STRATEGIC DESIGN RESEARCH JOURNAL

Field Hospitals to Face COVID-19: Requirements and Lessons Learned in the Design and Construction of the Lagoa Barra Hospital – Brazil

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ABSTRACT

The construction of field hospitals has been a strategy adopted worldwide to face the consequences of the pandemic impacts caused by COVID-19 on healthcare systems. Specific characteristics of this pandemic, such as different ways and speeds of the disease transmission, and the implications at the population health and the productive system, has made the project, management, and construction of field hospitals for the patients with COVID-19 present specific features. In this work, for each phase of the FHLB implantation, we present the main concepts, premises, restrictions, and challenges, focusing mainly on the needs programs of the project that guided the configuration of the environments, the definition of the circulation flows, the typology of the beds, the main management tools used during the project's planning and control process, and in the lessons learned.

Keywords: COVID-19, Emergency Assistance, Field Hospital, Temporary Hospital.

1. INTRODUCTION

At the end of 2019, an unknown type of coronavirus, initially identified in Wuhan – China, caused a disease called COVID-19. Due to its high capacity for contagion and to impact the population health, COVID-19 put the global public healthcare institutions on alert. The World Health Organization defined the disease as a pandemic on March 11, 2020 (WHO, 2020). The first case in Brazil was registered on January 23, 2020, and, since then, the curves of cases and deaths increase exponentially. The public healthcare system became incapable of attending all the infected population, causing a collapse due to the high demand in several Brazilian cities.

In the “COVID-19 Clinical Management Protocol in Primary Healthcare” mild cases require therapeutic management and social isolation. In contrast, severe cases are submitted to clinical stabilization procedures, and the highly severe ones need to be directed to emergency service or a hospital (Brazilian Ministry of Health, 2020). According to Brazilian Association of Intensive Care (AMIB) and Brazilian Association of Emergency Medicine (ABRAMED), the referral to the Intensive Care Unit (ICU) or the Inpatient Unit (IU) is defined according to the severity of the clinical condition detected during the screening performed on the patient who arrives at the hospital. For ICU admission, the highest degree of survival and patient capacity is also assessed, based on the organic dysfunction score SOFA (Sequential Organ Failure Assessment) (AMIB and ABRAMEDE, 2020).

In a study conducted in March 2020 by the Brazilian Association of Intensive Care, in 450 hospitals in Brazil (13,695 beds) it was found that the average stay of patients with COVID-19 in the ICU is ten days, with a 30% lethality rate and 67% of patients needing mechanical ventilation. According to Bertoni (2020), it was also found that the need for a highly equipped and available ICU is essential to reduce the lethality rate of highly complex patients.

In March 2020, AMIB estimated the need for 3,200 ICU beds, in addition to the 16,000 existing in the Unified Health System, considering an occupancy rate of 95% (AMIB, 2020). According to Rouhollah et al. (2018), in abnormal situations like this, in emergency related to public health, provisional units, by providing medical services at any time and place, have been a solution adopted to reduce the effects of delays in handling victims and the number of deaths. Field hospitals are deployed in a wide variety of settings, including natural disasters, epidemic outbreaks, armed conflicts, and refugee crises. Different treatment strategies and hospital structures are designed for each scenario. In the case of treatment with COVID-19, basically, two models of hospital structures are used. In the first, sports gyms, convention centers and other places where there is already a certain level of infrastructure are used, such as Riocentro Pavilion (Rio de Janeiro- Brazil), Liacouras Centre at Temple University (Philadelphia - USA), Hall 1 of the Belgrade Fair (Serbia) and High-Performance Badminton Centre (Caldas Rainhas - Portugal). In the second, subject of this study, new facilities are built, such as those that were built at the Pacaembu Stadium (São Paulo - Brazil), Maracanã Stadium (Rio de Janeiro - Brazil), in Central Park (New York - USA), Ostra Sjukhuset (Gothenburg - Sweden) and Wuhan (China).

Unlike temporary units that only receive victims of low and medium complexity before they can be safely transported to permanent facilities, field hospitals for those infected with COVID-19 must also be built to receive highly complex patients. In this study, the intensive care unit beds were designed to meet all the premises and care that a seriously ill patient requires. Every hospital department also followed the same concept. Thus, for example, to avoid contamination and protect health professionals, a specific system for filtering contaminated air and antechambers with pressure differentials has been strategically designed to segregate between “clean” and “contaminated” rooms.

The intensity in which COVID-19 affects human health, especially lung function, besides causing a significant portion of patients to need hospitalization, also demands a substantial number of ICU beds and the construction of field hospitals intended for patients infected with COVID have specific characteristics. Besides, the project, management, and construction processes of field hospitals during this pandemic have also presented specificities, since several units of this type are demanded simultaneously, and the pandemic has had several consequences for the productive system and the labour market, such as contamination of workers and product shortages. In this context, during these processes, at various times, professionals resent information that enables more efficient and effective decisions, not only due to the lack of previous experience but also due to the lack of literature on the subject.

This work contributes to filling this gap by presenting the requirements and lessons learned in the construction of the Field Hospital Lagoa Barra (FHLB). We approach the project's needs programs, the dimensioning of the environments, the definition of flows, the construction phases, and the management tools used during the project planning and control process.

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2. METHOD

The information defined by the authors as necessary for this work, mainly related to the characteristics, premises, and conditions of the enterprise, and the management procedures and tools used, were obtained by the first author, who worked as the project manager. Thus, it was also possible to collect and summarize the experiences about the enterprise since its initial phase. Daily, at the end of the working day, the information obtained was analyzed by the authors to identify inconsistencies and the need for complementation.

