Project of a conceptual design in BIM of a hospital

Document:
Report

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Degree:
Bachelor in Industrial Technology Engineering

Examination session:
Extension, 2023

BACHELOR FINAL THESIS

Abstract

Differences in climate, habits and diseases in different parts of the world create a great variability of care needs that the population needs to be covered. The most important of these is health. The aim of this project is to study the rooms needed in two specific units of a hospital, the surgical and the emergency unit, and to relate them to the population, in order to obtain an algorithm that quantifies and sizes them according to the population. Based on this algorithm, it is wanted to visualise the data dynamically and dump it in Revit to obtain a BIM model that is capable of varying the distributions depending on the selected inputs.

This project begins with the study of the care units of a hospital and then focuses on the functional plan of the surgical and the emergency unit. Based on the functional plan, the relationship between the inputs and the number and dimensions of the rooms in both units is studied. From these relationships, an algorithm is created and written in Python in order to calculate the results based on the data entered and to visualise them in a web environment. Finally, the formulation of coordinates that can locate each of the rooms in a plan according to the inputs, without overlapping one over the other, is studied and the data is dumped into Dynamo for its design in Revit.

This study demonstrates the variability in the dimensions and number of rooms needed in a hospital to serve a specific population, by number of people and by location. In the case of this project, the regulations were studied and applied at a state level, but the surgical and emergency unit attendance is different in each autonomous community, which is reason enough to present the possibility of making this study more generic and with more variables so that it can be used in any part of the world.

Resumen

Las diferencias de clima, de costumbres y de enfermedades en diferentes partes del mundo crean una gran variabilidad de necesidades asistenciales que la población necesita que se atiendan. La más importante es la salud. El objetivo de este proyecto es estudiar las salas necesarias en dos unidades concretas de un hospital, la unidad quirúrgica y la unidad de emergencias, y relacionarlas con la población, con tal de obtener un algoritmo que las cuantifique y dimensione en función de esta. A partir de ese algoritmo se desea visualizar los datos de una forma dinámica y volcarlo en Revit para obtener un modelo BIM que sea capaz de variar las distribuciones en función de los inputs seleccionados.

Este proyecto comienza con el estudio de las unidades asistenciales de un hospital para después centrarse en el plan funcional de la unidad quirúrgica y de emergencias. A partir del plan funcional, se estudia la relación de los inputs con la cantidad y dimensiones de las salas de ambas unidades. A partir de esas relaciones se crea un algoritmo que se escribe en Python para poder calcular los resultados en función de los datos introducidos y poder visualizarlos en un entorno web. Finalmente, se estudia la formulación de coordenadas que puedan ubicar en un plano cada una de las salas en función de los inputs, sin que se solapen una sobre la otra, y se vuelcan los datos en Dynamo para su diseño en Revit.

Con este estudio se demuestra la variabilidad en las dimensiones y en la cantidad de salas necesarias en un hospital para atender a una población concreta, por cantidad de personas y por localidad. En el caso de este proyecto se estudió y aplicó la normativa a nivel estatal, pero la frecuentación quirúrgica y de la unidad de emergencias es diferente en cada comunidad autónoma, motivo de peso suficiente para presentar la posibilidad de hacer que este estudio pueda realizarse de forma más genérica y con más variables para que pueda ser utilizable en cualquier parte del mundo.

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List of abbreviations / Glossary

BIM   Building Information Modelling

NHS   National Health System

SU   Surgical Unit

PACU   Post-Anaesthesia Care Unit

ED   Emergency Department

LOD   Level of Development

FM   Facility Management

FFM   Facility Maintenance Management

1. Introduction

1.1 Object

The aim of the project is to develop a generic hospital recommender, from which the defined blocks can be designed in BIM. A hospital has different facilities and equipment for the cure and care of the sick population or those in need of urgent medical attention, however, medical needs are different depending on the geographical location of the hospital. This project aims to design a recommender that defines the hospital based on the inputs depending on its location for its subsequent design in BIM.

1.2 Scope

This project focuses on the surgical and the emergency unit, and it includes:

- Definition of variables: Define the most important variables to size a hospital.
- Identification of the relationship between the variables: Define the relationship between the variables considered essential for dimensioning the hospital.
- Develop algorithm: Develop and program an algorithm that, with the above data, measures a hospital room.
- Reorganize the hospital: Based on the dimensioned rooms, propose an optimal distribution.
- Design in BIM: Design in BIM some of the dimensioned rooms.
- Budget: Economic evaluation of the project described in this document.
- Analysis and assessment of social implications: Brief study of its social impact, of as well as other possible proposals.
- Project Management: Monitoring of all the phases of the project described in this document.
- Continuity plan: Instructions for completing the project by carrying out the parts that are not included and that are specified at the end of this section.

This project does not include:

- None of the aforementioned points that refers to any unit other than the surgical or the emergency unit.
- The study and dimensioning of the resources that are shared between different units.
- The study and quantification of the material used in each hospital room.
- Does not include the creation of a database of hospital material.
- The selection, design and cost of structural elements are not included.

1.3 Requirements

The project will be carried out considering the following requirements:

- Spanish area: The rules and regulations to be considered in this project will be in the Spanish state.
- The Python programming language will be used, so that language should be known to carry out this project.
- The Autodesk Revit program will be used to make the BIM design.
- It is necessary to have a computer whose operating system allows you to work with the aforementioned environments.

1.4 Rationale

The buildings and facilities are designed and carried out following regulations depending on the country in which the project will be carried out. In the case of buildings and health facilities, these regulations are more restrictive and also depend on factors of the population that size these facilities. When carrying out a project to build a new medical building, the regulations that apply to it must be studied, as well as the data of the population to which it must provide service in order to dimension it optimally. This means that it will not be the same medical centre if it has to serve an entire city or if it will only serve two populations, nor will it be the same nor will it need the same depending on the study of the causes that cause admissions or visits in these centres. In order to dimension these medical buildings more quickly and not delay the project, the aim is to create a recommender that proposes the dimensioning of the different rooms in order to comply with the regulations and the needs of the population. This recommender, in this specific project, will be created for hospitals by means of an algorithm that, based on input data, proposes the necessary dimensioning. To carry out this algorithm, the necessary rules and regulations will be studied, as well as the relationship of these variables. Subsequently, a room will be dimensioned in order to be able to carry out the design in BIM and show what it would be like, despite the fact that in this project only the rooms are dimensioned, the facilities could continue to be dimensioned interiors, such as electricity, fire protection or water, among others. In addition, the recommender could be extended so that it also proposes the necessary equipment in each room and ends up creating a database with the costs of each element, with this it could end up having the full cost of the project only by entering some population values. With this project, a starting point is proposed for the dimensioning of medical buildings and facilities, since what is proposed and carried out in it for hospitals can be extrapolated in other projects for the rest of the medical buildings. This project offers speed and ease in sizing hospitals, so that the projects could be launched more quickly, in addition, in this way it is ensured that the regulations applied are complied with and that they are correctly sized for the population they must serve.

2 Background and/or review of the state of the art

The use of a BIM model to create and manage data has been studied on many occasions. All the literature presented below has been a guide and a learning experience in BIM design and management.

BIM LOD for facility management tasks (Alavi H. and Forcada N., 2019) studies the levels of development (LOD) required for different areas of the Operation & Maintenance phase for existing buildings. The paper highlights the need to work at the right level in order to get the right information. The study concludes that 60 percent of properties are non-essential for implementing facility management (FM) tasks. Among 40 percent, "service" category is required specific LOD with more detail.

BIM-Based augmented reality inspection for facility maintenance management (Alavi, H., Forcada, N., Fan, S. and San, W. 2021). This paper develops a framework to reduce the costs associated with building maintenance activities, as more than 65% of the total cost of buildings comes from Facility Maintenance Management (FFM).

Enhancing occupants' comfort through BIM-based probabilistic approach (Alavi, H., Forcada, N., Bortolini, R. and Edwards, D.J. 2021) proposes a better visualisation and subsequent interpretation of the opinions of the users of the buildings. These opinions, collected through questionnaires, can be transferred to a BIM model that facilitates data collection and improves visualisation. With the data collected, FM teams can make decisions to improve comfort.

The most energy-intensive systems in a building are heating, air-conditioning and ventilation, and they can also cause great discomfort for the occupants if they are not properly designed. The paper *User-Centric BIM-Based Framework for HVAC Root-Cause Detection* (Alavi, H. and Forcada, N., 2022) proposes BIM as a means to identify and visualise potential design problems, reduce equipment malfunctions and propose actions to solve them.

3   Methodology

The working methodology of this project is as follows:

- Based on documentation from the Ministry of Health and examples of existing hospitals, study the needs of the functional plan of the surgical and the emergency unit, as well as the operation of the two units and their required rooms.
- Define the variables and study the relationship between them.
- Develop an algorithm to obtain the number of rooms required and their dimensions and write it in Python.
- Analyse with existing hospitals that the results of the algorithm obtained are correct. Correct the algorithm if they are not.
- Develop a recommender that allows the results of the previous algorithm to be visualised.
- Make a proposal for the location of each room by means of coordinates.
- Design in BIM: Make a proposal for the design in BIM.
- Carry out the economic evaluation of the project described.
- Carry out an analysis of the environmental implications of the project.
- Define the continuity plan.
- Detail the conclusions drawn from the project.

4 Study of the care units

The project, as detailed in the specifications, is carried out in accordance with the quality and safety recommendations of the Spanish Ministry of Health for the National Health System. According to these documents, the care units found in a hospital are as follows:

- Surgical block
- Major outpatient surgery
- Palliative care
- Nursing in acute multipurpose hospitalisation
- Day hospital
- Maternity hospital
- Central sterilisation unit
- Intensive care unit
- Extra renal depuration unit
- Unit for multi-pathological patients
- Pain management unit
- Sleep unit
- Hospital emergency unit
- Heart care units
- Cancer care units
- Digestive system care units
- Childhood and adolescent cancer care units
- Diagnostic and imaging care unit
- Neonatology care unit
- Neurosciences care units
- Central clinical laboratory

In this project, which is the beginning of a study of all the care units that make up a hospital, in order to adapt it to the workload considered for it, two care units are studied: the surgical block and the hospital emergency unit. These two were chosen because they are independent blocks that can have a flow of patients from one to the other (hospital emergency department to surgical block).

4.1. Functional plan

The functional plan is the document that must specify the requirements of a given site in order to fulfil the function demanded and lay the foundations for drawing up an architectural project, determining the human resources and the necessary equipment.

The functional plan consists of analysing the environment and the population, establishing a model and drawing up a programme of surfaces and relationships.

Each unit must be defined on the basis of a demographic analysis and a study of the theoretical demand, among others.

This plan must take into account trends and changes in hospital demand. In the case of surgical activity, this has undergone changes, and interventions that were previously carried out in operating rooms have been shifted to other diagnostic and treatment areas with the support of day hospitals. This gives the operating rooms more availability and flexibility. On the other hand, in the case of the emergency unit, its frequentation has increased during the Covid-19 pandemic to levels of over-saturation, and this has also served as an indicator of how and when an emergency unit becomes saturated, in order to be able to obtain data and adapt the units to the increasingly variable needs of the population.

