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A Modular Structure for Immediate and Transitory Interventions to Guarantee Access to Basic Healthcare in Italy

Silvia Brunoro * and Lisa Mensi

Department of Architecture, University of Ferrara, 35-44121 Ferrara, Italy
* Correspondence: silvia.brunoro@unife.it; Tel.: +39-0532-293633

Abstract: The access to basic healthcare for people who are not registered in the national health system is nowadays a very urgent problem, both in Italy and in the rest of the world. Immigration and poverty are only some of the factors that make one of the primary rights of humanity—healthcare—not a right for everyone. The main problems, which have grown exponentially in the last decade, are at operational level, due to the lack of personnel (mostly volunteers) and the lack of spaces. This paper illustrates procedures and techniques for the design of a small emergency structure that can be moved and positioned in urban contexts. The first part consists of a deep analysis of the problem and of the state of the art of existing typologies. The second part is dedicated to the conceptual framework (requirements, conceptual model) and to the definition of the preliminary design for the new approach to basic non-conventional sanitary spaces. Finally, a virtual case study (project application) in Italy is presented.

Keywords: basic healthcare; modular architecture; sustainable design

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1. Introduction

The paper aims to investigate basic the healthcare access of those who are not enrolled in the Italian National Health System. Basic healthcare is guaranteed to everyone by the state, as a theoretical principle and from a legislative point of view, but in practice it presents consistent difficulties for those who are not regulated in the country. This is very common in Italy, but can be extended to every country interested in immigration problems. The objective of the research is the design of a flexible, adaptable and demountable space that can stand alone or work in synergy with existing sanitary structures. First of all, the research has regarded the analysis of the services needed, their requirements and the relationship between each other and the existing structures.

Efforts have been made to overcome standard models, by introducing new design methods able to speed rescue and assistance operations and by identifying the weaknesses of the current sanitary models, which is mainly excessive waiting periods for hospitalization [1,2].

This is done via two different strategies: thinking of a new preliminary design approach and introducing a new type of spatial unit: the social space. Thanks to the participation and availability of associations that deal with this issue and through the study of the literature it was possible to analyze how these services really operate in the Italian territory and, at the same time, to have a clear view of the main legislative and operative problems [3]. The state of the art analysis, of the very few structures operating in this field, was fundamental to list and comprehend space requirements for structures that deal with a non-conventional kinds of population. A different size (small, medium, large) prefabricated and modular structure has been designed to be placed in urban contexts where it is necessary to deliver this kind of service. In particular, it will be placed near dormitories and urban areas where the greatest concentration of population with economic criticalities subsist. The prefabrication of the elements guarantees an easy disassembly/reassembly so that it can follow the movements of users and can hopefully be a transitional measure: a first intervention towards the implementation of this service within the national service. The final objective of the research project is to design an innovative assistance model, achievable with a reduced construction time, which is aimed at a non-conventional category of users. Differing from concepts of flexible hospital structures—in particular, increased in the COVID-19 era [4]—the model proposes an applicable method throughout the Italian territory that adapts to the needs of every single context regarding migrants' and indigent people's assistance. This differs from flexible and temporary emergency structures for:

- the methodology. The aim of the research is to define a modular "ad hoc" solution, calibrated on users' needs to give a concrete response both to the effective need of health treatment and to social disease. Despite what is generally believed, the health of individuals is not only about the healing process, but includes a range of broader factors, including so-called determinants that involve the context within which each of us lives, our social status related to the work we do and the actual information and care we take of our body;
- the design strategy. The aim is to overcome standard temporary structures, by introducing public areas in the design concept. Migrants are generally young and healthy individuals who lose one or more of these determinants during their journey, causing damage to their health [5]. This worsens due to the fact that, once they arrived in the host country, the procedure for obtaining protection by the primary doctor is impracticable or often very complicated without an intermediary able to request the permission in place of the migrant;
- the technology. Standardized structures generally respond to emergencies and extraordinary events. The objective is to overcome the idea of single function structures, in favor of flexible structures that can be used for various functions. The technological response to the design of public/private spaces, this overcomes the use of container or other rigid codified models. Internal comfort and energy efficiency are requirements in this model;
- the financing model. The model proposes a structure that allows different furniture configuration, in order to make it multifunctional. This characteristic it is essential to optimize the investment. The project is part of a reality that is almost entirely financed through public and private donations. Therefore, the economy of the intervention is fundamental: the aim is to create an economic prototype that is also easy to make, so as to give the greatest number of associations that deal with this issue the possibility to achieve it, with or without the economic contribution of the National public sanitary system.