After completing the data collection stage, based on the reflective and interpretive analysis of the information obtained, we ordered and summarized this information according to the structure adopted for this work. The work was written jointly by the authors, aiming to integrate the different perspectives, multiplicity, and plurality of approaches.

3. MAIN CHARACTERISTICS OF THE FHLB

The FHLB was constructed in an area called Lagoa Barra, in the city of Rio de Janeiro-Brazil, offering care to patients from the Brazilian Public Healthcare System diagnosed with COVID-19. With a constructed area of approximately 7,400 m², the FHLB has 99 beds in the Intensive Care Unit (ICU), 101 in the Inpatient Unit (UI), 10 in the Screening Unit, and support, assistance and technical areas (Figure 1). The design and construction of the FHLB were carried out from April 6 to 25, 2020.

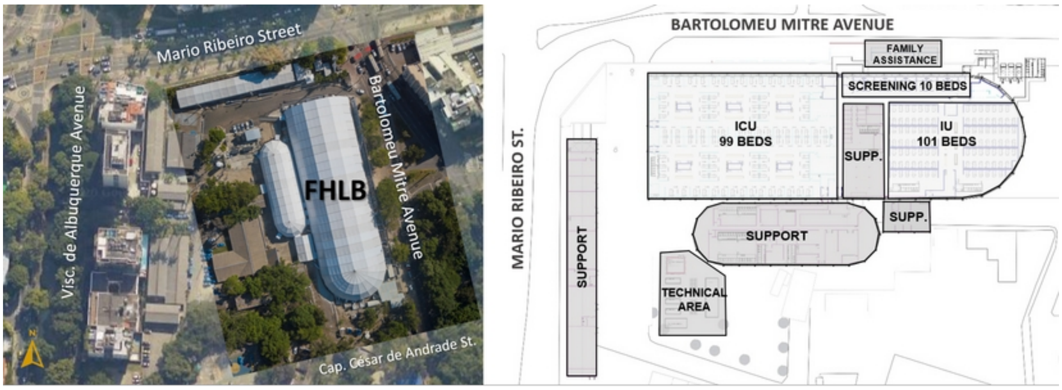

Figure 1. Location and layout of the FHLB.

4. PROJECT DEVELOPMENT

The architectural project of FHLB was developed in 10 days and had a workforce of approximately ten professionals, including architects, engineers, and health professionals. However, due to the short deadline established for the delivery of the project (20 days), the project development process had to be done in parallel with the project's planning and control and construction processes (Table 1).

Table 1. FHLB macro schedule.

PROCESS DESCRIPTION	TIME (DAYS)
PROJECT	10
PLANNING AND CONTROL	20
CONSTRUCTION	20

The FHLB's executive project met all the necessary premises and considered the demands and expectations of the clinical staff that would operate it. The development of the project

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was divided into two stages: Definition of the General, Specific and Complementary Needs Program, Dimensioning of Environments, Definition of Flows, and Typology of Beds. Table 2 shows the schedule of the FHLB project development processes.

Table 2. FHLB detailed schedule.

PROCESS DESCRIPTION	TIME (DAYS)
PROJECT	10
GENERAL PROGRAM	3
SPECIFIC PROGRAM	3
COMPLEM.PROGRAM	3
SIZING ROOMS	5
FLOWS DEFINITIONS	5
TYPOLOGY OF BEDS	5

5. GENERAL REQUIREMENTS OF THE FHLB NEEDS PROGRAM

The project started with a meeting with the health professionals of the future unit, aiming to obtain data for the FHLB's Essential Needs Program, which served as a basis for the 99 Intensive Care Unit (ICU) beds for highly complex patients and 101 Intensive Unit (IU) beds for mild and low complexity patients;

- 60 ICU beds equipped with mechanical ventilators for highly complex patients with respiratory problems, with the possibility of duplication (a “Y” connection was provided coupled to the Oxygen outlet);
- All beds with mechanical ventilator have an outlet with a battery system suitable for cases of power failure;
- 20 ICU beds equipped with a dialysis system for evidence of renal failure;
- Individual monitoring system in all ICU beds, according to the municipal legislation Law nº 5714 (Municipality of Rio de Janeiro, 2014);
- Ten screening beds for the level diagnosing of disease severity with individual bathrooms;
- Computed Tomography and mobile X-ray;
- Nursing call in all beds and baths;
- Rest area and food for health professionals;
- Outside space for family member's assistance.

6. SPECIFIC REQUIREMENTS OF THE FHLB NEEDS PROGRAM

One of the critical concepts for implementing a hospital with inherent contaminated areas due to coronavirus is the segregation between “clean” and “dirty” areas. Clean spaces are those in which there are no confirmed patients with COVID-19 (Assistance, Screening, and Support Areas). “Dirty” areas are the ones where patients are treated (ICUs and UIs).

The segregation zones between "clean" and "dirty” locations were strategically chosen according to the internal flow of patients and healthcare professionals. Areas with differential pressure, called antechambers, are inflated compartments with positive pressure

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that prevents the airflow (negative pressure) from a "dirty" area from invading a "clean" environment. Therefore, it is possible to minimize the contamination of objects and health professionals who have not yet undergone the process of dressing. Figure 4 outlines the distribution of areas and Figure 5 shows the details of the segregation site, as well as the air flow process.