For this reason, part of the functional plan is the analysis of the current society in order to be able to size resources. As an example of this, in August 2022 the NHS published the document Key data from Spain's National Health System, in which the data shown in figures 1, 2 and 3 were made public.
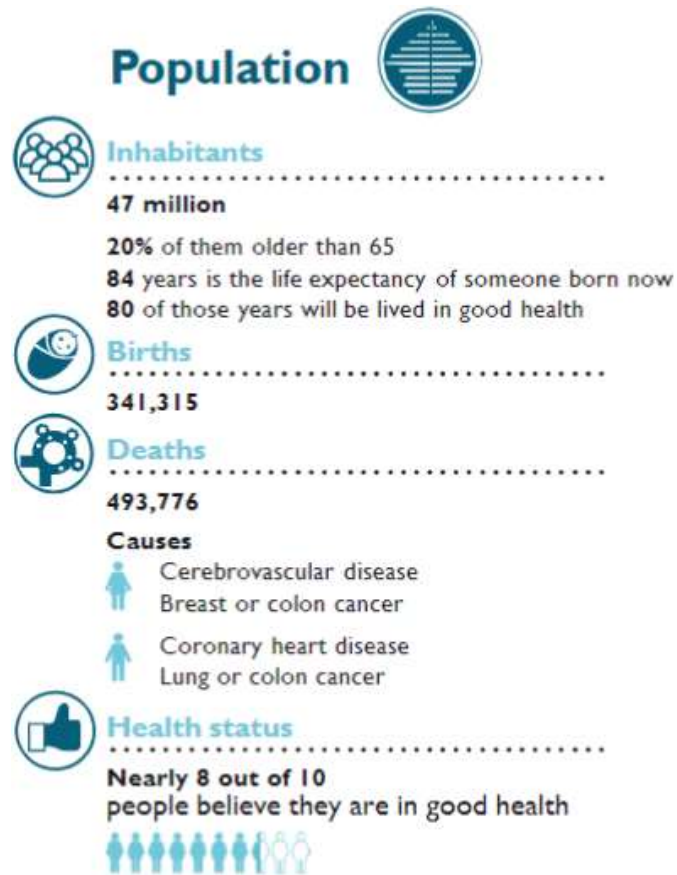
Figure 1. Population (Key data from Spain's national Health System)

Lifestyles

Obesity

16% in **adults**   16% 👩👨 17%

10% in **children and infants**   10% 👩👨 10%

Nutrition

68% eat **fruit**   71% 👩👨 64%

47% eat **vegetables** every day   52% 👩👨 41%

Physical activity

36% do not do any physical activity   40% 👩👨 32%

Tobacco

20% smoke **tobacco** daily   16% 👩👨 23%

Alcohol

35% drink weekly   25% 👩👨 46%

Other drugs

11% of adults have consumed **cannabis**   6% 👩👨 15%

and 3 % **cocaine**   1% 👩👨 4%

in the past 12 months
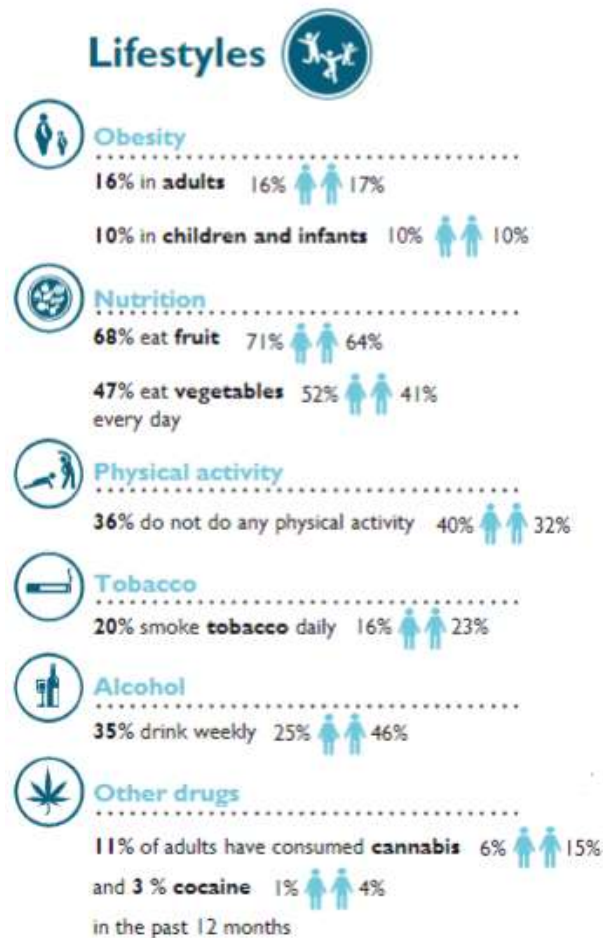
Figure 2. Lifestyles (Key data from Spain's national Health System)

Healthcare

Hospitals

464

114,000	beds
19,000	outpatient hospital places
297	reference centres, services and units
45	hospitals with an authorized transplant programme
4 million	hospital admissions
	8.1 **days** overall average stay
	6.8 **days** average stay in acute-care hospitals
	€ 5,034 average cost of each hospital stay
73 million	consultations
	115 **days** average waiting time for first consultation
2,8 million	surgical interventions (with or without hospitalization)
	170 **days** average waiting time for non-urgent surgical interventions
4,781	transplants
17 million	emergencies

Figure 3. Healthcare (Key data from Spain's national Health System)

4.2. The surgical unit

The first block to be dealt with will be the surgical block. The surgical block is defined, from a structural point of view, as the space in which all the operating rooms are grouped together, with the necessary equipment and characteristics to carry out all the planned surgical procedures.

The surgical block is an intermediate unit that serves the final clinical services, i.e., those that discharge a patient.

Surgery accounts for the majority of hospital visits in developed Western countries. During 2020, the surgical interventions performed in NHS hospitals by autonomous community were as shown in the following table:

Table 1. Surgeries by autonomous communities in 2020

Autonomous community	Surgical interventions (thousands)	Frequentation per 1000 inhabitants
NHS	2.805,00	59,2
Andalucía	388,2	45,8
Aragón	86,7	65,1
Asturias, Principado	51,4	50,6
Balears, Illes	59	48,6
Canarias	85	37,9
Cantabria	31,9	54,8
Castilla y León	148,6	62,1
Castilla-La Mancha	89,6	43,8
Cataluña	629,1	82,2
Comunitat Valenciana	294,9	58,6
Extremadura	63,9	60,4
Galicia	168,7	62,5
Madrid, Comunidad de	386,3	57,2
Murcia, Región de	71	47,1
Navarra, C. Foral de	41,5	63,2
País Vasco	180,4	82,4
Rioja, La	22,6	71,4
Ceuta y Melilla	6,2	36,6
Ceuta	-	-
Melilla	-	-

As can be seen in the table, the Basque Country and Catalonia are the two autonomous communities with the highest surgical frequency per 1000 inhabitants.

It should be borne in mind that the surgical block does not include minor surgery, performed in consultation or treatment rooms, nor does it include endoscopy cabinets or haemodynamic or electrophysiology rooms.

4.2.1. Principles of organization

With regard to the structural organisation of this unit, different aspects must be taken into consideration.

The surgical unit, within the hospital centre, should be located in proximity to the critical care unit, easily accessible from the emergency department and the multipurpose hospitalisation units assigned to surgical specialities and with adequate communication - which may be telematics; pneumatic tube; etc. - with anatomical pathology, diagnostic imaging and laboratories.

The operating rooms should be as multi-purpose as possible, so that operating rooms are not assigned by speciality, and surgical sessions are distributed according to scheduling criteria.

People, when they move, are the main sources of micro-organisms. The bacterial load is reduced by reducing the number of people and their movements, as well as ensuring an adequate flow and renewal of air, and therefore, at an organisational level, each room in the unit must be located in such a way that the flow of patients and workers is optimal, ensuring a minimum passage through the rest of the rooms.

The segregation of circulations does not reduce the risk of infection; however, it is sometimes justified for reasons of internal organisation, distribution of internal traffic in the unit, or compliance with fire protection regulations. Designs with a single circulation corridor for the different traffic flows in the unit (patients, staff, sterile material and used material) are proven solutions with high satisfaction rates, which do not encourage errors or ambiguities in operation, although they require training and discipline of the unit's staff.

In order to avoid the accumulation of people, and thus reduce the risk of infection, it should be considered that the patient entering the surgical block may come from home, from the emergency department or from the hospital ward. It is advisable to schedule the surgical activity appropriately to avoid unnecessary waiting times, especially for the surgical patient coming from home, who should have a space specifically designed for waiting.

Maximum use of the surgical unit should be sought. A reasonable target for the utilisation of scheduled operating rooms could be at least 10 hours every working day and 7 hours on Fridays, which would allow an utilisation of 47 hours per operating room per week.

The centres with surgical block should be aware of the average times for most of their surgical procedures and have the appropriate information to establish a good management of their surgical scheduling.

4.2.2. Structure and typologies

The need to make an efficient use of available resources has prompted the centralisation of the surgical block in two ways:

- Physically grouping all operating rooms into a single surgical block in order to make better use of equipment and avoid duplication of staff.
- Unify the management of the operating rooms in order to optimise the use of equipment, optimise staff allocation and plan with long-term global objectives.

Generally, operating rooms are reserved for emergency, trauma and general care.

In the absence of a dedicated emergency operating room, surgeries should be scheduled in such a way that a scheduled surgery can be cancelled.

Despite the need to maximise the versatility of operating rooms, there are two reasons to justify specialised operating rooms:

- Specific equipment that cannot be transported or is too expensive to equip all operating rooms with.
- Prevention of cross-contamination.

In order to restrict access to various areas and segregate traffic elements within the surgical block, four zones can be defined:

- General access zones. These have no restrictions for persons admitted to the surgical block. These are the patient reception area, administrative areas of the unit, changing rooms and toilets for medical staff and staff rest room.
- Limited access areas. Only people who need to reach premises adjacent to restricted access areas or operating areas (storerooms and PACU) are admitted.
- Restricted access areas. Only persons needing to reach the surgical area are admitted. These areas would be the surgical scrub area, pre-anaesthesia and dirty office.
- Operating areas. Operating room and preparation of sterile trolleys.

Regarding the design of corridors, there is no scientific evidence that there should be a clean and a dirty corridor, however, they should be designed in such a way as to avoid the passage of staff and material from dirty to clean areas.

The elements to be segregated should be considered to be patients, staff, supplies and waste.

The corridor system should facilitate easy and economical circulation, and of all the possibilities, the single aisle is the best of all. The patient transport system to be used for the transfer from the operating room to the inpatient ward should be considered in the choice of the corridor.

In addition to the single corridor, corridor systems in the surgical suite can be double corridor systems in the following ways:

- Staff and patients are segregated from supplies and waste.
- Staff, patients and supplies are segregated from waste.
- Patients and waste are segregated from staff and supplies.

Below, in Table 2, the structural and organisational requirements of the operating room are shown.

Table 2. Surgical unit activities and requirements

Process sequence	Activities	Structural requirements
Access	• Reception of the patient at the hospital. • Accompanying the patient and relatives to the SU / Transfer from the hospital ward / Transfer from the emergency department. • Transfer from the emergency room. • Reception at the SU.	• Reception area • General waiting area (comfortable and independent from hospitalisation). • Family information office. • Computer equipment. Computer networks. • Direct telephone. • Intercom with medical staff on duty.
Reception	• Identification of the patient.	In the SB, within the area not restricted to general circulation. • Toilets and changing rooms. • Lockers for personal belongings.
Pre-surgical area	• Patient assessment	
Operating room	Anaesthetic technique. • Protocols for specific surgical procedures	• Operating rooms.
Area of post-anaesthetic recovery	• Income. • Patient assessment • Discharge and registration of operating theatre data	• In the SU, within the unrestricted area for general circulation.

4.2.3. Functional plan of the surgical unit

The functional plan of the surgical unit should include the points mentioned below, however, since this project is intended to dimension the block based on inputs and without access to a hospital database, it is worth mentioning that the functional plan is not made, but parameters are chosen and will be presented later.

The functional programme shall include the following studies:

- Demographic analysis of the environment (with special reference to the population included in the catchment area of the unit and the criteria for patient selection) or market research for private facilities.

- Theoretical demand study of surgical activity (scheduled with admission and emergency) based on the volume of procedures included in these modalities of care and trends in surgical frequentation. The capacity of the unit to penetrate its surroundings, once it is fully operational, must be taken into account.
- Analysis of production capacity in different scenarios: working hours, throughput, operating times for different specialities and types of surgery.
- Study of the need for personnel and equipment of the SU according to the demand, the foreseen activity and the portfolio of services proposed for the hospital.
- Determination of the number of operating theatres and PACU stations, as well as the main premises of the unit, based on the above analyses.
- Development of the functional requirements of each area of the unit, as well as a programme of the premises with the necessary equipment for the development of the programmed activity.
- The functional programme shall be adapted to the specific characteristics of each healthcare organisation. For the development of the functional programme, it is necessary to analyse the different activities and functions performed by the different users of the unit: patient, surgeon, anaesthesiologist, nurse, preventive medicine, maintenance and cleaning staff, etc.
- The functional programme shall include the type of relationship and how it is resolved between the SU and the rest of the hospital's care units.
- The unit shall describe its operation with reference to the manual of standards and protocols for the prevention of nosocomial infection within the unit, and shall have circulation diagrams for patients, staff, relatives and material. This may be set out by means of a graphic diagram of areas and premises that expresses the relationship between them and the connections and circulations of the different users within the hospital: patient, staff, supplies and material used. The graphic scheme of circulations and relations between the different areas and premises of the unit is considered a prerequisite for the determination of the programme of spaces and surfaces required for the subsequent phase of the unit's design. Particularly important is the adoption of a general circulation scheme within the unit.
- The unit shall carry out a feasibility study reflecting both the budget needed for infrastructure, equipment, personnel and maintenance to carry out the activities, and the economic and health impact of its activity on the institution on which it depends.

