April 09, 2021). In total, Hedi Chaker Hospital has a maximum capacity of 140 beds. The medical teams of the university hospital, along with the residents and hospital-sanitary staff, provide the necessary care.

In addition, to strengthen its capacities in COVID-19 units, following the saturation of health facilities in Sfax, *“the Minister of Health, Faouzi Mehdi, announced on Tuesday, September 22, that his department has decided to transform the new hospital in Sfax into a COVID-19*

center” (Webdo, 2020). This initiative aims to improve the care provided to infected patients in Sfax. The COVID unit comprises a total of 68 beds, distributed across “two units as follows: the Green Zone with 36 beds and the Orange Zone with 32 beds” (Rania, 2021) (refer to Figure 13 and Figure 14). The Green Zone functions as an inpatient department, while the Orange Zone serves as the Resuscitation department.



Figure 13: Green Zone of the Military Hospital in Thyna, Sfax: Captured by Jallel Amara, 2021. Source: [www.facebook.com/photo?fbid=10157817284996650&set=pcb.10157817285261650](https://www.facebook.com/photo?fbid=10157817284996650&set=pcb.10157817285261650)



Figure 14: Orange Zone of the Military Hospital in Thyna, Sfax: Captured by Jallel Amara, 2021. Source: [www.facebook.com/photo?fbid=10157817284996650&set=pcb.10157817285261650](https://www.facebook.com/photo?fbid=10157817284996650&set=pcb.10157817285261650)

#### 4.2.2.2. Extension of a COVID-19 Unit

To isolate individuals affected by COVID-19 and prevent their contact with patients at Sahloul University Hospital, architects Imen Bouali and Malek Belghith (Kapitalis, 2020) have designed a COVID-19 health unit as part of a charitable initiative (refer to Figure 15). The construction of this unit is currently underway and is expected to be operational within 15 days. The extension has the capacity to accommodate up to thirty patients affected by the virus.



Figure 15: 3D Plan of the COVID Health Unit and a 3D View of a Patient Room, Sahloul, Sousse, Tunisia. Source: <http://kapitalis.com/tunisie/2020/04/09/sousse-lunite-covid-19-de-lhopital-sahloul-sera-prete-la-semaine-prochaine-photos/>

Boukef Riadh, the head of the emergency department, stated, "This health unit, called the 'COVID-19 Unit,' has been constructed on a 400 square meter area. It comprises a waiting room, 8 hospitalization rooms with a capacity of 3 patients each, and a large room designed for non-COVID patients, accommodating a maximum of 6 patients" (WMC & TAP, 2020). Additionally, to ensure the safety of medical personnel, the COVID unit includes two guard rooms situated adjacent to a monitoring station. This station enables the monitoring of vital

signs such as heart rate and blood circulation, while also facilitating remote communication with patients. These measures aim to minimize direct contact with contaminated patients.



**Figure 16: The Hospital Spaces within the COVID-19 Unit in Sahloul, Sousse: The Corridor Atmosphere and Hospitalization Rooms.** Source : <https://lapresse.tn/58494/inauguration-de-lunite-sanitaire-covid-19-a-lhopital-universitaire-sahloul-de-sousse/>

Professor Faouzi Addad (2020), a cardiology expert, emphasizes, "*the coronavirus has elevated health to a top priority worldwide. Therefore, the COVID-19 facility at Sahloul Hospital will remain a symbol of effective epidemic management in Tunisia*". It is evident that this extension serves as an intervention to address the crisis at hand. The organization and design of hospital spaces prioritize physical distancing between patients and healthcare staff. Furthermore, this structuring facilitates the coordination of patient care pathways and ensures efficient workflow and mobilization of medical personnel.

#### **4.2.2.3. Conversion of Space into a Dedicated COVID-19 Care Area**

Among the interventions, sports halls such as the El Menzah gym in Greater Tunis were converted into temporary hospitals with the addition of resuscitation rooms. These temporary facilities were established to accommodate patients infected with Covid-19.

As part of the interventions, sports halls such as the El Menzah gym in Greater Tunis have been converted into makeshift hospitals to accommodate Covid-19 patients through the temporary installation of a resuscitation room. "*The room has been divided into two sections: the area with the blue sign is dedicated to patients requiring respiratory assistance, while the intensive care and emergency rooms are located in the section marked with the red sign*" (Yassine, 2021).

The area marked with the blue sign houses the hospitalization service, including the setup of the emergency room. It is an open space that comprises examination and individual hospitalization rooms, separated by canvas partitions and arranged in a continuous manner. These rooms are designed to facilitate the examination, treatment, and monitoring of patients affected by Covid-19. They are identical and versatile in nature. On the other hand, the section marked with the red sign is a completely open and well-ventilated space. This area consists of resuscitation beds equipped with modern medical technologies.

## **5. Result**

This study will enable us to identify several principles for the spatial organization of hospital spaces during the COVID-19 health crisis. Firstly, the creation of flexible isolation zones

has proven to be essential. This involves establishing specific areas to isolate and treat COVID-19 patients, with the ability to quickly adapt these spaces according to changing needs.

Secondly, optimizing the use of existing space is a key principle. The designers of hospital spaces have aimed to maximize the efficiency of the facilities by reevaluating the allocation of different areas and adapting available spaces to accommodate the influx of patients. This may include converting certain areas for intensive care or creatively utilizing multipurpose spaces to meet specific requirements.

Additionally, the integration of advanced communication technologies played a significant role in promoting the resilience of space organization. This encompassed the utilization of virtual communication systems, telemedicine solutions, and remote monitoring technologies to facilitate coordination among medical teams, reduce physical contact, and optimize patient care.

Lastly, the implementation of adapted traffic flows was crucial in minimizing the risks of cross-contamination. This involved creating specific circulation routes for COVID-19 patients, segregating patient flows in waiting and triage areas, and establishing clear protocols to guide the movement of patients and medical staff. These planning principles were implemented by hospital space designers to enhance the resilience of spatial organization and effectively address the challenges of the health crisis.

## **6. Discussion**

Hospital facilities are facing unprecedented challenges due to the COVID-19 health crisis, requiring an immediate and efficient reorganization to manage the overwhelming number of patients. This study examines the various adaptations made by hospital space designers in response to the crisis, with a focus on the resilience of spatial organization.

The planning guidelines identified in this study have proven their efficacy in promoting the resilience of hospital spaces during times of crisis. The implementation of flexible isolation zones has enabled a swift response to emergencies by providing dedicated areas for the treatment of COVID-19 patients. This approach facilitates rapid adaptation to evolving needs and reduces the risk of contamination.

This study sheds light on the unique aspects of spatial organization implemented in hospitals in Tunisia. Concrete examples of hospital space renovations in Tunisia were presented, showcasing the modifications made to address urgent needs. These illustrations provide valuable insights into effective configurations within specific contexts. The ability to design, construct, modify, and transform specific areas of a facility is a crucial element of disaster preparedness. Therefore, in Tunisia, with the guidance and recommendations provided by the Ministry of Health and INSEA, healthcare institutions across various regions have witnessed significant changes at the organizational level of hospital spaces during the COVID-19 health crisis.

## 7. Conclusion

This research highlights the importance of the resilience of spatial organization in hospital settings during the COVID-19 health crisis. Planning principles, such as the creation of flexible isolation zones, optimization of existing space utilization, integration of advanced communication technologies, and implementation of adapted traffic flows, have proven to be effective in addressing the challenges of the crisis. These principles have enabled designers to rapidly adapt hospital spaces to meet urgent needs while ensuring the safety of patients and medical staff.

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