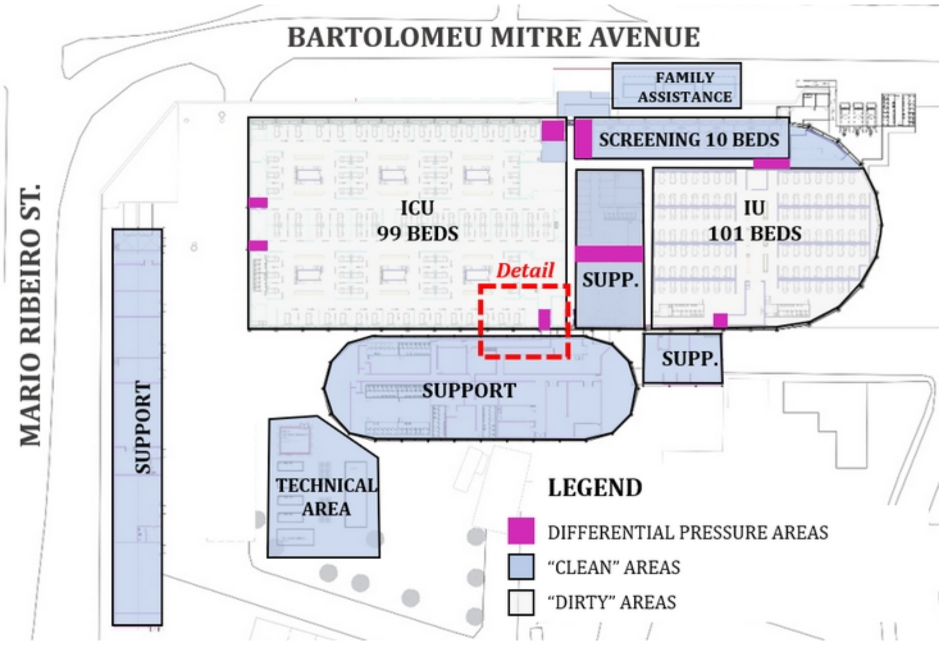

Figure 2. "Clean" and "dirty" areas" and antechambers.

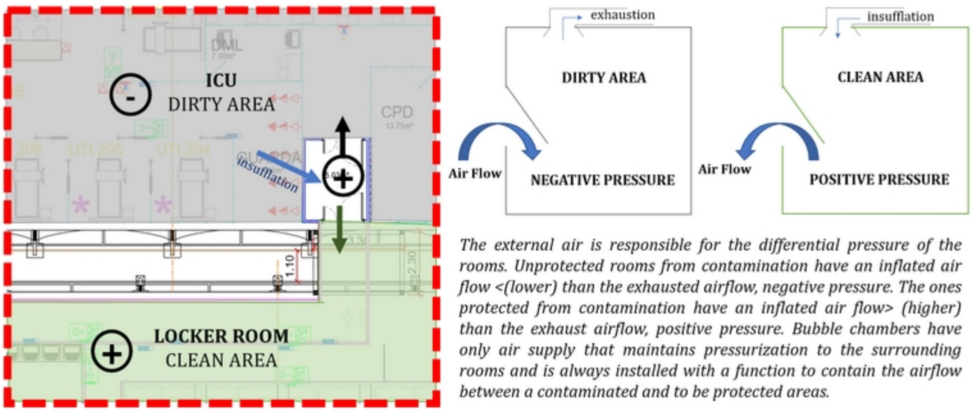

Figure 3. Example of segregation site - Detail of the antechamber between tents.

7. DIMENSIONING OF ROOMS, DEFINITION OF FLOWS AND TYPOLOGY OF BEDS

The premises for the HCLB project followed the recommendations of regulation nº. 50 (RDC, 2002). The RDC 50/2002 was established by the Brazilian National Health Surveillance Agency (ANVISA) as the main document to guide medical facilities construction and operation. The resolution came into force on February 21, 2002, and it details the quantity and size of medical spaces and building installations, environmental comfort and circulation conditions, infection avoidance measures, and fire safety protocols.

Each sector of the HCLB was designed according to the specific characteristics of the pandemic. In Figure 6, it can be noted that the top five spaces that overcome what the legislation recommended are related to the entrance of ambulances, pharmacy, and storage

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of clothes (clean and dirty) and garbage. The COVID-19 approach demands intense cleaning processes and continuous replacement of the items used during the patient's treatment.