4.2.4. Areas of the surgical unit

In order to be able to carry out the recommender, it is necessary to know the rooms to be considered. The structure of a SU unit responds to the main functions performed in it and has the zones defined in the following sub-sections.

4.2.4.1. Access and reception area

The zones forming part of the access and reception area are as follows:

- Entrance and lobby

Access to the block should only be from an internal circulation corridor that is well connected to the emergency and inpatient units. This will be used for patient transfer to the surgical area.

According to the NHS, it is recommended that there should be only one access to the block, so that security can be controlled inside the unit.

- Reception and control

The reception post must have good visual control of access and circulation in the area, as its main functions are access control and patient care.

Figure 4. Entrance hall and checkpoint (Bloque quirúrgico. Estándares y recomendaciones)

- Control dispatch

The control office is for the organisation of the unit's activity, to control the movement of patients and to liaise with other hospital units. This office should be close to the reception and the established circulation to the operating room access.

The internal alarm centre of the surgical unit can be located in this room.

- Information dispatch

This office is intended to inform the relatives and companions of the patient who is undergoing surgery in this unit, respecting the patient's privacy.

This room should be located near the waiting room for relatives and/or accompanying persons.

Figure 5. Information office (Bloque quirúrgico. Estándares y recomendaciones)

- General waiting room

The waiting room for relatives and accompanying persons is located outside the surgical block, in an area close to the entrance, the information office and the post-anaesthesia resuscitation unit.

This room is sized according to the anticipated surgical activity, but as an indicator, a minimum of 1, 5 seats per patient in any room of the unit should be considered.

It should be considered that this room will also have machines for dispensing drinks and cold food.

Figure 6. General waiting room (Bloque quirúrgico. Estándares y recomendaciones)

- Patients changing rooms

Toilets and changing rooms for patients undergoing scheduled surgery who come to the block from outside the hospital, i.e. there is no prior admission to the inpatient unit.

Given that the changing room will be the room that connects the general area to the surgical area, it must have a sluice design that acts as a filter to the clean area for the patient.

These changing rooms should house lockers, personal items and toilets.

4.2.4.2. Logistics area

The rooms that form part of the logistics area are defined below:

- Changing rooms and staff toilets

These changing rooms are intended for the preparation of surgical personnel, and will therefore have an access that functions as an airlock from the outside of the block to the inside of the same.

This room will have a toilet and shower. The capacity will be 20-25 persons.
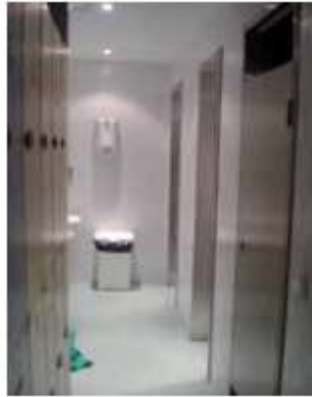
Figure 7. Changing rooms and staff toilets (Bloque quirúrgico. Estándares y recomendaciones)

- Changing rooms for cleaning staff

The changing rooms for cleaning staff shall have an airlock design from the outside to the inside of the changing room. Toilet and shower facilities shall be provided.

- Staff lounge

Space designed for staff rest. It incorporates a refreshment area.

Figure 8. Staff lounge (Bloque quirúrgico. Estándares y recomendaciones)

- Storage of sterile material

This room is used to store sterile material, surgical tools, prostheses and consumables.

Its dimensions and location depend on the position of the operating rooms and the planned activity.

Figure 9. Sterile material warehouse (Bloque quirúrgico. Estándares y recomendaciones)

- Sterilisation sub-central

Sterilisation of equipment is carried out outside the operating theatre, so there must be a sterilisation sub-centre where urgent equipment can be sterilised.

Figure 10. Sterilization substation (Bloque quirúrgico. Estándares y recomendaciones)

- Material storage

This room is used for the storage of pharmacy and consumables. The warehouse is sized in relation to the layout and number of operating rooms.

Figure 11. Stock warehouse (Bloque quirúrgico. Estándares y recomendaciones)

- Equipment storage

Storage room for all portable equipment such as radio diagnostics, surgical lasers and respirators, among others.

Figure 12. Equipment store (Bloque quirúrgico. Estándares y recomendaciones)

- Cleaning trade

Storage room for equipment and cleaning products.

This room is very important for the prevention of infections in the surgical unit, so it must have the necessary support facilities for the correct development of this activity.

Figure 13. Cleaning office (Bloque quirúrgico. Estándares y recomendaciones)

- Dirty trade

This room is intended for the storage of soiled linen and waste. The room must be connected to the operating theatre soiled linen exit and its transport to the hospital's sterilisation and waste central.

Figure 14. Dirty trade (Bloque quirúrgico. Estándares y recomendaciones)

- Work office

The working office is a room for the medical staff to write reports on interventions.

4.2.4.3. Pre-surgical preparation room

The pre-surgical preparation room may be a single common room or be distributed. In this room, preoperative instructions are given, anaesthetic assessment and patient preparation such as venoclysis is performed.

4.2.4.4. Surgical area

- Hand washing

Room adjacent to the operating room for hand disinfection and mask fitting. It is separated from the circulation of patients in the surgical unit.

It should have at least two water points per operating room, and one hand-washing station could be shared for every two operating rooms.

Figure 15. Hand washing (Bloque quirúrgico. Estándares y recomendaciones)

- Operating room

Space in which the surgical intervention is performed and where different traffic flows in the unit; the patient, the staff, the sterile material and the used material.

Each operating room must have a minimum surface area of 40 m^2, with a free height (up to the false ceiling) of 3 m. In addition, the walls of the operating room must be at least 3 m from the centre of the operating table.

The operating theatre must have an access from the staff preparation area, an exit to the PACU and another for the dirty exit of the room.

Figure 16. Operating room (Mejor con salud. Organización y distribución de un quirófano)

4.2.4.5. Post-surgical area

- Post-Anaesthesia Care Unit (PACU)

This unit is a room with a capacity of 1,5 - 2 places per operating room. Each operating room has 12 m^2 of usable space.

This room is open-plan and has natural lighting.

- Nursing control

The nursing station should be centrally located in the post-surgical area. It should allow direct observation of all patients.

Figure 17. Post-anesthetic recovery unit and nursing control (Hospital de Gandia)

- General store

Storage of PACU linen and consumables.

- Clean trade

Space for the preparation of medicines. It should be located near the nursing control.

- Dirty trade

Storage space for soiled linen and waste. Must have sufficient space for advanced waste sorting.

- Equipment storage

Storage room for portable resuscitation equipment needed for resuscitation, as well as respirators or other equipment needed in the area.

- Cleaning trade

Storage place for equipment and cleaning products. It must have a water point and a waste disposal site.

Having detailed the rooms that are part of the surgical unit and that will be the object of design in this project, the following is a summary of which rooms are restricted and which are not, so that the flow of patients can be worked out.

- The unrestricted area includes: staff toilets, reception, offices, staff lounge.
  The non-restricted area is separated from the semi-restricted area by the nursing control.
- The semi-restricted area is the access corridor to the operating rooms and storerooms.
- The restricted area comprises the operating rooms and the corridors in between where the toilets are located.
- The soiled area comprises the access corridor and the soiled airlocks between the operating rooms.

4.3. The emergency unit

According to the National Health System Standards and Recommendations document, the hospital emergency unit can be defined as an organisation of healthcare professionals, located in a hospital, which offers multidisciplinary care, fulfilling functional, structural and organisational requirements, in such a way as to guarantee the appropriate conditions of safety, quality and efficiency to attend to emergencies and emergencies.

This unit is an intermediate unit that provides services to the patient until the clinical condition for which they came is stabilised. Patients who need it, after stabilisation, will be admitted. For those who do not need it, the emergency unit is a final service once they have been discharged.

In terms of data, the Inpatient Health Establishment Statistics show that in 2007, 79,4% of emergencies in Spanish hospitals were in public hospitals and the estimate of hospital emergencies in Spain is 585,3 emergencies per thousand inhabitants, with a percentage of admissions of 10,5%. Between 2001 and 2007, hospital emergencies increased by 23,2%. This trend lies in the overcrowding and inappropriate use of hospital emergencies.

The number of emergency unit attendances in Catalonia in 2020 was 385,6 per 1000 inhabitants.

4.3.1. Principles of organization

In order to differentiate the level of severity for the care of a patient, they shall be distinguished according to the following:

- Urgency: An unanticipated onset of a health problem of varying severity, leading to an awareness of an imminent need for care.
- Emergency: An urgent situation that puts the patient's life or organ function in immediate danger.

- Critical care: Care required by patients with a level of need for care 1 to 3, according to the following table from the UK Department of Health.

Table 3. Description of the need for assistance

Level	Description of the need for assistance
0	Patients whose needs can be attended in a conventional hospitalization unit of an acute care hospital.
1	Patients at risk of their condition deteriorating, or coming from a higher level of care, whose care needs can be met in conventional hospitalization with advice and support from the critical care team.
2	Patients requiring more frequent observation or intervention, including organ system support, or postoperative care or those coming from higher levels of care.
3	Patients requiring advanced respiratory support or basic respiratory support along with at least two organ system support. This level includes all complex patients requiring support for multiple organ failure.

Due to the important characteristics of the demand for emergency care, and because it is an unscheduled care, it requires an adequate provision and allocation of resources, as well as good coordination with other hospital units.

This coordination is very important because in conditions such as stroke, polytrauma and acute coronary syndrome a relationship has been demonstrated between the time of care from the presentation of the problem and the effectiveness of care in terms of reduced mortality or improved life expectancy and quality of future life, so it is essential to establish close coordination between the pre-hospital emergency department, the emergency unit and the critical care unit.

One of the most important aspects to avoid or reduce is overcrowding in the ED. Overcrowding in the ED is a problem for the entire hospital, not only for that unit, as the causes involved in overcrowding are the following:

- Obligation of the unit to attend a patient with a non-urgent pathology. In some hospitals this exceeds 70% of emergencies.
- Referral of elderly or multi-pathology patients to the emergency unit.
- High-frequency patients.
- Seasonal factors, such as influenza in winter or bronchial asthma in spring.
- Low number of healthcare staff or inadequately trained staff.
- Delays in admission or ambulance transport.

And the most important cause of emergency unit overcrowding, according to many studies:

- Lack of beds for hospital admission.

4.3.2. Structure and typologies

The following activities are carried out in the emergency unit:

- Triage. Triage is the first clinical management activity. It enables priority of care to be assigned.
- Attention to life-threatening emergencies.
- Attention to urgent pathology.
- Care for non-urgent pathology.
- Clinical observation. This observation enables the treatment of the patient and/or the monitoring of their evolution.

This unit must be well linked to the diagnostic imaging laboratory, surgical block, intensive care unit and/or other critical care units.

4.3.3. Functional plan of the emergency unit

The functional plan of the emergency unit must include the points mentioned below, however, given that this project is intended to dimension the block based on inputs and without access to a hospital database, it is worth mentioning that the functional plan is not made, but rather parameters are chosen and will be presented later.

The functional programme will include the following studies:

- Socio-demographic analysis of the hospital environment. This should include seasonal variations and population estimates.
- Study of the theoretical demand for each of the unit's healthcare services and the trends observed in attendance.
- Analysis of the physical resources in which the unit's activities will be carried out.
- Dimensioning of the unit's care resources.
- Programme of spaces, including their characteristics and dimensions, quantification and organisational criteria.
- Definition of its operating criteria.
- Configuration of the care circuit, functional organisation scheme and functional relations with the other hospital units.
- Study of staff and equipment needs, taking into account demand, expected activity and the hospital's portfolio of services.
- Analysis of production capacity.
- Study of the viability of the unit's operation project.
- Economic-health impact of its operation.
- The functional programme must take into account signage, location, relationship with other units, security and information system.