2. State of the Art

Flexible and demountable structures have been diffused in the Italian territory since 1968, when extreme events such as earthquakes interested the country. The main diffused solutions for the emergency events are tents and containers [6,7]. These structures are much less flexible, equipped with full visual dividers, and less-acoustic requirements, made with sheets anchored to the roof [8]. Recently, temporary structures for COVID-19 emergencies have become diffused [9]. The fast spread of the COVID-19 pandemic has disrupted healthcare systems globally and has imposed great challenges on the construction industry [10]. Various strategies and innovations have been proposed to ensure the capacities of healthcare facilities during and after disasters, e.g., optimization of public hospital resources under calamitous situations [10].

The use of modular construction as a response to emergency situations allows flexibility of design and required materials. As an example, Italian architects Carlo Ratti and Italo Rota have used basic shipping containers as a main component that could be adapted and fixed to existing structures of hospitals for medical treatments [11].

The proposed model does not comply only with an emergency structure or with the treatment of a unique pathology. In COVID-19 temporary hospitals, functional zoning is primarily based on the organization of isolation wards and modules allow flexibility of zoning layout, providing less potential of contamination between contaminated and non-contaminated passages [12].

To understand the problem and define the requirements some personnel that operate as volunteers in the main Italian cities have been involved.

On this basis, it is important to remember that in Italy the access to basic health is a constitutional right mentioned in article 32 of the Italian Constitution and also falling under article 25 of the Declaration of Human Rights signed by the United Nations.

Currently only about 20 cooperatives and private social associations are available to replace the general practitioners and follow the progress of the Foreigners Temporarily Present code to allow access to national health facilities [13]. Usually, volunteers or retired doctors provide those services. It is preferred not to offer to indigents, due to the overcrowding of Italian citizens.

An accurate survey of six emergency realities in the Italian territory was carried out. The main indications coming from the surveys regarding kinds of users, access turnout and the need for healthcare are summarized in the table below (Table 1).

Table 1. Users' data on six existing structures in Italy. [a] Data on single care not available.

Structure	Average Number of Users per Year (2017–2020)	Main Provenience (More than 10%)	Type of Care
Caritas Diocesana di Ferrara e Comacchio—FERRARA	1688	-	General medicine 73% Specialist medicine [a] 17% Pediatrics 10%
Ambulatorio"Querce di Mamre, Caritas Reggiana—REGGIO EMILIA	1066	Georgia 13% Nigeria 10% Albania 8%	Specialist medicine 100% (Dentistry 19% Orthopedic 13% Cardiovascular 11% Gynecology 8% Dermatology 8% Mental 7% Other 34%)
Ambulatorio Paolo Simone, Maundodé, Caritas—SENIGALLIA	254	Tunisia 12% Romania 8% Afghanistan 8% Marocco 7%	General medicine 62% Specialist medicine [a] 35% Pediatrics 3%
Ambulatorio SOKOS—BOLOGNA	3500	-	Specialist medicine 100% (Gynecology 16% Dentistry 14% Cardiology 9% Cardiovascular 5% Diabetes 5% Mental 4% Other 47%)
Ambulatorio Giovanni Paolo II, SERMIG—TORINO		Marocco 22% Nigeria 10% Romania 7%	Specialist medicine 100% (Orthopedic 20% Gynecology 16% Dermatology 11% Dentistry 9% Cardiovascular 5% Dressing/sutures 3% Mental 3% Other 32%)
Ambulatorio Biavati, BOLOGNA	3836	-	General medicine 75% Specialist medicine [a] 17% Pepediatrics 8%

A consistent part of the analysis consists in the identification of deficiencies and weaknesses that are common to the analyzed structures. Analyzing existing structures and their problems was crucial to define the strategy for the preliminary design, that meets different requirements, according to users' access and flow.

3. Materials and Methods

This research has adopted a multi criterial strategy to define a modular adaptive model to fit basic healthcare for people who are not enrolled in the Italian National Health System.