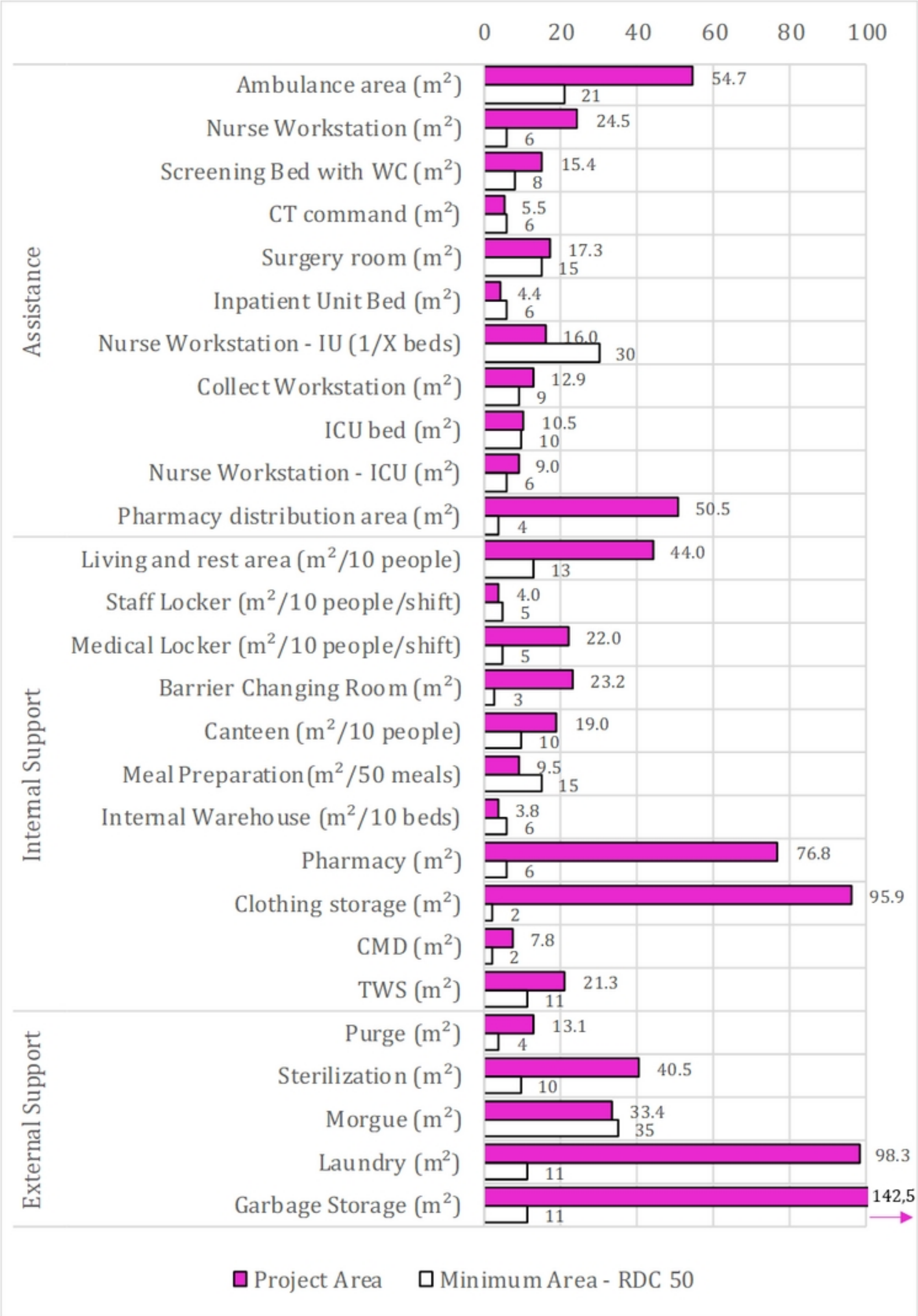

Figure 4. Comparison of areas projected and minimum recommended (RDC 50).

Subsequently, internal and external flows were designed in order to avoid crossing people, medicines, clothes, and contaminated and clean supplies. For the external environment, six inflows and outflows were defined: patient/companion, doctors, collaborators, clean inputs, dirty inputs, and morgue. The internal flow of patients and collaborators consists of the admission of the patient and, necessarily, undergo an evaluation in the screening sector so that the health professional can measure the degree of complexity of the disease. After that, they would take them to the respective sector, ICU, or UI. Both external and internal flows are shown in Figure 7.

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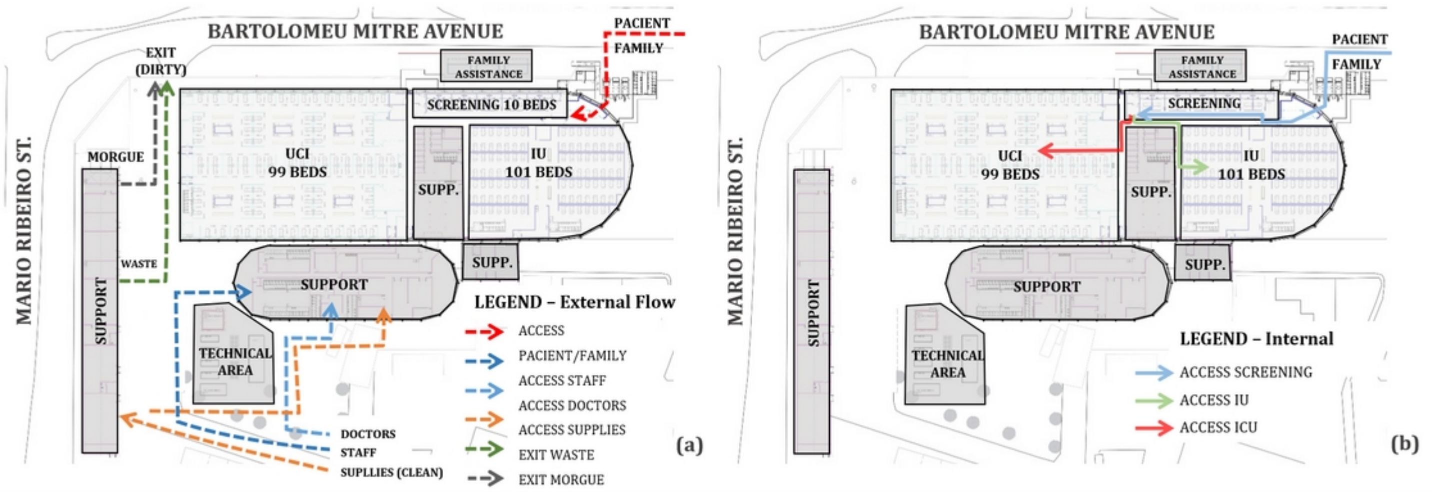

Figure 5. Circulation Flows: (a) External and (b) Internal Flows.