4.2.4. Areas of the emergency unit

The following are the areas that are part of this block and should be considered in the recommender.

4.2.4.1. Space outside the unit

Outdoor space immediately adjacent to the emergency unit with protection from inclement weather to facilitate patient unloading. These must have adequate lighting.

In addition, the outdoor space must allow for the circulation of two ambulances in parallel. There must also be parking space for ambulances.

Figure 18. Space outside the unit (Estándares y recomendaciones)

4.2.4.2. Reception, classification and waiting

- Entrance

The Emergency Unit must have, whenever its size and the volume of patients attended to allow it, two independent entrances, for urgencies and emergencies, from which the rest of the areas of the unit are sequentially arranged and which serve as a reference for the structure of the interior circulations of the unit.

The entrances must be covered and protected to facilitate ambulatory patient access and patient unloading on a stretcher. The entrances to the ED should have a wind lobby with automatic doors to facilitate wheelchair or stretcher patient access. The size of the wind lobby space should be sufficient (at least 3,5 metres in the case of stretcher access) to prevent draughts inside the unit.

- Lobby

The general foyer, associated with the ED entrance, is a space that is heavily used for access by most of the unit's patients/companions (adults and paediatrics).

Its dimensions must be sufficient to avoid overcrowding, even at times of special affluence, so that the situations foreseen in the functional programme of greater number of emergencies (peaks) must be considered.

- Reception and admission

This includes the space necessary for the care of patients attending the ED and their companions during the admission process in which affiliation, admission, if applicable, appointment determination, etc. are carried out. Consideration should be given to the need for a certain degree of privacy, which can be achieved by the existence of a well-marked waiting distance from other people at the admission desk.

The reception and admissions desk controls both the general entry of urgent patients and the entry of emergency situations. The administrative area will operate twenty-four hours a day and will have the necessary equipment to carry out its activity efficiently (office automation, computers, e-mail, telephones, fax, etc.) and provide space to store specific documentation: protocols, information leaflets, etc. The admissions desk shall be designed so that it is accessible from the main entrance and easily located for patients and their companions, and so that reception staff can observe the entrance door, public circulation and the general waiting area of the unit. It shall have an area that allows care to be provided without architectural barriers and with users in wheelchairs.

Figure 19. Reception and admission (Estándares y recomendaciones)

- Triage box

Located in such a way as to allow a view of the entrance area and the waiting room and adjacent to the admission area, it is a room intended for the classification of patients in order to prioritise urgent care according to their seriousness, determining the time of care and the most appropriate resource in each case. Classification is a preliminary assessment of urgency/severity based on the reason for consultation and the existence of other obvious signs and symptoms, which does not require a medical diagnosis. Therefore, the design of the premises should preferably aim to achieve conditions of privacy and comfort in accordance with the nature of this activity, allowing privacy for a brief clinical examination and/or confidential information and facilitating the immediacy of care and patient rotation. It should allow at least two professionals to work simultaneously at peak demand. The triage boxes are located between the reception area and the consultation, examination and diagnosis area.

- General waiting room

Adjacent to the reception and admission of the unit and the triage box, there should be a specific space for the stay of patients who have not yet been seen and their companions.

The sizing of the care resources must be established according to the expected volume of patients and the estimated relative frequency for the different levels of severity, with a provision of at least two comfortable seats (waiting times may be long) per patient in any area of the unit, taking into account the forecasts of the functional programme in terms of the peaks of affluence at the ED.

This room will have direct access from the general entrance hall, will allow visual contact with the admission desk and will give access to the care area where patient care is carried out.

There will be a specific waiting room for paediatric patients and family members in the specific paediatric emergency area of the unit.

- Multipurpose offices

Their number will depend on the volume of emergencies in the ED. They have the following functions:

  o Informing: Enabled for medical and healthcare staff to provide relatives and companions of patients with information on their clinical evolution, under appropriate conditions of privacy.
  o Patient care: In those EDs that require it due to their volume of activity, a patient care office can be located in the reception area with sufficient privacy conditions for taking data and attending to patients and their companions in conditions of privacy.

- o Attestations and reports: Depending on the volume of emergencies attended at the ED, a room may be required to guarantee privacy conditions in the preparation of attestations and reports, for security and press personnel.
  - o Inter-consultations and videoconferences.
  - o Social work: Social assistance for patients who require it.

- Wheelchair space

Adjacent to the main entrance, storage space is required for wheelchairs and stretchers. It should be highly accessible to facilitate their availability in case of need, but should not interrupt the circulation in the lobby and reception area.

4.2.4.3. Consultation area

- Consultation room

The consultation room is the physical space where the examination and examination of patients who, according to the triage results, require medical attention, is carried out.

The consultation room must be large enough to accommodate the physician and, if necessary, the medical staff required. In addition to the office furniture (table, armchair and chairs), an examination couch accessible from both sides, examination lamp, oxygen and vacuum outlets and clinical furniture to contain the consumables and instruments used in the consultation. The layout of the space shall facilitate as much as possible the privacy of the consultation and communication with other adjacent consultations, in order to allow for the circulation of health care personnel. The number of consultation rooms shall be determined by the expected volume of activity, in a schedule of continuous operation twenty-four hours a day.

- Consultation waiting room

Associated with consultations and intended for the patient / family member / companion, who has accessed the urgent care area after reception and triage, during the time they are waiting to be seen or awaiting the results of the diagnostic tests that have been carried out.

The structural characteristics of the consultation waiting room will be similar to the other ED waiting rooms, adapting its size to the number of ED consultation rooms, the average expected duration of the care episode in this resource and the expected peak demand for care. It must have public toilets, one of them adapted.

4.2.4.4. Exploration, diagnosis and treatment area

- Resuscitation box

Intended for the recovery of critically ill patients with cardiorespiratory arrest, polytrauma or serious illness, whose vital condition does not allow for delay in care. Located next to the UUH emergency entrance. A space with direct access from the outside and a wide door that allows access to beds, differentiated from the rest of the urgent outpatients.

With capacity to attend to at least two patients simultaneously, with access from both side and separated by partitions or curtains that allow a certain degree of privacy.

- Multipurpose box

This is a multi-purpose area for the examination, diagnosis and care of medical or surgical patients who, according to the triage results, are not sent to the consulting room, do not

require level 1 care (emergency) and do not require special resources (traumatology, ophthalmology, etc.). Patients coming from the consulting room may also be referred to this box when the need for a higher level of care is indicated.

- Traumatology box

Designed for the care of patients who have suffered trauma and require a similar level of care to that described for the multi-purpose box. It is recommended that it forms a functional unit with the plaster room, which will be adjacent to it, with communication between the two spaces.

- Plaster room

It shall have the necessary infrastructure for the care of the trauma patient requiring immobilisation and for the manoeuvrability of the medical staff assisting the patient.

- Treatment room

Space for the performance of cures and sutures. With similar structural characteristics to the multi-purpose box, but with the equipment and facilities for carrying out minor surgery, both clean and dirty. It has oxygen, medical air and vacuum gas intakes. It must be located close to and well communicated with the critical patient resuscitation room of the ED.

- Nursing checkpoint

The urgent care area shall have a checkpoint for the work of the nursing staff, which shall be located in an area close to the access to the area and as close to the centre of gravity of the area as possible, in order to minimise travel and facilitate vision and access to the examination and diagnostic boxes.

Figure 20. Nursing checkpoint (Estándares y recomendaciones)

- Staff lounge

Intended for staff resting during their working hours in the ED. The room should have comfortable seating and an area equipped for staff refreshment: washbasin, microwave, refrigerator, etc. It should have privacy from relatives and patients and be located next to the nursing control.

- Clean trade

Next to the nurse's control desk, it is used for the preparation of clean and storage of medicines as well as for the unit's sterile material.

- Offices

Office for the nursing supervisor and for the medical work of preparing hospital reports and analyses.

- Warehouses

There are different storerooms for storing materials, such as the expendable material storeroom, such as serum, the linen storeroom, for all the unit's textiles, and the material and equipment storeroom. The latter stores the area's large portable equipment, as well as the equipment carriers.

- Dirty and cleaning trade

Space for sorting the unit's waste. Dirty trolleys are also parked here until they are removed.

In the cleaning office, the material and the cleaning trolley are stored.

4.2.4.5. Observation area

- Observation room

For the care of patients requiring treatment or sequential assessment of clinical status over several hours.

- Nursing checkpoint

The observation area shall have a control station for the work of the nursing staff, which shall be located in an area near the centre of the observation room.

- Staff lounge

Intended for staff resting during their working hours in the ED. The room should have comfortable seating and an area equipped for staff refreshment: washbasin, microwave, refrigerator, etc. It should have privacy from relatives and patients and be located next to the nursing control.

- Clean trade

Next to the nurse's control desk, it is used for the preparation of clean and storage of medicines as well as for the unit's sterile material.

- Offices

Next to the nurse's control desk, it is used for the preparation of clean and storage of medicines as well as for the unit's sterile material.

- Warehouses

There are different storerooms for storing materials, such as the expendable material storeroom, such as serum, the linen storeroom, for all the unit's textiles, and the material and equipment storeroom. The latter stores the area's large portable equipment, as well as the equipment carriers.

- Dirty and cleaning trade

Space for sorting the unit's waste. Dirty trolleys are also parked here until they are removed.

In the cleaning office, the material and the cleaning trolley are stored.

- Catering trade

Room prepared and equipped to provide food to the patient admitted to the observation room, as well as for the distribution of plated food.

4.2.4.6. Paediatric emergency area

It is recommended that within the ED there be a specific paediatric emergency area that has in common with the general area, the access, reception and admission areas, but which has specific resources for waiting, immediate care (examination, diagnosis and treatment), and observation, with a common nursing control for the latter two areas.

The following rooms are located in this area:

- Waiting room

Specific waiting room with play area and furniture appropriate to the age of the users, located next to the paediatric toilet.

Figure 21. Waiting room (Estándares y recomendaciones)

- Multipurpose box

Identical characteristics and functionality as for adults, as described above.

- Treatment room

Identical characteristics and functionality as for adults, as described above.

- Observation room

Adjacent to the examination, diagnosis and treatment boxes. The characteristics are similar to those for adults.

- Work area for nursing control staff

Located between the examination boxes and the observation room. Similar characteristics to the one described above.

- Staff lounge

Similar characteristics to those described in adults.

- Clean trade

Similar characteristics to those described in adults.

- Warehouses

Warehouse for consumables and linen with the same characteristics as those described for adults.

4.2.4.7. Staff area

This area includes the spaces necessary to adequately develop the care and teaching activities. It also includes the space necessary for staff to rest.

- Offices

The number of offices is proportional to the size of the workforce. In particular, professionals whose activity requires the use of an office, whether individual or collective.

- Secretary

Office for the administrative work of the unit.

- Meeting room

Space for team-building sessions and staff training.

- Staff lounge

Room equipped for staff refreshments.

- Dormitories of doctor son call

Staff dormitories.

- Changing rooms and toilets

Changing rooms with washbasins, toilets and showers, with space for lockers.

5 Resource sizing

Once the rooms that form part of both units, the surgical block and the emergency unit, are known, the hypotheses and calculations necessary to dimension each of them can be made.

5.1. The surgical unit

Prior to any calculations, the following aspects should be considered:

- Demographic, epidemiological, clinical and management factors.

The number of inhabitants to be served by the hospital is a determining factor for its sizing and will therefore be an input value for the recommender. Given that this project deals with the study of two units of a hospital that would be located in Catalonia, there is no epidemiological factor other than what is recommended by the NHS to be considered at the time. In the event that this project is adapted for another country, the effect that the diseases in that country would have on its sizing should be studied by studying the causes of illness and death in that country, as is done in the functional plan.