To start, a comprehensive users' need analysis on the basis of the existing structures data was conducted. Then a conceptual framework was developed, based on the requirements definition of each space: architectural features, privacy grade, relationship between each module and/or existing structures, and technical equipment.

To define in detail each space, an abacus was created by considering the main characteristics, such as architectural preliminary requirements, facilities and norm of reference. The basic principle that guided the design phase was the progressive implementation of the structure: the greater the number of people who can be accommodated, the greater the choice of services the clinic can offer. Basic services are general practice, listening center, and socialization space. Therefore, as the structure grows, specialist assistance can be added to create not just a health center, but a space of hospitality and aggregation with laboratories for social integration or simple rest areas [14,15].

Finally, guided by the conceptual framework, a virtual-case study application of the model in a real context was conducted.

3.1. Conceptual Framework and Preliminary Design

In the proposed model, the canonical hospital structure has been revisited by reconverting corridors in aggregation and socialization space facilities. A modular grid has been designed to progressively aggregate all the spaces and to allow application and adaptation in different contexts (please see Figure 1).

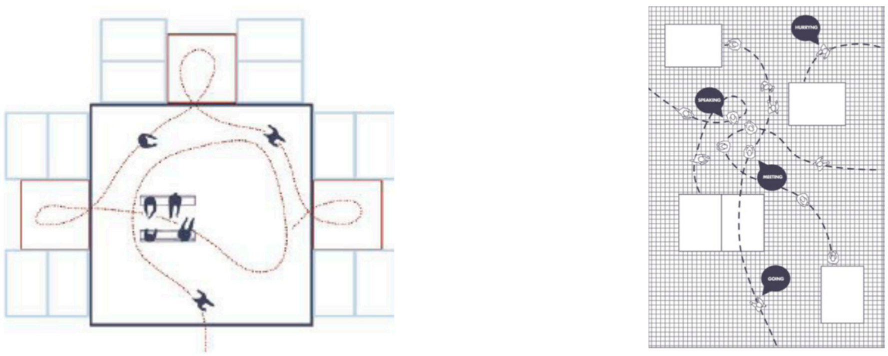

Figure 1. Conceptual framework of the model. The project is divided into several "macro-areas" which are marked by open spaces. Every open space works as a connection to closed spaces. Typologically, the designs of prefabricated hospitals and clinics are subject to rigid spaces configuration. In this model, a mono-functional design approach is avoided.

Common areas surround the clinics: the "free" area—where it is not necessary to have the same privacy of the clinics, nor the same plant equipment—contrasts with the closed and rigid form of the surgery spaces. According to the studies carried out by the proxemic, it is possible to vary the interpersonal distances depending on the functions that take place in the different areas [16].

Two elements define the grid: the modules and the platform. The first ones are the healthcare spaces, doctor's offices or private spaces; the second is a common and transition area in which, despite what usually happens, people can meet each other. In contrast to corridors and other services, when natural light is not necessary, one important requirement was to have natural light along the platform [17].

Modules must be capable of moving as freely as possible on the platform to achieve the greatest flexibility. As a result, an abacus of usable spaces within the project has been designed, based on the module of 1.25 mt. $\times$ 1.25 mt. It is possible to use the aggregation of 3×3 or 6×3 modules due to the peculiar space request. Spaces identified as fundamental to be included in the project are below listed (Table 2):

Table 2. Space characterization for fundamental spaces in modular basic healthcare structures.

Space	Dimension	Space Characterization
General practice	3 × 3 mod.	Generally, it is used for basic healthcare, in the minimal aggregation of the project it can be used also in gynecology
Special medicine	3 × 6 mod.	Provides a private toilet and sterilization machine (as the equipment is not sent to auxiliary facilities to be sterilized).
Listening Centre	3 × 3 mod.	A private room where the patient can talk with the therapist or the psychotherapist without feeling anxiety.
Administrative area	3 × 3 mod.	This space is different from the triage area because it is dedicated to more personal issues such as economic aid or individual problems.
Storage and Pharmaceutical Bank	3 × 3 mod.	It is not essential in clinics where there is not enough space available. It is possible to form crowds in the structure.
Restroom	3 × 3 mod.	It is essential if the structure is not adjacent to a principal structure (e.g., a hospital) where toilets are available.
Staff area	3 × 3/3 × 6 mod.	It depends on the size of the service, and on the number of personnel.