Due to the evaluation of the screening sector, patients with stable health conditions are referred to inpatient units and those of greater severity to intensive care and allocated to beds according to the level of complexity. Four types of beds were designed, one for UI (Type 1) and three for ICU (Types 2, 3, and 4). Type 1 beds are used for stable patients and ICU beds that have been stabilized to undergo an observation period. Type 2 beds are for medium severity patients and types 3 and 4 for highly complex patients. The difference between types 2 and 3 is that in the latter, patients who need mechanical ventilation are treated. In typology 4, in addition to the use of respirators, dialysis mechanisms were provided for renal treatment. The characteristics of each typology are shown in Figure 8 and summarized in Table 1.

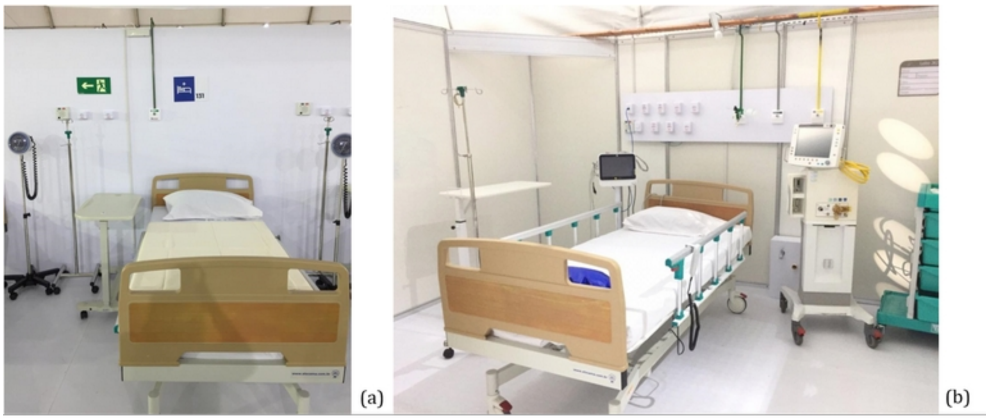

Figure 6. Examples of beds: (a) Type 1 and (b) Type 4.

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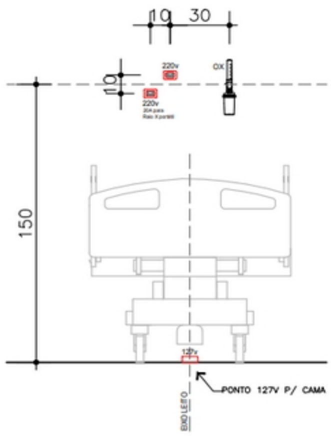
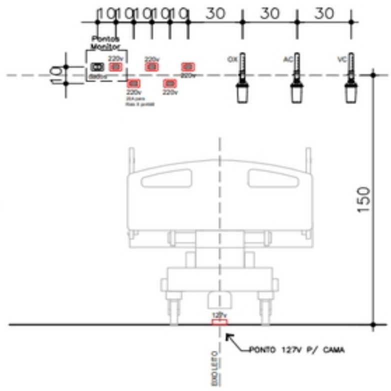
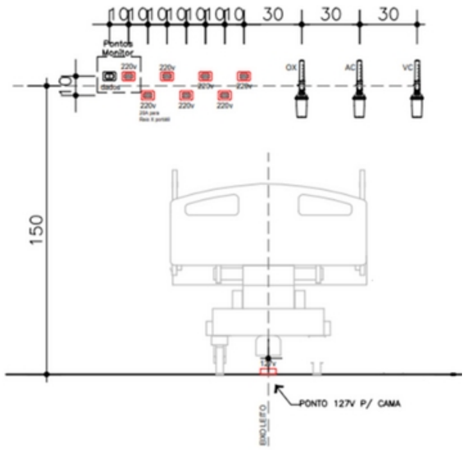
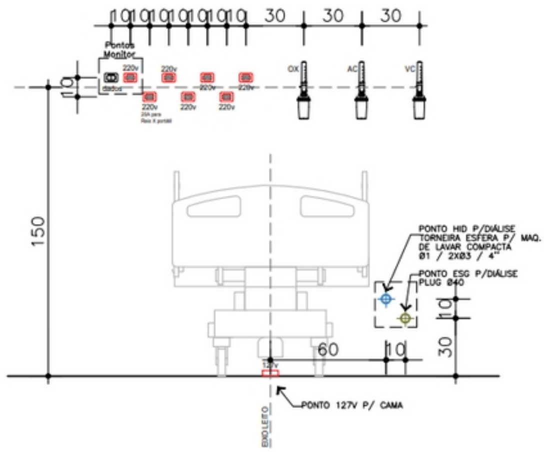
Table 3. Typology of bed.

<table>
<tr><th>TYPE 1 – IU
Patients of low complexity</th><th>TYPE 2 - ICU without ventilator
Patients of mild complexity</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>

- 1 pt 127 V (bed)
- 1 pt (OX)
- 1 pt 220 V – 20 A (x ray)
- 1 pt 220 V – 10 A (extra)

</td><td>

- 1 pt 127 V (bed)
- 3 pts (OX, CA e VC)
- 1 pt 220 V – 20 A (x ray)
- 3 pts 220 V – 10 A (extras)
- 1 pt 220 V – 20 A (heart monitor)
- 1 pt (data for heart monitor)

</td></tr>
<tr><th>TYPE 3 - ICU with ventilator
Patients of high complexity</th><th>TYPE 4 - ICU with ventilator and dialysis
Patients of high complexity</th></tr>
<tr><td>
</td><td>
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<tr><td>

- 1 pt 127 V (bed)
- 3 pts (OX, CA e VC)
- 1 pt 220 V – 20 A (x ray)
- 4 pts 220 V – 10 A (extras)
- 1 pt 220 V – 10 A (nobreak for ventilator)
- 1 pt 220 V – 20 A (heart monitor)
- 1 pt (data for heart monitor)