- Surgical frequency (operations per 1000 inhabitants and year)

The surgical frequency is another determining factor for the sizing, so it will also be an input parameter. In point 4.2. a table was presented with the surgical frequency per 1000 inhabitants in the last year for which data was obtained, 2020. This table shows the variability of this parameter depending on the geographical location, which is why it was decided that it should not be a fixed parameter, but one that can be set by hand.

However, as an aid to sizing, it would be ideal to have the latest data published (that of 2020) saved and to have it by default unless it is changed by hand. This way you will always have a reliable reference value.

- The number of interventions tends to grow as a result of technological innovations and clinical advances.

Due to improvements in surgical equipment and advances in technology and medicine, it is increasingly possible to use surgery for a larger group of citizens, i.e. patients who previously suffered from a pathology that made surgery incompatible or who, due to their condition, would be dangerous to perform, are now in many cases suitable candidates for surgery, and if they are not, they will be in the coming years.

It is not possible in this project to consider more operating theatres to accommodate this trend, given that this would imply more staff and more beds in the hospitalisation areas, and this is too high a cost to take into account without first carrying out an in-depth study of this trend. This study could not be carried out due to lack of access to clinical data.

However, what will be done in the recommender is to round all stays upwards.

The following forms of calculation are made according to the standards and recommendations of the Ministry of Health and Social Policy of the Spanish Government.

Surgical frequency

Surgical frequency, SFI, is defined as the annual rate of surgical interventions per thousand people, and depends on the number of expected surgical procedures and the number of inhabitants of the area.

$$SSP = PHA \leftrightarrow SFI/1000$$

Where:

SSP is the total number of surgical procedures expected in a year in the reference area.

PHA is the projected number of inhabitants of the area.

Part of these procedures will be scheduled and the rest urgent. Considering, for example, the percentage of scheduled procedures out of the total, we have:

$$Surg.\ Proc.\ Sched. = Surg.\ Sched. \leftarrow \%\ Perc.\ Surg.\ Sched.$$

Where:

Surg. Proc. Sched. is the total annual number of surgical procedures scheduled for the reference population.

% Perc. Surg. Sched. is the percentage of scheduled surgical procedures out of the total number of surgical procedures.

On the other hand, depending on the hospital, there will be a percentage of interventions that will be performed as major outpatient surgery, outside the surgical block. Thus:

$$Proc.\ SU = Surg.\ Proc.\ Sched. \leftrightarrow (100 - \%.MOS)$$

Where:

Proc. SU is the number of scheduled surgical procedures performed in a year at the SU.

% MOS is the percentage of surgical procedures typified as MOS and performed in a stand-alone surgical unit (outside the SU) out of the total number of scheduled surgical procedures.

The estimation of these parameters will, in practice, depend on the information available.

In the case of this project, two sizing options will be considered, one of them is considering a fixed frequency value, which will coincide with the surgical frequency in Catalonia per 1000 inhabitants in 2020, as this is the latest information published at the time this work was carried out. The value that will be given as the default value, following the information presented in table 4.2, will then be 82,2/1000. On the other hand, the option will be given to modify this data, in order to have the possibility of adjusting the dimensioning for each specific situation.

Operating room

In order to calculate the number of operating rooms (ORR) required to handle the expected number of surgical procedures at the SU to be performed in a year, the following parameters have to be considered, which configure the capacity utilisation profile of the production capacity taken as the planning horizon:

- Operating room available time (TAOR), which must coincide with the period in which patients can be scheduled for surgical procedures in the BQ and with the effective operating time of the operating rooms.
  The TAOR shall be given, in turn, by the following expression:

$$TAOR = N^{\circ}\frac{hours}{session} \leftrightarrow N^{\circ}\frac{sessions}{week} \leftrightarrow N^{\circ}\frac{weeks}{year}$$

Where:

Nº hours/session is the expected number of operating hours per surgical session.

Nº sessions/week is the planned number of surgical sessions per week.

Nº weeks/year is the expected number of weeks the operating theatres will operate during the year.

In this case, a schedule of Monday to Thursday from 8-18h and Friday from 8-15h is considered, that is 47h of operating room use.

The number of weeks/year will be 52.

The gross utilisation of the operating theatre will be set at 77%.

This means that the available operating room time is as follows:

$$TAOR = 47 \cdot 52 \cdot 0{,}77 = 1881{,}88h$$

The duration of the procedures (ATI) will be set at an average of 90 min.

The number of operating rooms (ORR) is determined by the following equation:

$$\boldsymbol{ORR = \left(\frac{SIY \cdot ATI}{TAOR}\right) + 2}$$

Where:

$$SIY = PHA \cdot SFI \cdot 0{,}8$$

Where 0,8 refers to the estimated percentage of planned surgeries.

Post-anaesthetic recovery

The operating room and post-anaesthesia recovery stations are identified as the basic healthcare resource of the SU. For the sizing of the post-anaesthesia recovery stations, the standards and recommendations of the Ministry of Health propose an average of one and a half to two stations per operating room.

The time available for post-anaesthesia recovery posts, TDPRPA, shall be calculated as:

$$TDPRPA = n^{\underline{o}} \frac{days}{year} \leftrightarrow n^{\underline{o}} \frac{hours}{day}$$

Where:

No. days/year is the number of days the PARR will operate.

No. hours/day is the number of hours the PARR will operate each day.

Since we do not have the necessary information to make the latter calculation, it will be done considering 1.5 post-anaesthesia recovery posts for each operating theatre, but they will be in a recovery room with a capacity of 18 posts. Therefore, the post-anaesthesia recovery room (PARR) will be calculated and not the posts.

With this:

$$\boldsymbol{PARR = \frac{1{,}5 \cdot ORR}{18}}$$

5.1.1. Resource definition

From the presentation of the necessary spaces made in point 4, together with the calculations made in section 5.1., it is now possible to obtain a list of all the variables, as well as to define how the value of each one of them will be calculated.

In the following, a summary table is presented with the information that is necessary as input for the calculation of each variable.

Table 4. Surgical block calculation inputs

Description	Acronym	Value
Population of the hospital area	PHA	Variable
Surgical frequentation	SFI	Default value 0,082
Scheduled surgery percentage	SSP	80%
Time available in operating rooms	TAOR	1881,88 h
Average time of interventions	ATI	1,5 h
Scheduled interventions per year	SIY	PHA·SFI·0,8

In the following table, the fixed and variable quantities of each of the rooms are defined. If it is a fixed value, it means that in quantity, it will not be different for any case of study, it does not depend on any input. The variable values are related to the inputs, and for these cases the equations that define them are presented.

Table 5. Quantification of surgical blocks rooms

	Acronym	Fixed quantity	Variable quantity
Access, reception and control area			
Lobby entrance and patient transfer	LE	1	
Reception and control	RC	1	
Staff control office	SCO	1	
Information office	IO	1	
Waiting room	WR	1	
Public toilet	PT		ORR / 6
Adapted toilet	AT		(ORR / 6) / 2
Living room for patients with scheduled surgery	LRS	1	
Changing rooms/patient toilets	CRP		ORR / 6
Logistics area			
Changing rooms/staff toilets	CRS		ORR / 3
Personal cleaning wardrobe	PCW	1	
Staff lounge	SL		ORR / 6
Sterile material warehouse	SMW		ORR / 4
Sterilization Substation	SS	1	
Stock footage	SF		ORR / 4
Preparation warehouse	PW	1	
Equipment store	ES		ORR / 4

Cleaning office	CO		ORR / 4
Dirty office	DO		ORR / 4
Work office	WO	1	
Pre-surgical preparation area			
Pre-surgical preparation room	PR	1	
Surgical area			
Hand washing	HW		ORR
Operating room	ORR		$((SIY \cdot ATI)/TAOR)+ 2$
Post-surgical area			
Post anaesthesia recovery room	PARR		$(1,5 \cdot ORR) / 18$
Nursing control	NC	1	
General storehouse	GW	1	
Clean trade	CT	1	
Dirty trade	DT	1	
Equipment store	ESP	1	
Cleaning office	COF	1	

These will be the resources to be declared in Python from the surgical unit, and will be declared as presented in the tables above.

On the other hand, in order to fully define the design, it is necessary to know the surface area of each of the above-mentioned rooms. In order to know what surface area is necessary for each room, given that except for operating theatres there are no regulations in this respect, only recommendations, the functional plan set out in annex 16 of the document *Bloque Quirúrgico*. Standards and recommendations of the Ministry of Health and Social Policy.

Based on the surface areas set out in this annex, the surface areas in square metres of the surgical block shall be declared in Python as follows:

Table 6. Surface area of surgical blocks rooms

	Acronym	Fixed surface	Variable surface
Access, reception and control area			
Lobby entrance and patient transfer	SLE		$4,17 \cdot ORR$
Reception and control	SRC		$0,67 \cdot ORR$
Staff control office	SSCO	12	
Information office	SIO	12	
Waiting room	SWR		$4,17 \cdot ORR$
Public toilet	SPT	6	

Adapted toilet	SAT	5	
Living room for patients with scheduled surgery	SLRS		2,5·ORR
Changing rooms/patient toilets	SCRP	10	
Logistics area			
Changing rooms/staff toilets	SCRS	30	
Personal cleaning wardrobe	SPCW	20	
Staff lounge	SSL	20	
Sterile material warehouse	SSMW	10	
Sterilization Substation	SSS	20	
Stock footage	SSF	10	
Preparation warehouse	SPW	12	
Equipment store	SES	12	
Cleaning office	SCOO	4	
Dirty office	SDO	8	
Work office	SWO	18	
Pre-surgical preparation area			
Pre-surgical preparation room	SPR		10·ORR
Surgical area			
Hand washing	SHW	8	
Operating room	SORR	42	
Post-surgical area			
Post anaesthesia recovery room	SPARR		216·PARR
Nursing control	SNC	18	
General storehouse	SGW	6	
Clean trade	SCT	10	
Dirty trade	SDT	6	
Equipment store	SESP	12	
Cleaning office	SCOF	4	

5.2. The emergency unit

In order to quantify resources, medium-term demand must be estimated and the unit adjusted in quantity and size.

It would be best to calculate demand and peaks from historical data, but as these are not available, the following formulae recommended by the Ministry of Health in its Standards and Recommendations document will be used.

Peak Daily Workload (DPW): is determined according to a Poison distribution, with a 99% confidence interval, and is calculated using the following formula:

$$DPW = DA + 2{,}33 \cdot \sqrt{MPWA}$$

Where MPWA refers to the average daily number of patients seen in the month of peak demand. This is calculated as follows:

$$MDWA = \frac{MPW}{30{,}5}$$

The MPW refers to the monthly peak workload, which represents the maximum number of patients seen in a month. It is approximately 10% of the ED demand.

To separate this value into paediatric and general, it is assumed as a hypothesis that hospital EDs have an age distribution similar to that of Spain, which means 14.5% of patients under 14 years of age.

With all the formulas presented above, the DPW presented in Table 7 can be obtained.

In order to analyse the peak shift and hourly workload in general and paediatric EDs, the following is considered:

- The peak shift workload represents the maximum number of patients in an 8-hour shift. It coincides very roughly with 50% of the DPW, so it can be estimated with this method as follows:

$$PPWS = 0{,}5 \cdot PDPW$$

$$GPWS = 0{,}5 \cdot GDPW$$

Where:

PPWS is the peak paediatric workload per shift.

GPWS is the overall peak workload per shift.

PDPW is the peak daily paediatric workload.

GDPW is the overall peak daily workload.

- Peak hourly workload represents the maximum number of patients in one hour. It is calculated as follows:

$$PPWH = \frac{PPWS}{7}$$

$$GPWH = \frac{GPWS}{7}$$

Where:

PPWH is the peak paediatric workload per hour.

GPWH is the general peak hourly workload.

In order to quantify the number of consultations and boxes needed, the following requirements should be considered:

- General consultations (CH)

$$CH = \frac{GPWH \cdot 0,6 \cdot 20}{60 \cdot 0,85} + 2$$

- Paediatric consultations (CON)

$$CON = \frac{PPWH \cdot 0,6 \cdot 20}{60 \cdot 0,85} + 2$$

- General multipurpose exploration and diagnosis box (ME)

$$ME = \frac{GPWH \cdot 0,6 \cdot 60}{60 \cdot 0,85}$$

- Paediatric multipurpose exploration and diagnosis box (ED)

$$ED = \frac{PPWH \cdot 0,6 \cdot 60}{60 \cdot 0,85}$$

5.2.1. Resource definition

As in section 5.1.1., from the presentation of the necessary spaces made in point 4, together with the calculations made in section 5.2., it is now possible to obtain a list of all the variables, as well as to define how the value of each one of them will be calculated.