On the other hand, some flexible spaces do not have the specified dimensions; it depends on the project, as indicated in Table 3. Flexible spaces can be inserted in all the configurations, as they grow with the project.

Table 3. Space characterization for flexible spaces in modular basic healthcare structures.

Space	Dimension	Space Characterization
Triage area	No dim.	It is used for the first diagnosis of users and guidance in the service.
Waiting area	No dim.	Nearby the practice.
Social area	No dim.	All around the building.

Although the project is adaptable to the most varied contexts without being necessarily bound to a pre-established form, it is possible to identify from minimum to maximum configuration (Figure 2), according to different situations. Minimum configuration fits with new construction in emergency or other sanitary extreme events or expansions of existing structures. The project can be adapted to specific contexts by creating an almost infinite number of different configurations, thanks to the intrinsic flexibility of its technological solution. A maximum module configuration can include all the necessary services, when needed.

Where the space is minimal, a basic configuration (Figure 2a) includes the general practice, the listening center, the staff area and the toilets.

In medium interventions (Figure 2b), the waiting room is bigger and common to several specialist clinics. When the number of clinics is high, the waiting room is divided in two or more parts. In this large (maximum) configuration (Figure 2c), the crowd of people is very large.

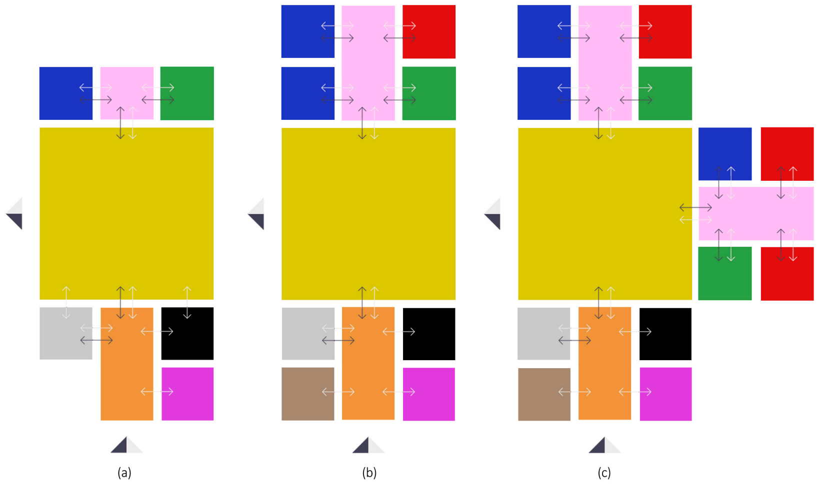

Figure 2. Preliminary design schemes: (**a**) basic configuration (**b**) medium configuration (**c**) maximum configuration. (blue) = basic medical practice, (red) = specialist, (green) = counseling center, (yellow) = social area, (pink) = waiting room, (grey) = restroom, (orange) = triage station, (violet) = administration office, (black) = operating room, (brown) = storage and pharmaceutical area.

3.2. Technological Features

Modular construction represents the highest level of prefabricated construction technologies [18].

After the detailed design of the modular spaces, a detailed technological design was carried out. The construction system that best suits the requirements of flexibility, construction speed and low impact is based on dry prefabricated elements, which can be assembled on-site [10]. The transposition of design requirements at the construction level has led to the choice of two systems: one for the platform and one for the modular boxes.

Functionally, the two systems are independent, but structurally the platform, including the decking, the external vertical closures and the rooftop, is directly connected to the foundations [19]. The boxes are made of a self-supporting frame system that allows the creation of the modular grid, upon which the boxes can unload the weight to the foundations. The analysis of the construction system also took into account other factors: for instance, the need to expand or move the structure after an estimated time of 5/10 years, due to the change in the migration flows and seasonal work. For this reason, focal requirements have been identified in reuse and reassembly, according to the requirements of the reference association. The choice of a prefabricated system that can be reused and composed was also useful to the limited budget which private social associations can afford. Therefore, using a long-term strategy, the costs dilute over the years and become accessible to all these small institutions [20].