</td><td>

- 1 pt 127 V (bed)
- 3 pts (OX, CA e VC)
- 1 pts 220 V – 20 A (x ray)
- 2 pts 220 V – 10 A (extras)
- 1 pt 220 V – 10 A (nobreak for ventilator)
- 1 pt 220V – 20 A (monitor)
- 1 pt 220 V – 20 A (heart monitor)
- 2 pts 220 V – 20 A (dialyse)
- 2 pts (dialyse: water and sewage)

</td></tr>
</table>

8. PLANNING AND CONTROL OF CONSTRUCTION PROCESSES

Just as the pandemic scenario is atypical, the planning and control process for this enterprise was no different. The FHLB had its planning phase parallel to all the other enterprise activities (Table 4), due to the short time to complete the construction. Another particularity was the need for daily reviews of the physical and financial schedule because as the works progressed, the management team was faced with new scenarios, services, and even loss of the workforce due to contamination.

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Table 4. Activities of Planning and Control phases

PROCESS DESCRIPTION	TIME (DAYS)
PLANNIG AND CONTROL	20
SPONSOR AND GP NOMINATION	1
TIME DEFINITION	1
SCHEDULE AND BUDGET	19
MANAGEMENT TOOLS	19

The planning process started with the demand to build the hospital. The first step was to nominate the Sponsor and Project Manager. Subsequently, the project team schedule and detailed project budget were defined. Due to the acceleration in the number of people infected by COVID-19 and the increasing scarcity of beds in the public sector, the deadline for completion of the hospital was the central premise considered for the success of the project. The management tools used during the Construction Planning and Control processes were:

- Deadline and Cost Management: Physical and Financial Schedule, to monitor deadlines and cash flow; Cost Spreadsheet of Services Performed (incurred and trends) to compare economic and financial advances; Weekly reports of physical and financial monitoring to be sent to the sponsor;
- Production Management: Daily field reports to highlight the activities performed daily; Control of equipment hours worked, to check possible idleness; Daily Video Team Meetings Calls for suggestions, criticisms and general project issues; Daily Monitoring of Physical Progress to check at the end of the day which schedule was not fully executed; Daily Staff Control to monitor how many employees worked at the end of the day; Check-List of deliveries to verify that deliveries were in accordance with the project;
- Safety, Healthcare, and Environment Management: Daily monitoring of the temperature of all employees entering the construction site (fever is an indication of COVID-19 contamination); General and specific PPE (masks and alcohol gel) to avoid contagion; Documentation control of companies and employees (ASO, CT, PPRA, and PCMSO) to guarantee the liability of contractors in the event of accidents at work;
- Supply Chain Management: Acquisition and management of all materials and services acquired in compliance with corporate compliance requirements;
- Suppliers Assessment: At each delivery, suppliers were evaluated according to the following criteria: quality, deadline, support service, safety, and organizations. In this way, the construction team decided if there was a need to change the supplier or just an adjustment of conduct.

9. CONSTRUCTION OF THE FIELD HOSPITAL

Worldwide, the selection of the constructive model of a field hospital may differ due to aspects related to medicine and health, and engineering. On the one hand, consideration should be given to the evolution of the number of people infected and killed by COVID-19, forms of treatment depending on the clinical condition and the number of professionals

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involved in the hospital operation. On the other hand, it must also be considered which spaces are available to build a temporary unit, investment level for construction, the deadline for project completion, and technical capacity for building. The construction of the FHLB obeyed all these needs.

To meet the deadlines and costs established for the HCLB, a temporary construction structure was used, similar to those adopted in sporting events and shows, due to three factors: for being a structure usually known and of quick assembly; for meeting the characteristics of the land selected for construction; and for meeting the need program. Besides, another important reason for achieving the final objective was the great parallelism between all activities, as shown in Table 5.

Table 5. Work Schedule

DESCRIPTION	TIME (DAYS)																				
CONSTRUCTION	20	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
PRELIMINAR SERVICES	5	x	x	x	x	x															
ELEVATED FLOOR	5	x	x	x	x	x															
TENT ARCHES	5		x	x	x	x	x														
CANVAS COVER	7		x	x	x	x	x	x	x												
VINYL FLOORING	5							x	x	x	x	x									
INTERNAL WALLS	9							x	x	x	x	x	x	x	x	x					
INSTALATIONS	11				x	x	x	x	x	x	x	x	x	x	x	x	x				
FINISHING AND CARPENTRY	3														x	x	x				
VISUAL IDENTITY	2																x	x	x	x	x

FHLB's construction process consisted of setting up support tents, assistance, and container systems that were used as restrooms. After assembling the elevated floor and lifting the tent arches, it can be covered with canvas so that workers could work internally without the action of the weather. Then, the entire laminated vinyl floor was installed. The room partitions were initially designed to be in a modular system of aluminium tubes in TS type panels (OCTANORM). This modular system gained prestige due to the ease of use of the material and, mainly, the system assembly productivity. However, due to many field hospitals that were being built at the time, the supply of this system was impaired, which forced us to also use another construction method: the construction of partitions in wooden walls covered with Nappa.

The data facilities and closed-circuit monitoring were built with security level to protect the privacy and provide the necessary analyses to the health professionals. The hydraulic and sewage facilities were installed under the raised floor and ascended through holes in the floor to feed the entire hospital distribution network. This criterion was also adopted for electrical installations and medicinal gases, supplied using equipment located in the technical area and distributed through apparent piping, as shown in Figure 11.