In the following, a summary table is presented with the information that is necessary as input for the calculation of each variable.

Table 7. Emergency Unit calculation inputs

Description	Acronym	Value
Population of the hospital area	PHA	Variable
Emergency unit year frequentation	EUF	Default value 0,3856
Population under 14 years	PUY	14,12
Daily peak workload	DPW	PHA·0,3856·0,00424
Paediatric daily peak workload	PDPW	DPW·0,1412
General daily peak workload	GDPW	DPW-PDPW
Paediatric peak workload per shift	PPWS	0,5·PDPW
Paediatric peak workload per hour	PPWH	PPWS / 7
General peak workload per shift	GPWS	0,5·GDPW
General peak workload per hour	GPWH	GPWS / 7

In the following table, the fixed and variable quantities of each of the rooms are defined. If it is a fixed value, it means that in quantity, it will not be different for any case of study, it does not depend on any input. The variable values are related to the inputs, and for these cases the equations that define them are presented.

Table 8. Quantification of emergency unit rooms

	Acronym	Fixed quantity	Variable quantity
Reception			
Lobby	LB	1	
Space for wheelchairs and stretchers	WH	1	
Admission	AD	1	
Triage box	TB	1	
General emergency waiting room	GE	1	
Public toilet	PTH		CH/2
Paediatric emergency waiting room	PEW	1	
Public toilets for paediatric emergencies	PTP		CON / 2
Dispatch of information	DI	1	
Patient care office	PCO	1	
Ambulance room	AR	1	
Urgent attention			
Critical patient resuscitation box	CPR	1	
Consultations	CH		$((GPWH·0{,}6·20) / (60·0{,}85))+2$
Consultation waiting room	CW	1	
Multipurpose exploration and diagnosis box	ME		$((GPWH·0{,}6·60) / (60·0{,}85))$
Special boxes	SB	2	
Trauma box	TBX	4	
Cast room	CR	2	
Treatment room	TR	1	
Patient waiting room	PWR	3	
Patient toilets	PTO	2	
Checkpoint	CP	1	
Assisted shower	ASH	1	
Observation			
Checkpoint	CPH	1	
Observation room	OB	1	
Toilet for patients	TP	2	
Paediatric emergency			
Paediatric checkpoint	CHP	1	
Paediatric consultations	CON		$((PPWH*0{,}6*20)/(60*0{,}85))+2$

	Acronym	Fixed quantity	Variable quantity
Paediatric exploration and diagnosis boxes	ED		((PPWH*0,6*60)/(60*0,85))
Paediatric resuscitation box for critical patients and emergencies	RB	1	
Paediatric observation room	OBS	1	
Paediatric dispatch of information	DIN	1	
Paediatric nursery room	NR	1	
Paediatric toilets for patients	TPP	1	
General supports			
Livingroom for the staff	LS	1	
Cleaning office for pharmacy preparation	COP	1	
Office of meals	OM	1	
Warehouse of expendable material	WE	1	
Clothing store	CS	1	
Equipment store	EST	1	
Traumatology warehouse	TW	1	
Dirty office and waste classification	DOW	1	
Cleaning office	COF	1	

These will be the resources to be declared in Python for the emergency unit, and will be declared as presented in the tables above.

As for the surgical unit, in order to fully define the design, it is necessary to know the surface area of each of the above rooms. In order to determine the surface area required for each room, given that there are no regulations in this regard, but only recommendations, the functional plan set out in annex 5 of the document *Unidad de urgencias hospitalarias. Estándares y recomendaciones* of the Ministry of Health and Social Policy.

Based on the surface areas set out in this annex, the surface areas in square metres of the emergency unit shall be declared in Python as follows:

Table 9. Surface area of emergency unit rooms

	Acronym	Fixed quantity	Variable quantity
Reception			
Lobby	SLB		0,79·(PPWH+GPWH)
Space for wheelchairs and stretchers	SWH	6	
Admission	SAD		0,63·(PPWH+GPWH)
Triage box	STB	24	
General emergency waiting room	SGE		2,5·GPWH
Public toilet	SPTH	12	

Paediatric emergency waiting room	SPEW		4·PPWH
Public toilets for paediatric emergencies	SPTP	6	
Dispatch of information	SDI	12	
Patient care office	SPCO	12	
Ambulance room	SAR	6	
Urgent attention			
Critical patient resuscitation box	SCPR	36	
Consultations	SCH	16	
Consultation waiting room	SCW		0,94·GPWH
Multipurpose exploration and diagnosis box	SME	18	
Special boxes	SSB	16	
Trauma box	STBX	20	
Cast room	SCR	24	
Treatment room	STR	24	
Patient waiting room	SPWR		0,94·GPWH
Patient toilets	SPTO	12	
Checkpoint	SCP	25	
Assisted shower	SASH	10	
Observation			
Checkpoint	SCPH	25	
Observation room	SOB		10·0,75·GPWH
Toilet for patients	STP	4	
Paediatric emergency			
Paediatric checkpoint	SCHP	25	
Paediatric consultations	SCON	16	
Paediatric exploration and diagnosis boxes	SED	16	
Paediatric resuscitation box for critical patients and emergencies	SRB	18	
Paediatric observation room	SOBS	40	
Paediatric dispatch of information	SDIN	12	
Paediatric nursery room	SNR	12	
Paediatric toilets for patients	STPP	4	
General supports			
Livingroom for the staff	SLS	12	
Cleaning office for pharmacy preparation	SCOP	10	
Office of meals	SOM	10	
Warehouse of expendable material	SWE	10	

Clothing store	SCS	8
Equipment store	SEST	6
Traumatology warehouse	STW	6
Dirty office and waste classification	SDOW	6
Cleaning office	SCOF	6

6   Explanation of the code

The recommender code consists of 948 lines, and follows the following structure:

- Surgical Unit
  - Declaration of inputs
  - Declaration of resources
- Emergency Unit
  - Declaration of inputs
  - Declaration of variables that depend on the peak workload and the average.
  - Declaration of resources
- Description of output messages
- Design body

In the following points, it is briefly explain what is written in each point.

Firstly, before separating the code into two blocks, as we want to be able to study the resources on the basis of population or location, we define the default frequency values and give the option of calculation for both location and population:

```
class Resources:
    DEFAULT_SFI = 0.082
    DEFAULT_EUF = 0.3856
    def __init__(self, location, sfi=DEFAULT_SFI, euf=DEFAULT_EUF):
        self.location = location
        self.pha = self.location.population
```

6.1. Surgical Unit

In this first part of the code, the default values and inputs defined in table 4 are defined.

```
# SURGICAL UNIT
        self.sfi = sfi # (Input) Surgical frequentation

        self.taor = 1881.88 # Time available in operating rooms (h)
        self.ati = 1.5 #Average time of interventions (h)
        self.siy = self.pha * self.sfi * 0.8 #Scheduled interventions per year
```

Subsequently, the resources defined in table 5 and the surface area of these resources declared in table 6 are defined.

Both the number of resources and their surface area are required to be whole values, so they will be rounded upwards.

As an example, it is shown how the operating theatres and their surface area have been defined:

```
 # Number of resources
        orr = (( self.siy * self.ati ) / self.taor ) + 2
        self.orr = max(int(round(orr)),1)
# Surface m2
        self.sorr = 42
```

6.2. Emergency Unit

As for the surgical unit, the inputs are first defined, which in this case were presented in table 7. It is worth mentioning that they are defined according to two criteria, according to peak workload calculations or according to average.

```
#EMERGENCY UNIT
        self.euf = euf # (Input) Emergency unit year frequentation

        # for the peak workload calculation
        self.dpw = self.pha * self.euf * 0.00424 #Daily peak workload
        self.pdpw = self.dpw * 0.1412 #Paediatric daily peak workload
        self.gdpw = self.dpw - self.pdpw #General daily peak workload
        self.ppws = 0.5 * self.pdpw #Paediatric peak workload per shift
        self.ppwh = self.ppws / 7 #Paediatric peak workload per hour
        self.gpws = 0.5 * self.gdpw #General peak workload per shift
        self.gpwh = self.gpws / 7 #General peak workload per shift
# for the average calculation
        self.da = ((self.euf * self.pha) / 12) / 30 #Daily average
        self.pda = 0.1412 * self.da #Pediatric daily average
        self.npda = self.da - self.pda #General daily average
        self.ppwsa = 0.5 * self.pda #Pediatric average per shift
        self.ppwha = self.ppwsa / 7 #Pediatric average per hour
        self.gpwsa = 0.5 * self.npda #General average per shift
        self.gpwha = self.gpwsa / 7 #General average per hour
```

With this, the resources and surface area can now be defined. As for the surgical block, the emergency unit will also be rounded up to whole numbers.

```
 # Number of resources
 ch = ((self.gpwh * 0.6 * 20) / (60 * 0.85)) + 2
        self.ch = max(int(round(ch)),1)
 # Surface m2
        slb = 0.79 * (self.ppwh + self.gpwh)
        self.slb = max(int(round(slb)),1)
```

6.3. Output messages

Once all the inputs and variables have been declared, the messages to be displayed on the screen are defined.

In the case of the surgical block, it appears according to the surgical frequency. Some lines of code are shown as an example.

```
def surgical_message(self):
        # print(f'For the Surgical Block')
        print(f'Based on the number of population and surgical frequency,
        the number of rooms required are:')
        print(f'Lobby entrance and patient transfer: {self.le}')


        print(f'The surface in m2 of these rooms are:')
        print(f'Lobby entrance and patient transfer: {self.sle}')
```

In the case of the emergency unit, as mentioned above, the data will be displayed according to peak workload or average workload, so the messages will be differentiated in this way.

For the case of calculation according to peak workload:

```
def emergency_message(self):
        # print(f'For the Emergency Unit')
        print(f'Based on the number of popultion and the emergency unit
 frequentation, the number of rooms required are as listed below.')
        print(f'Calculated for peak workload:')
        print(f'Lobby: {self.lb}')
        print(f'The surface in m2 of these rooms are:')
        print(f'Lobby: {self.slb}')
```

For the case of calculation according to the mean:

```
        print(f'Calculated according to average need for this population
 and frequentation, the number of rooms required are as listed below.')
        print(f'Lobby: {self.lb}')
        print(f'The surface in m2 of these rooms are:')
        print(f'Lobby: {self.slba}')
```

6.4. Design body

As mentioned in previous points, it is interesting to be able to size the hospital according to the population to be served or the locality to which it will have to attend patients. This is proposed because it could be the case that a hospital is going to serve a specific locality or that it is going to serve a group of populations. In the first case, it is designed in such a way that by typing the name of the population, the hospital can obtain the population it can serve from a database. In the second case, it is enough to simply write the value of the population to be served.

To do this, a selector is made that initially asks for the form of calculation:

```
def select():
    choice = input('Select the input of calculation, p=population and
l=location [p/l]: ')
    choice = choice.lower()
    if choice == 'l':
        show_message_from_location()
    elif choice== 'p':
        show_message_from_population()
    else:
        print('Invalid option')
```

In the case of choosing to calculate according to population (option p), it asks us which block we want to dimension, whether the surgical (s) or the emergency (e) block, and it will display the messages shown in point 6.3. :

```
def show_message_from_population():
    population = int(input('population: '))
    choice = input('Select the block to size [s/e]: ')
    choice = choice.lower()
    if choice == 'e':
        euf = float(input(f'Emergency unit frequentation ({Re-
sources.DEFAULT_EUF}): ') or Resources.DEFAULT_EUF)
        rec = Resources.get_from_population(population, euf=euf)
        rec.emergency_message()
    elif choice == 's':
        sfi = float(input(f'Surgical frequentation ({Resources.DE-
FAULT_SFI}): ') or Resources.DEFAULT_SFI)
        rec = Resources.get_from_population(population, sfi=sfi)
        rec.surgical_message()
    else:
        print('Invalid option')
```

If you choose to calculate according to locality (option l) it will load an Excel file in .csv format with the list of Catalan localities and their populations. This list is extracted from the Institut d'Estadística de Catalunya as of December 2022.
It will ask you to enter the name of the locality, and then if you wish to obtain data from the surgical block and the emergency block. Once selected, it will display the messages of point 6.3:

```
def show_message_from_location():
    df = load('data/cat-population.csv')
    name = int(input('Location: '))
    choice = input('Choose the block [s/e]: ')
    choice = choice.lower()
    if choice == 'e':
        euf = float(input(f'Emergency unit frequentation ({Re-
sources.DEFAULT_EUF}): ') or Resources.DEFAULT_EUF)
        rec = Resources.get_from_name(df, name, euf=euf)
        rec.emergency_message()
```

```
elif choice == 's':
    sfi = float(input(f'Surgical frequentation ({Resources.DE-
FAULT_SFI}): ') or Resources.DEFAULT_SFI)
    rec = Resources.get_from_name(df, name, sfi=sfi)
    rec.surgical_message()
else:
    print('Invalid option')
```

7   Results visualisation

To visualise the data, a web viewer is designed using Python to interact with the inputs and obtain the results on screen.