3.2.1. Platform

The platform is a modular steel structure, composed by elements sized 585 $\times$ 385 cm. Thanks to the small modules composition, it is possible to assemble and adapt the building to different urban areas. Furthermore, this also simplifies the design when the structure is adjacent to existing buildings. Foundations are also demountable, and consist of adjustable jacks in certified steel, suitable for each type of terrain, which may be inserted even in existing asphalt. On the top is welded a metal plate that allows the anchoring of the elevation structure beams and pillars.

The framework structure is made of steel components: the main beams, used both in the foundation and in roofing, made by IPE300 profile; secondary beams IPE160; and pillars, HEA 200 profile. The floor slab is made of prefabricated wooden panels anchored off-site to an embossed metal sheet; the final prefabricated panel is ready for assembly on-site in 128 $\times$ 280 cm elements (Figure 3).

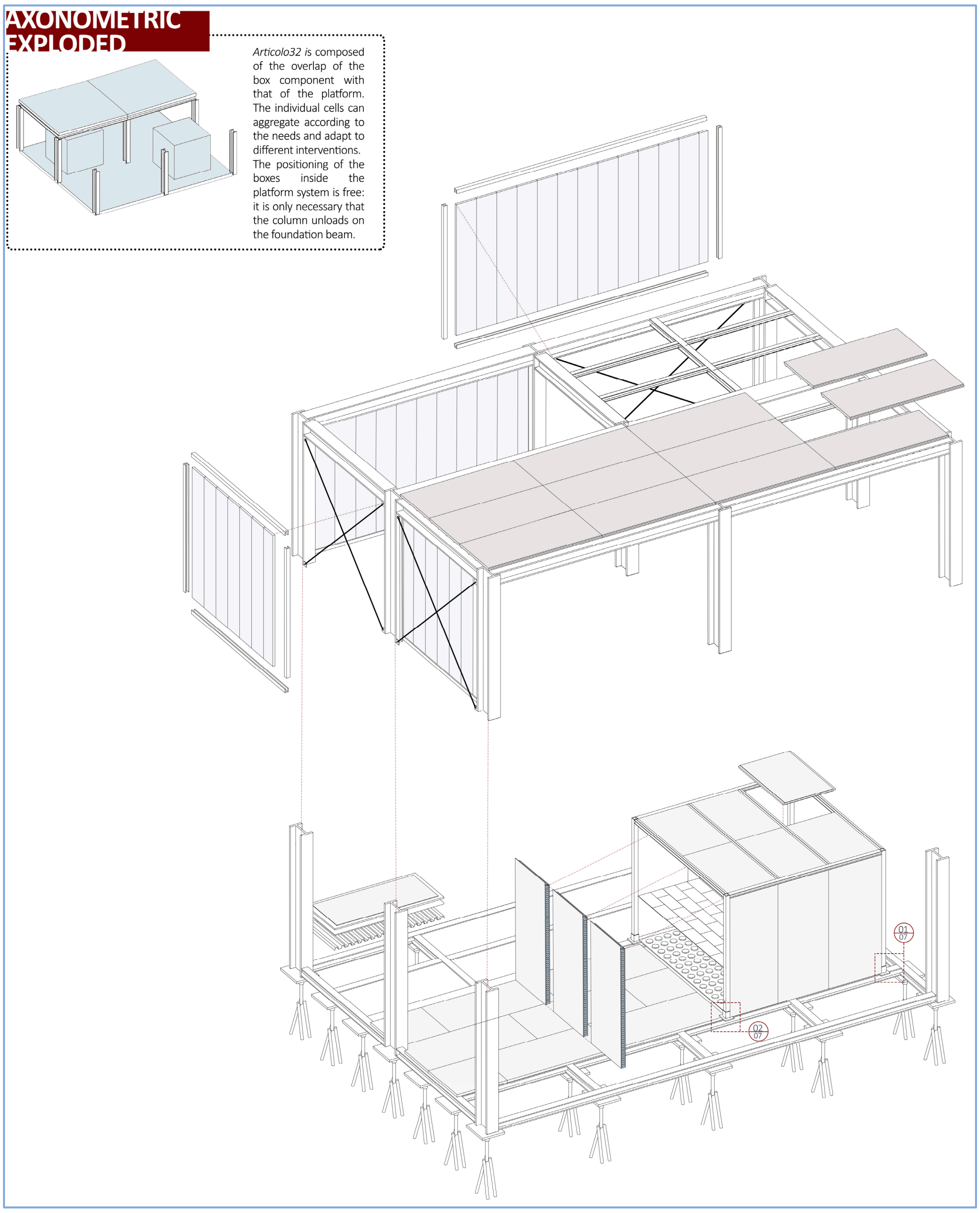

Figure 3. Details of the modular structure consisting of platform and boxes.