As advantages, it can be highlighted the productivity and ease of maintenance. For shortages of water, electricity and medicinal gases, HCLB has the following autonomies: 48 hours of water supply through internal reservoirs; 45 hours of power supplied through a generator system; 30 minutes of autonomy of own batteries in case of delay in entering the generator system for IT installations and electrical outlets dedicated to specific clinical engineering

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equipment; approximately seven days of oxygen supply (OX), from a second oxygen tank; and variable autonomy of Vacuum (VC) and Compressed Air (CA), ensured by a central VC and AR cylinder used as a backup, where the autonomy varies according to the number of cylinders currently available. Also, in parallel with the above steps, the air conditioning of all the tents that make up the FHLB structure was built, which corresponds to the availability of 600 tons of refrigeration (TR) or 7.2 million BTU / h, considering the air renewal system.

The climatization of 'clean areas' was made through a textile duct, chosen due to its flow rate capacity, renovation of air, and lightness of the material. On the other hand, in 'dirty areas', air conditioning Splits type was chosen to insufflation and an independent renovation air system. To both areas, the adequate temperature projected is between 20º and 24º. Figure 11 exemplifies the functioning of both zones mentioned.

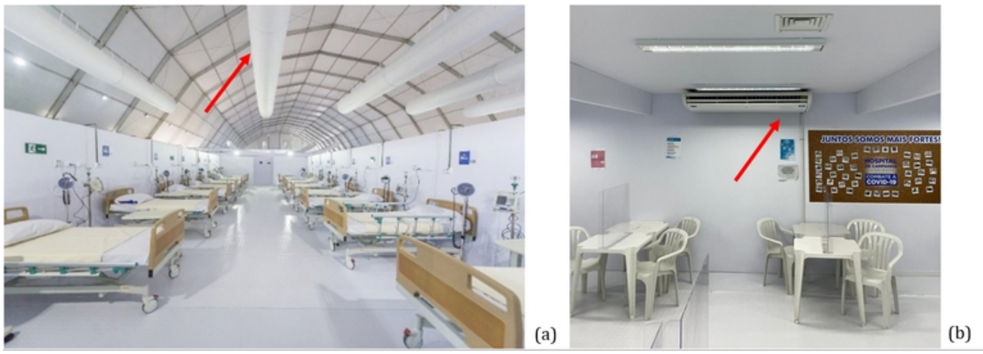

Figure 7. Types of refrigeration: (a) Textile ducts in dirty areas and (b) Splits in clean areas.

10. CONCLUSIONS AND LESSONS LEARNED

The Field Hospital concept has incorporated evolutions and expansions over time, mainly due to the nature of its purpose. Provisional units have been built around the world as an emergency way to assist victims of armed conflicts, natural disasters, epidemics, and pandemics, as is the case with the new coronavirus, which required field hospitals to be built worldwide. Planned and constructed according to the characteristics of the situations faced, they can have variable physical structures and must be easy to transport and install, to be viable even in remote or hostile regions. Each Field Hospital has the specific infrastructure to ensure safety for patients and employees, prevention and control of infections, provision of supplies, water supply, sewage, and solid waste collection, and provision of medical care at various levels of complexity.

The design characteristics and constructive methodologies of field hospitals for COVID-19 treatment may vary, mainly depending on the demand of patients and available physical space. The Pacaembu Campaign Hospital, in São Paulo, and the Campaign Hospitals Parque dos Atletas and Maracanã, in Rio de Janeiro, are examples of hospitals with similar characteristics to this study. In both cases, patients' demand was discharged for low and high complexity cases, which required hospital beds and intensive treatment.

In care units such as the Clementino Fraga Filho University Hospital (HUCFG / UFRJ) and Rio Centro Campaign Hospital, both in Rio de Janeiro, the existing structures have been adapted. In the case of HUCFG, due to the low demand of patients, constructive interventions aimed at adaptations were low. In addition to forecasting high patient demand, the Rio Centro Campaign does not have a hospital infrastructure, but rather a convention center, demanded a more significant effort of design and construction.

The design and construction of the FHLB were developed according to two main objectives: to meet the specificities of treatment of patients and to prevent the transmission of infectious particles between people. In this sense, taking into account the recommendations issued by the Brazilian Association of Intensive Care Medicine AMIB (2020), the electrical, hydraulic, and HVAC installation projects were developed to provide adequate environments and equipment for intubation and continuous monitoring, for hemodynamic support and dialysis, for surgical procedures, and X-ray and ultrasound examinations at the bedside and in a specific room, aiming at improving diagnosis and the therapeutic plan.

Aiming at isonomy in the care of patients with disabilities, the project considered the ABNT NBR 9050: 2015 standard requirements, especially concerning horizontal and vertical signage, bathroom size, floor characteristics, circulation space for wheelchair users, and ramps access. Also, all bathrooms are equipped with electric showers, ensuring hot water for patients and healthcare professionals.

Some challenges of designing and building this enterprise model are not unlike any other, such as: the logistics of inputs, preparation and control of physical and financial schedule or specialized labor. However, within the scenario in which the FHLB construction project was inserted, it is worth highlighting three specific challenges.

The first concerns the context in which the enterprise was developed: a short period of 20 days and the need for the enterprise planning and control to be carried out during a pandemic, whose consequences were also reflected in the reduction of public transport for the workforce, in the worker's fear of contaminating family members, in the scarcity of hospital PPE such as masks and gel alcohol, in the absence of contaminated workers, among other factors that impacted productivity. Also, the events market, the sector that provided the most significant amount of inputs and construction services, had little experience in this type of situation, which meant that the schedule needed to be reviewed daily, also because the productivity indexes were not known in the civil construction market, which required the planning metrics to be obtained during activities.