Initially, a design is proposed that allows us to choose which hospital unit we wish to dimension (in the case of this project, surgical unit or emergency unit) and to select how we wish to perform the calculation, whether from the population or from the locality.

With this approach, a local web viewer is designed with the following appearance:
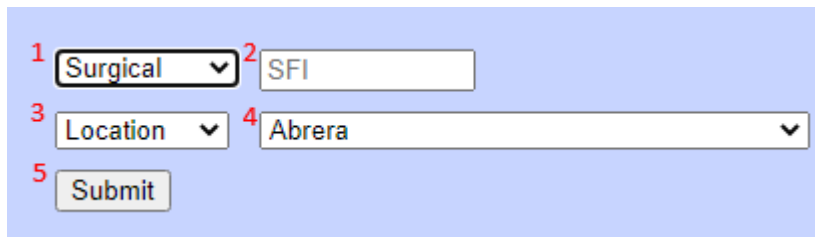
Figure 22. Web display
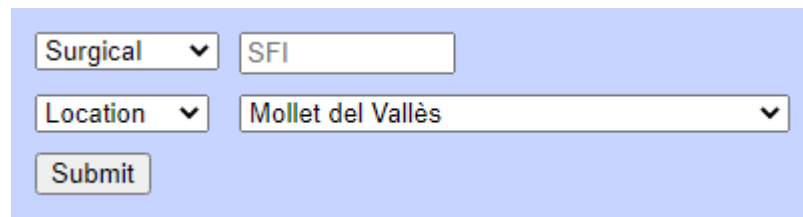
Each field allows for the following:

1. In this drop-down menu it can be chosen the block to be sized, *Surgical* for the surgical unit and *Emergency* for the emergency unit.
2. Field in which to write the surgical or emergency frequentation depending on the unit to be sized. In the case of having selected the surgical unit, it says SFI, which is the acronym for the surgical frequency. If a value is entered above, the calculations will be made according to this frequency, if no value is entered, the default value will appear, 0,082, which corresponds to the number of surgical interventions in Catalonia in 2020, 82,2 per 1000 inhabitants. If the emergency unit is selected, the frequency of the unit (EUF) must be entered. If nothing is entered, the default value, 0,3856, will be used.
3. Drop-down to select whether is wanted to perform the calculation according to locality or according to population.
4. If wished to perform the calculation by locality, select the locality of Catalonia from the drop-down menu. The name can also be typed and it will select the correct name from the list. If it has been selected to calculate by population, enter the population number.
5. Press *Submit* to obtain the results.

To make it more visual, in the case of sizing the surgical unit, the background of the web page screen is blue and in the case of sizing the emergency unit, the background colour of the web page screen is pink.

Once selected what is wanted on the main page, you obtain the results of the number of resources and surface area according to what you want.
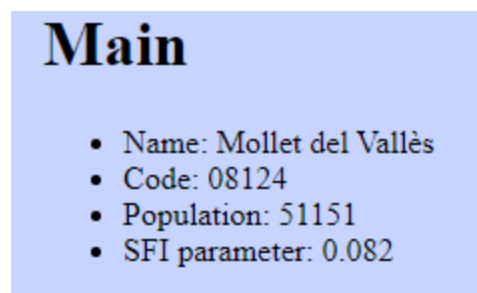
Some possibilities are presented below as examples.

- Dimensioning of a surgical unit for the city of Mollet del Vallès with the default frequency value:

Figure 23. Surgical unit example selector

In this case, the results are obtained as follows:

Figure 24. Calculation data of the surgical unit example

The results are visually divided into two parts, number of rooms and surface area of each:

Rooms
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Based on the number of population and surgical frequency, the **number of rooms** required are:

- Lobby entrance and patient transfer: 1
- Reception and control: 1
- Staff control office: 1
- Information office: 1
- Waiting room: 1
- Public toilet: 1
- Adapted toilet: 1
- Living room for patients with scheduled surgery: 1
- Changing rooms/patient toilets: 1
- Changing rooms/staff toilets: 2
- Personal cleaning wardrobe: 1
- Staff lounge: 1
- Sterile material warehouse: 1
- Sterilization Substation: 1
- Stock footage: 1
- Preparation warehouse: 1
- Equipment store: 1
- Cleaning office: 1
- Dirty office: 1
- Work office: 1
- Pre-surgical preparation room: 1
- Hand washing: 5
- Operting room: 5
- Post anaesthesia recovery room: 1
- Nursing control: 1
- General storehouse: 1
- Clean trade: 1
- Dirty trade: 1
- Equipment store: 1
- Cleaning office: 1

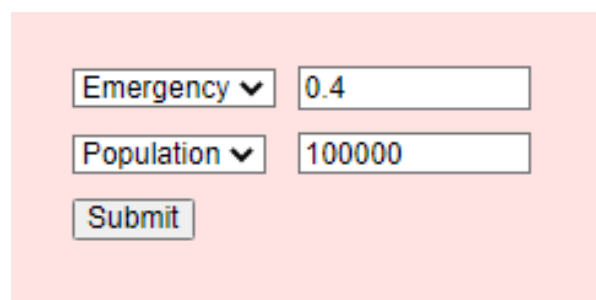*Figure 25. Number of rooms of the surgical unit example*

Surface

The **surface in m2** of these rooms are:

- Lobby entrance and patient transfer: 21
- Reception and control: 3
- Staff control office: 12
- Information office: 12
- Waiting room: 21
- Public toilet: 6
- Adapted toilet: 5
- Living room for patients with scheduled surgery: 12
- Changing rooms/patient toilets: 10
- Changing rooms/staff toilets: 30
- Personal cleaning wardrobe: 20
- Staff lounge: 20
- Sterile material warehouse: 10
- Sterilization Substation: 20
- Stock footage: 10
- Preparation warehouse: 12
- Equipment store: 12
- Cleaning office: 4
- Dirty office: 8
- Work office: 18
- Pre-surgical preparation room: 50
- Hand washing: 8
- Operting room: 42
- Post anaesthesia recovery room: 216
- Nursing control: 18
- General storehouse: 6
- Clean trade: 10
- Dirty trade: 6
- Equipment store: 12
- Cleaning office: 4
- The total useful surface is: 868

Figure 26. Surface of the surgical unit example

- Dimensioning of an emergency unit for 100.000 inhabitants with a frequency of 0,4:

Figure 27. Emergency unit example selector

In this case, the results are obtained as follows:

Main

- Name: Custom Location
- Code: ---
- Population: 100000
- EUF parameter: 0.4

Figure 28. Calculation data of the surgical unit example

As in the surgical unit, the results are visually divided into two parts, number of rooms and surface area of each:

Rooms

Based on the number of population and the emergency unit frequentation, the **number of rooms** required are as listed below (calculated for peak workload):

- Lobby: 1
- Space for wheelchairs and stretchers: 1
- Admission: 1
- Triage box: 1
- General emergency waiting room: 1
- Public toilets: 2
- Paediatric emergency waiting room: 1
- Public toilets for paediatric emergencies: 1
- Dispatch of information: 1
- Patient care office: 1
- Ambulance room: 1
- Critical patient resuscitation box: 1
- Consultations: 4
- Consultation waiting room: 1
- Multipurpose exploration and diagnosis box: 7
- Cleaning office for pharmacy preparation: 1
- Office of meals: 1
- Warehouse of expendable material: 1
- Clothing store: 1
- Equipment store: 1
- Traumatology warehouse: 1
- Dirty office and waste classification: 1
- Cleaning office: 1

Figure 29. Number of rooms of the emergency unit example

- Special boxes: 2
- Trauma box: 4
- Cast room: 2
- Treatment room: 1
- Patient waiting room: 3
- Patient toilets: 2
- Checkpoint: 1
- Assisted shower: 1
- Observation checkpoint: 1
- Observation room: 1
- Toilet for patients: 2
- Paediatric checkpoint: 1
- Paediatric consultations: 2
- Paediatric exploration and diagnosis boxes: 1
- Paediatric resuscitation box for critical patients and emergencies: 1
- Paediatric observation room: 1
- Paediatric dispatch of information: 1
- Paediatric nursery room: 1
- Paediatric toilets for patients: 1
- Livingroom for the staff: 1

Figure 30. Number of rooms of the emergency unit example (Part 2)

Surface

The **surface in m2** of these rooms are:

- Lobby: 10
- Space for wheelchairs and stretchers: 6
- Admission: 8
- Triage box: 24
- General emergency waiting room: 26
- Public toilets: 12
- Paediatric emergency waiting room: 7
- Public toilets for paediatric emergencies: 6
- Dispatch of information: 12
- Patient care office: 12
- Ambulance room: 6
- Critical patient resuscitation box: 36
- Consultations: 16
- Consultation waiting room: 10
- Multipurpose exploration and diagnosis box: 18
- Special boxes: 16
- Cast room: 24
- Treatment room: 24
- Patient waiting room: 10
- Patient toilets: 12
- Checkpoint: 25
- Assisted shower: 10
- Observation checkpoint: 25
- Observation room: 78

Figure 31. Surface of the emergency unit example

- Toilet for patients: 4
- Paediatric checkpoint: 25
- Paediatric consultations: 16
- Paediatric exploration and diagnosis boxes: 16
- Paediatric resuscitation box for critical patients and emergencies: 18
- Paediatric observation room: 40
- Paediatric dispatch of information: 12
- Paediatric nursery room: 12
- Paediatric toilets for patients: 4
- Livingroom for the staff: 12
- Cleaning office for pharmacy preparation: 10
- Office of meals: 10
- Warehouse of expendable material: 10
- Clothing store: 8
- Equipment store: 6
- Traumatology warehouse: 6
- Dirty office and waste classification: 6
- Cleaning office: 6
- The total useful surface is: 994

Figure 32. Surface of the emergency unit example (Part 2)

In order to make the reading of data by locality more dynamic and to be able to compare results, a map version is made in which results can be visualised.

The limitations of this web visualisation are the same as for the previous type of visualisation, only Catalonia.

In this case, there is a dynamic map with the populations of Catalonia, a drop-down menu where you can select which hospital unit you want to dimension and the desired frequency. In the case of not setting anything, the default value is the same as for the previously presented visualizer, as the calculation formula is identical, the only thing that changes is the way in which the results are presented.