The wooden flooring is placed once the structure is finished. In the platform slab it is not necessary to provide a special space for heating system, wiring or water plant. The external envelope is made of translucent polycarbonate panels that can be painted at strategic points of the building, such as multilingual entrances or information points. The polycarbonate panels module is 50 cm and the technology provides the possibility of inserting, in the same step, a window to ensure natural ventilation. The whole structure is closed by a metal bracing structure. The roof is made by 100 × 140 cm rock wool–metal sheet sandwich panels, joined male, taped outside, and covered with a reflective waterproofing membrane.

3.2.2. Box

The boxes contain medical furniture and are equipped (heating, wiring, etc.).

The platform grid allows the placement of the boxes, according to the foundation beams that remain visible until the final phase of the floor covering to avoid cuts in the screed. The floor slab is the same as the platform floor, but integrated with a patented radiant heating system made by prefabricated panels that are positioned above the platform slab and covered by a wooden panel.

In the design process, it must be considered that the boxes can be combined; however, for no reason is the doubling of a wall necessary.

The walls consist of prefabricated sandwich panels (3 × 6 or 3 × 3 mt.) assembled on both sides according to the needs of the adjacent boxes. The supporting structure is a steel frame. The galvanized tubular steel pillars are connected by the glass to the foundation beam of the platform, while the edge and roof beams are IPE 80, anchored through plates to the tubular. Both vertical and horizontal envelopes are composed in different materials, depending on the design needs.

Although each panel has a different function, the composition of the prefabricated sandwich panels remains basically the same: insulating stone wool supported by metal C, which ensures the self-support of the panels, and closed on both sides by OSB panels, treated from the inside to prevent the entry of steam and condensation. Walls are classified according to an abacus of different characteristics and requirements (Table 4, Figure 4).

Table 4. Panel abacus for modular boxes: requirements and description.

Title 1	Title 3
External Vertical panel	125 × 300 cm size, thickness 11.2 cm. Defines the spaces between inside and outside, does not require plant equipment.
Roof Panel	120 × 188 cm side, thickness 8 cm. Designed with a different pitch to be anchored to the frame cover, the panel is necessary because the box is heated. Contained more metal C to prevent bending.
Inner Vertical panel	125 × 290 cm size, thickness 9.9 cm This panel is similar to the external vertical panel except for the height, that is lower, being placed under the frame beams to allow the anchoring. Additionally, it is thinner, due to less insulation inside.
Sliding door panel	Panels are cut to insert a door-frame for the access to the box. Prefabrication system is optimized. Standard opening 90 × 210 cm.
Window opening panel	Similar to door panel. A window frame 90 × 210 cm instead of the door. A moveable vasistas window to optimize the space, to discourage intrusions and ensure privacy in the interior environment.
Wiring panel	The OSB panel is cut and shaped to allow wiring and the LED lighting, both inside the box and outside, in the platform). Cables are placed in the empty space under the platform structure.
Toilet panel	A floor tile covering characterizes this panel typology. Drain pipes are not inside the panel, but in an implemented cavity. It is possible to use washbasin and toilet on the same wall when there are in two adjacent boxes.