Second, concerns the lack of knowledge of specific aspects of the pandemic by the designers and other Brazilian professionals dedicated to the design and construction of hospitals. Also, the labour used, although having extensive experience in temporary installations, had no previous experience in plants with the necessary characteristics, which required a great deal of interaction between designers and contractors.

The third concerns the characteristics and configurations of the internal environment, which demanded specific strategies to protect patients and health professionals against the contamination and spread of the virus, such as, for example, an HVAC system containing specific filters that prevent the dispersion and spread of droplets expired indoors; pressure differential zones that segregate "dirty" and "clean" environments, and circulation flows designed and integrated with strict safety processes. In addition, there was also a concern that other contaminants could penetrate the internal environment.

To provide subsidies for the design and construction of field hospitals for the prevention of epidemics that have characteristics like those of COVID-19, for each phase of the project, we summarize in Table 6 the main concepts and premises and their respective conditions.

Table 6. Phases of the Hospital implementation: premises and restrictions.

Phase	Premises	Restrictions
Project Elaboration	Needs Program	1. The capture of health professionals' demands and expectations; 2. Definition of a program of general needs (number and model of beds, specification of support and assistance areas), specific (characterized by the reason why the unit is being implemented) and complementary (meeting corporate and government requirements);
	Segregation between 'clean' and 'dirty' zones	A strategic choice for transit locations for infected and non-infected people. Use of specific filtering equipment to prevent the spread and proliferation of the virus. Use of antechambers with pressure differential so that "clean" environments, positive pressure is contaminated by "dirty" environments, negative pressure;
	Procedures Room	Located in a "clean" environment with air conditioning with specific filtration;
	CT and mobile X-Ray	Specific clinical engineering requirements for virus diagnosis. Located in a "dirty" environment;
	Sizing Rooms	The sizing must be carried out according to the relevant regulatory agency in each country. In Brazil, it is N ° 50 (RDC, 2002)
	Internal and External Flows	Avoid crossing contaminated and clean people, medicines, clothes, and supplies;
	Beds Typology	1. UI (TYPE 1) - low complexity patients; 2. ICU (TYPE 2) - medium complexity patients, does not require the use of mechanical ventilators; 3. ICU (TYPE 3) - highly complex patients, requires the use of mechanical fans; 4. ICU (TYPE 4) - highly complex patients, requires the use of mechanical ventilators and a dialysis system;
Planning and Control	Project Time	Definition of Sponsor, Project Manager, and Project Team;
	Management Tools	1. Time and cost monitoring tools; 2. Tools for monitoring field services; 3. Tools for monitoring the safety, health, and environment of employees; 4. Tools for monitoring contracts; 5. Tools for assessing suppliers;
Construction	Constructive Model	1. Choice of the provisional structure according to the assembly speed, ease of implantation in the available terrain for the construction of the hospital and technical capacity to accommodate the needs program; 2. To guarantee the 20-day construction period, there was a need for parallelism between all field activities; 3. All apparent infrastructure facilities for productivity gains and ease of maintenance; 4. A central cooling system through textile ducts capable of overcoming the entire perimeter of the hospital; 5. Guarantee of autonomy for vital systems of operation of the unit (water, electricity, medical gases, and plugs to service clinical engineering equipment);
	Activity Sequencing	1. Preliminary Services; 2. Installation of the Raised Floor; 3. Installation of tent arches; 4. Installation of the Canvas; 5. Installation of the Vinyl Floor; 6. Installation of partitions; 7. Electrical, Hydro-sanitary, Medical, and Special Gases Installations; 8. Finishes and Joinery; 9. Visual Programming

To detect points of improvement for future projects of this nature, after the end of HCLB activities, meetings were held with designers and professionals who participated in the unit's operation. We found three points that deserve featured. The first refers to the proportion of ICU and ICU beds. Patient volumes admitted to the unit were mostly of high complexity, which meant that the proportion 50% initial threshold for beds of UIs and ICUs did not correspond to the need. The second point concerns the space allocated to the screening beds. Because it is a unit exclusively for patients previously tested positive for SARS-CoV-2, this bed typology was oversized. With that, this space could be better used for another purpose, such as ICU beds. Finally, although no case of contamination between patients and health professionals demonstrated the effectiveness of the system HVAC, antechamber doors designed with pressure differential, not always remained closed, mainly due to the hospital routine. Devices with automatic closing would resolve this issue.

The present study has two main limitations. The first relates to the possibility that some important contribution has not been addressed in this analysis. However, an attempt has

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been made to present all the construction processes of the case in question. The second concerns the constructive variability of a Field Hospital, depending on the purpose, time of construction, availability of materials and services, and technological and financial contributions.

It is not known when there will be another outbreak, such as coronavirus. However, as a suggestion for future research, three possibilities are pointed out. The first is a comparative study between the different structures for provisional units, seeking to identify the main construction methods and application for each environment, considering regional climatic factors, market availability for each model, and an analogy between investment levels with tight deadlines.

The second, a bibliographic review of hospital solutions adopted in highly infectious environments. In this article, it was presented the applied solution in FHLB that enables healthcare professionals donning and doffing and to use the support areas with low risk of contamination and dissemination of the virus. The implemented solution was in the HVAC discipline, causing a pressure differential that prevents the virus from entering "clean" environments. Other subjects and solutions can be presented and broaden the debate in this regard.

And finally, the last suggestion is a study, through qualitative analysis, of different user's experiences in field hospitals build for this COVID-19 pandemic.

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