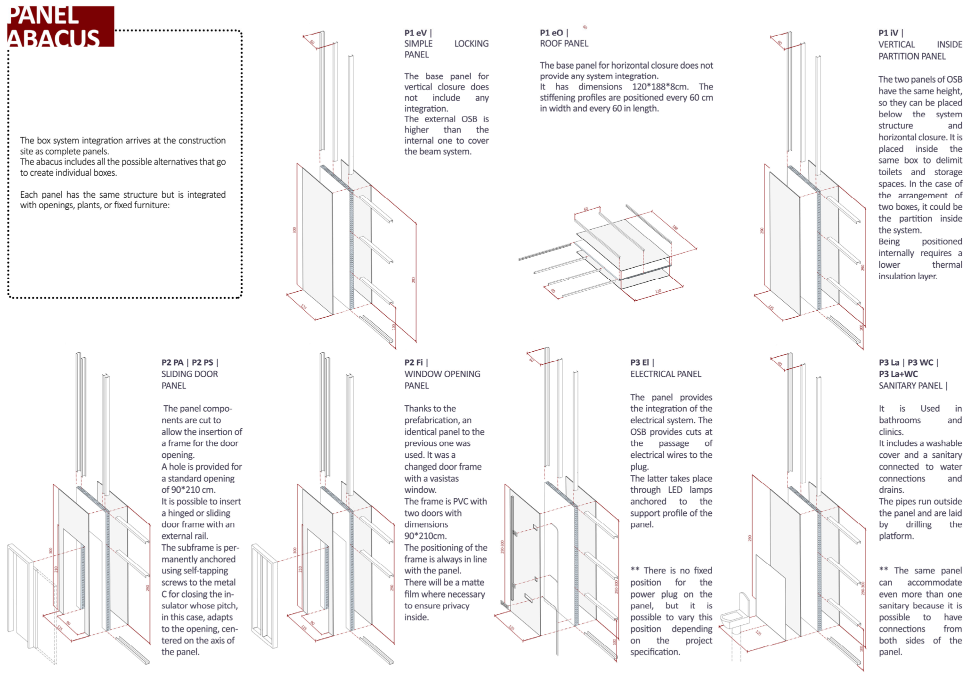

Figure 4. Panel abacus for modular boxes: Technological design.

4. Case Study—A Project Application in Italy

A virtual application has been tested in the urban context of Trento, a small city in the north of Italy. This study has been carried out firstly to switch from the theoretical model to an application in a real context, and secondly to assess the economic sustainability of the model.

The sanitary structure works as a support of a cooperative that operates just outside the historic center, adjacent to services for indigent people such as canteens and dormitories. First of all, an urban analysis concerning the building constraints and the existing services was carried out, and consequently it was decided to place the polyclinic in a small car park nearby, over an area of about 200 square meters; this was supported by building regulations.

The project has been sized on users' needs and turnout that emerged from the data obtained from associations working in the city of Trento: "Cooperativa Punto d'inconto" and "GrIS—Gruppo Immigrazione e Salute" (Table 5).

Table 5. Users' data regarding the city of Trento, in Italy.

	Average Number of Users per Year (2020–2021)	Main Provenience (More than 10%)	Type of Care
City of Trento, several association	1114	-	General medicine 35% Gynecology 8% Certifications of violence 3% Visits to inadequate low-threshold aid facilities 41% Infirmary 7% Other 6%

The new temporary sanitary structure includes general medicine, a listening center, toilets, administrative area, and personnel locker room, for a total of 12 box units and 12 platform units (Figure 5). The size of the intervention (number of services and personnel) has been calculated according to the data collected during the analysis and compared with a number of users registered by the cooperative.

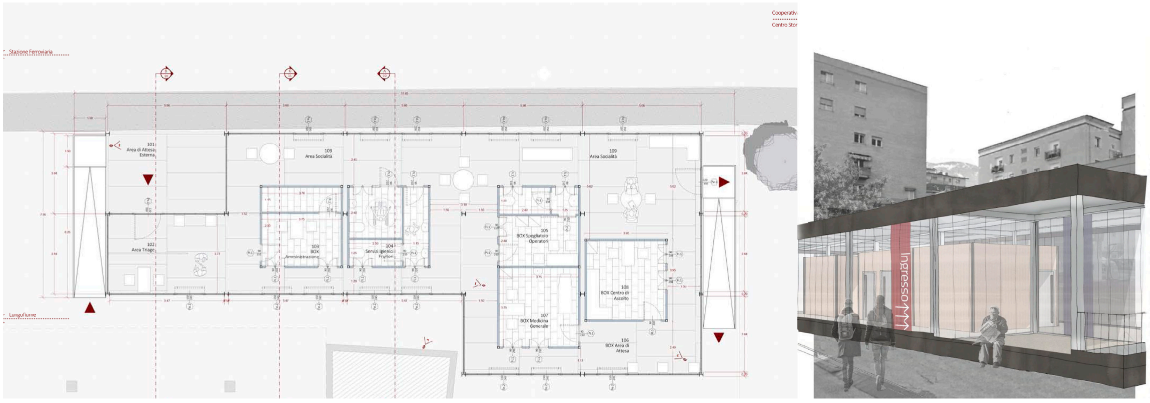

Figure 5. Case study application in Trento. Plan and virtual image of the modular application.

A final step has been performed to verify the economic feasibility of the intervention, both during the first installation phase and then also during a hypothetic reuse phase, after 10 years. One of the first assumptions is the total reuse of the modules in other contexts; this means that the lifecycle of the module does not finish after its dismantling, but includes the reuse in another place. First, the construction costs of the individual elements were quantified through the estimated metric calculation of the individual modules. In the case of the first use, all material costs were calculated and added to labor and construction charges. The single platform module cost EUR 18,833, and the box EUR 7238.

This was followed by a cost and revenue analysis that counted construction cost multiplied by the number of modules in the project: 12 for the platform, totaling EUR 226,000; and 5 for the boxes, totaling EUR 36,190. Moreover, these production costs were added in percentages the costs of professional and security charges, amortization, and insurance. The total amounts to EUR 307,510 for the first year of investment and depreciation of 26,219 EUR/year for the 10 following years. To this must be added 8794 EUR/year for operating expenses including utilities and personnel costs. In total, there is a cost of 35,013 EUR/year from the second to the eleventh year of use. Since this is not an activity that can generate revenue, it is not possible to calculate a payback period. However, it is possible to estimate the funding needed by the company for the first use of the structure, by calculating the investment risks [21], and the discounting values. The total cost of the facility is between EUR 54,500 and 54,800 EUR/year for 11 years, depending on the amount of the percentage of debt that the company will have to ask for. In the reuse scenario, construction costs are lowered, because they are limited to labor, demolition and reconstruction, and transportation of material. The total is EUR13,700.

Repeating the same analysis to calculate the financing reveals that the production costs are EUR 15,384 for the first year and EUR 541 for the following 10. The operating costs remain the same as in the previous case.

Calculating the annual financing needed for the investment with the same risk factors as before, we obtain a range of 8100 and 8200 EUR/year for 11 years.

From the total cost of construction, it was also possible calculate mean days to estimate construction timeline. Two teams were estimated, composed of seven professional figures including two workers specialists, two ordinary workers and three unskilled workers. By doing so the total estimated period of the construction of the modules on site is 23 days.

5. Conclusions

This paper has presented a design strategy of a modular construction for healthcare facility delivery in response to an urgent phenomenon regarding people who need care without being regular citizens.

Based on the preliminary analyses of existing models [22] and structures operating in Italy, a novel framework was developed to facilitate efficient delivery of modular healthcare facilities to address the issue of assistance in several situations, from emergency management to ordinary (operating in synergy with existent contexts) situations.

Compared with the existing frameworks of emergency management, it is innovative in several aspects.

First of all, the project is suitable for the most varied contexts without being necessarily bound to a pre-established form; therefore, it is possible to identify from minimum to extreme configurations. Creating spaces that involve only one medical response would be sufficient, but not exhaustive as the main objective is the implementation of the lifestyles of indigent people who, once the purely medical treatment is over, would find themselves alone on the street.

The project has been developed by taking into account two degrees of flexibility: with regard to the size of the building, as the project develops in a modular way adapting to the flow, and with regard to the context by adapting the model to different requirements.

The aim of the project was to address small institutions operation by going directly from the promoters of the service, which increasingly require mobile and reusable services to face emergency situations and/or to reach all those people who cannot, by physical or linguistic means, reach the hospitals.

The main difference between this model and other temporary models also investigated in the "state of the art" definition is firstly in the masterplan design: open areas are entirely dedicated to the humanization of services for indigent people who need a place to spend the day [23]. As it emerged unanimously from the meetings with doctors who operate in this activity, health prevention is an important issue to deal with in these situations. A place to stay safe and secure can reduce the percentage of chronic disease. Additionally, it involves a series of new principles, such as the goals of modular construction-driven response, not only improving efficiency but also enhancing sustainability.

Second, the project fits into organizations that are almost entirely financed through public and private donations; therefore, the economy of the project is fundamental, as well as the ease of assembly. The prototype has been created to meet the requirements of the greatest number of associations, and give them the opportunity to operate with or without the National Sanitary Authority support.

Once the service has been provided, it is possible to reuse the project in another context because, as mentioned before, the target user it is not stable but varies according to the seasons, routes and geopolitical situations.

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