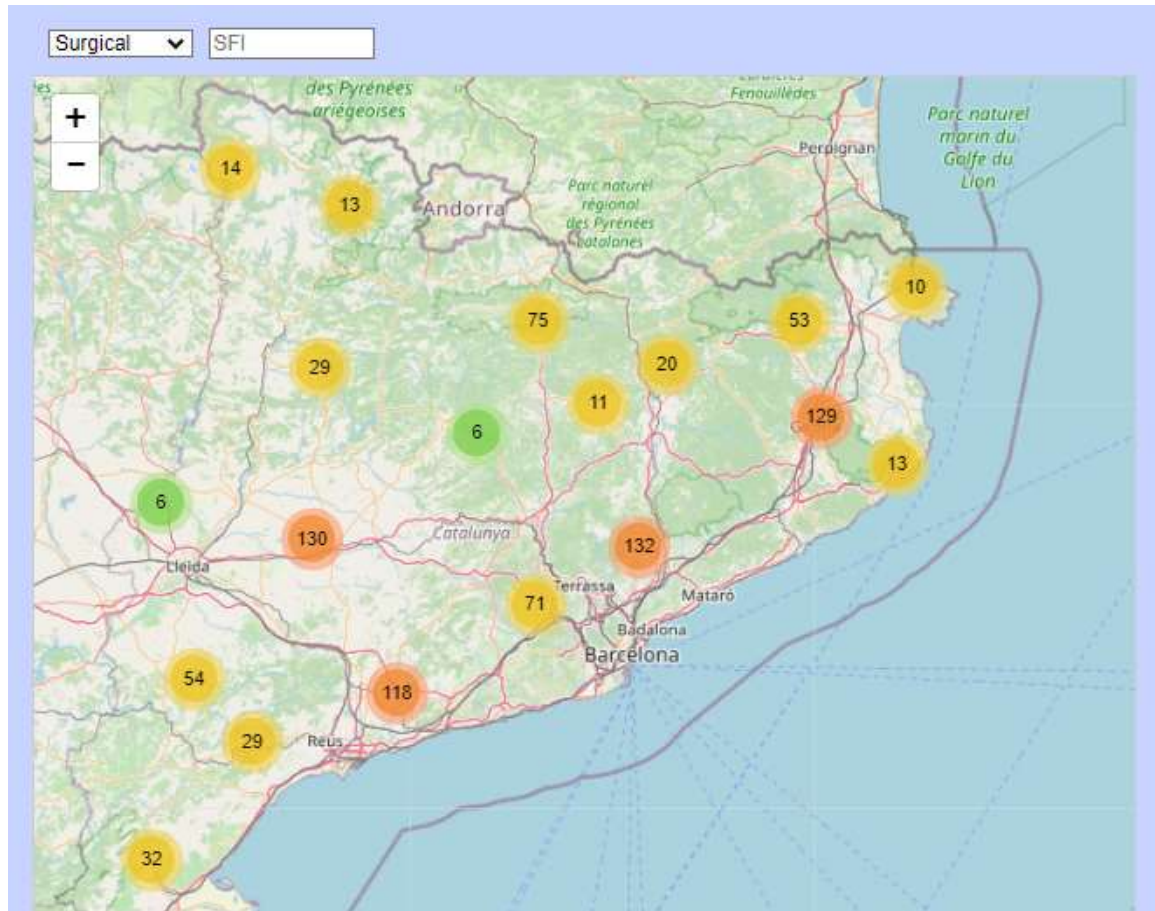The initial presentation is as follows:

Figure 33. Map display

To search for a town, zoom in on the map until the desired town appears.

An example is shown below, which would consist of the sizing of the surgical unit with the default frequency in the town of La Garriga. In order not to reprint the entire list, only a few rooms are shown.
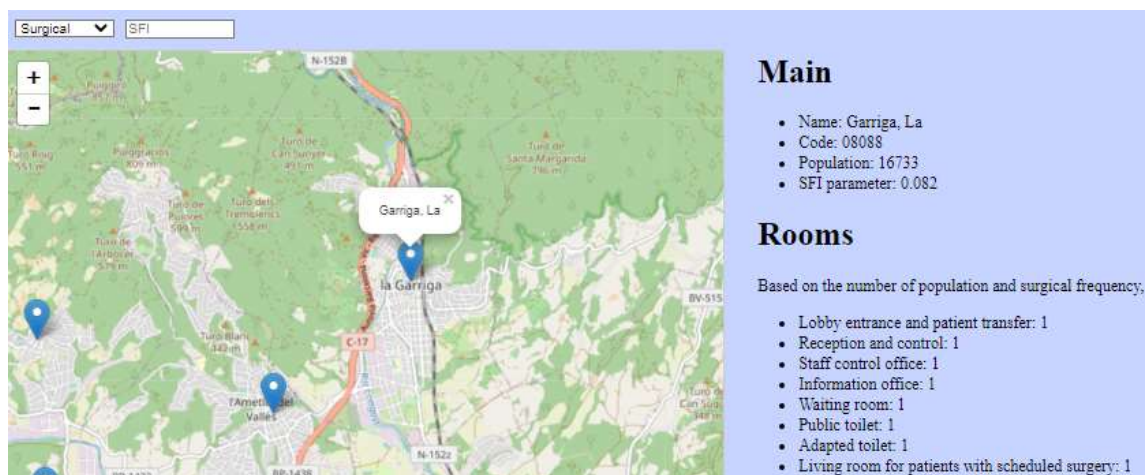

Figure 34. Surgical unit map example

In the case of selecting the emergency unit, the rooms required for that unit are displayed. The background of the page is in pink, in order to follow the criteria presented above.

Figure 35. Emergency unit map example

In figure 35, as in figure 34, the need is calculated for the population of La Garriga, but in this case for the emergency unit. Identically to the previous example, in this case only a few lines are shown to not repeat them.

8 BIM design

8.1. Definition of coordinates

First of all, in order to be able to place the location of each block on a plan, it is necessary to know the dimensions of each room. As the recommender already designed provides the surface area in m^2 of each room according to the variables already presented, one of the two coordinate values will be set, in this case the y-coordinate (width), and the x-coordinate (length) will be variable.

All rooms are supposed to be rectangular.

For the surgical unit, the coordinates of each room shall be defined as follows:

Table 10. Coordinates of surgical blocks rooms

	Acronym y	Dimension (m)	Acronym x	Dimension (m)
Access, reception and control area				
Lobby entrance and patient transfer	SLEY	5	SLEX	SLE/SLEY
Reception and control	SRCY	2	SRCX	SRC/SRCY
Staff control office	SSCOY	2,5	SSCOX	SSCO/SSCOY
Information office	SIOY	2,5	SIOX	SIO/SIOY
Waiting room	SWRY	6	SWRX	SWR/SWRY
Public toilet	SPTY	1,7	SPTX	SPT/SPTY
Adapted toilet	SATY	2	SATX	SAT/SATY

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Living room for patients with scheduled surgery	SLRSY	4	SLRSX	SLRS/SLRSY
Changing rooms/patient toilets	SCRPY	2,5	SCRPX	SCRP/SCRPY
Logistics area				
Changing rooms/staff toilets	SCRSY	4	SCRSX	SCRS/SCRSY
Personal cleaning wardrobe	SPCWY	5,7	SPCWX	SPCW/SPCWY
Staff lounge	SSLY	3,5	SSLX	SSL/SSLY
Sterile material warehouse	SSMWY	2,5	SSMWX	SSMW/SSMWY
Sterilization Substation	SSSY	3	SSSX	SSS/SSSY
Stock footage	SSFY	2,5	SSFX	SSF/SSFY
Preparation warehouse	SPWY	2,5	SPWX	SPW/SPWY
Equipment store	SESY	2	SESX	SES/SESY
Cleaning office	SCOOY	2	SCOOX	SCOO/SCOOY
Dirty office	SDOY	2	SDOX	SDO/SDOY
Work office	SWOY	3	SWOX	SWO/SWOY
Pre-surgical preparation area				
Pre-surgical preparation room	SPRY	8	SPRX	SPR/SPRY
Surgical area				
Hand washing	SHWY	1,1	SHWX	SHW/SHWY
Operating room	SORRY	6	SORRX	SORR/SORRY
Post-surgical area				
Post anaesthesia recovery room	SPARRY	10	SPARRX	SPARR/SPARRY
Nursing control	SNCY	2	SNCX	SNC/SNCY
General storehouse	SGWY	2	SGWX	SGW/SGWY
Clean trade	SCTY	2	SCTX	SCT/SCTY
Dirty trade	SDTY	2	SDTX	SDT/SDTY
Equipment store	SESPY	2	SESPX	SESP/SESPY
Cleaning office	SCOFY	1,5	SCOFX	SCOF/SCOFY

For the emergency unit, the coordinates of each room shall be defined as follows:

Table 11. Coordinates of emergency unit rooms

	Acronym y	Dimension (m)	Acronym x	Dimension (m)
Reception				
Lobby	SLBY	5	SLBX	SLB/SLBY
Space for wheelchairs and stretchers	SWHY	1,7	SWHX	SWH/SHWY

Admission	SADY	4	SADX	SAD/SADY
Triage box	STBBY	3,5	STBBX	STB/STBBY
General emergency waiting room	SGEY	6,5	SGEX	SGE/SGEY
Public toilet	SPTHY	2	SPTHX	SPTH/SPTHY
Paediatric emergency waiting room	SPEWY	4	SPEWX	SPEW/SPEWY
Public toilets for paediatric emergencies	SPTPY	3,5	SPTPX	SPTP/SPTPY
Dispatch of information	SDIY	2,5	SDIX	SDI/SDIY
Patient care office	SPCOY	2,5	SPCOX	SPCO/SPCOY
Ambulance room	SARY	2	SARX	SAR/SARY
Urgent attention				
Critical patient resuscitation box	SCPRY	4,5	SCPRX	SCPR/SCPRY
Consultations	SCHY	3	SCHX	SCH/SCHY
Consultation waiting room	SCWY	4	SCWX	SCW/SCWY
Multipurpose exploration and diagnosis box	SMEY	3	SMEX	SME/SMEY
Special boxes	SSBY	3	SSBX	SSB/SSBY
Trauma box	STBXY	3	STBXX	STBX/STBXY
Cast room	SCRY	3,5	SCRX	SCR/SCRY
Treatment room	STRY	3,5	STRX	STR/STRY
Patient waiting room	SPWRY	4	SPWRX	SPWR/SPWRY
Patient toilets	SPTOY	2	SPTOX	SPTO/SPTOY
Checkpoint	SCPY	3,5	SCPX	SCP/SCPY
Assisted shower	SASHY	3	SASHX	SASH/SASHY
Observation				
Checkpoint	SCPHY	3,5	SCPHX	SCPH/SCPHY
Observation room	SOBY	10	SOBX	SOB/SOBY
Toilet for patients	STPY	1,5	STPX	STP/STPY
Paediatric emergency				
Paediatric checkpoint	SCHPY	3,5	SCHPX	SCHP/SCHPY
Paediatric consultations	SCONY	3	SCONX	SCON/SCONY
Paediatric exploration and diagnosis boxes	SEDY	3	SEDX	SED/SEDY
Paediatric resuscitation box for critical patients and emergencies	SRBY	3	SRBY	SRB/SRBY
Paediatric observation room	SOBSY	5	SOBSX	SOBS/SOBSY
Paediatric dispatch of information	SDINY	2,5	SDINX	SDIN/SDINY

Paediatric nursery room	SNRY	2,5	SNRX	SNR/SNRY
Paediatric toilets for patients	STPPY	1,5	STPPX	STPP/STPPY
General supports				
Livingroom for the staff	SLSY	3	SLSX	SLS/SLSY
Cleaning office for pharmacy preparation	SCOPY	2,5	SCOPX	SCOP/SCOPY
Office of meals	SOMY	2,5	SOMX	SOM/SOMY
Warehouse of expendable material	SWEY	2	SWEX	SWE/SWEY
Clothing store	SCSY	2	SCSX	SCS/SCSY
Equipment store	SESTY	2	SESTX	SEST/SESTY
Traumatology warehouse	STWY	2	STWX	STW/STWY
Dirty office and waste classification	SDOWY	2	SDOWX	SDOW/SDOWY
Cleaning office	SCOFEY	2	SCOFEX	SCOFE/SCOFEY

After dimensioning the necessary rooms according to the inputs, it is necessary to establish coordinates that allow each of the rooms to be plotted on the plan without overlapping one on top of the other.

Given the complexity of the point, in order not to make the project too extensive, the proposed coordinates of the surgical unit are presented in the Annexes document. These coordinates have been defined following all the criteria and recommendations for each room that have been presented in this project.

To facilitate the movement of patients through the unit without them, or their relatives, passing through restricted areas, a design has been established in which the operating rooms are in the centre. The logistical areas are located next to the operating rooms, with access to each through the hand-washing rooms, thus preventing any patient or family member from accessing them.

The pre-surgical and post-surgical areas are located next to the other access to the operating rooms, with the pre-surgical area adjacent to the access, reception and control area. The following is a basic outline of the proposed layout of the areas.
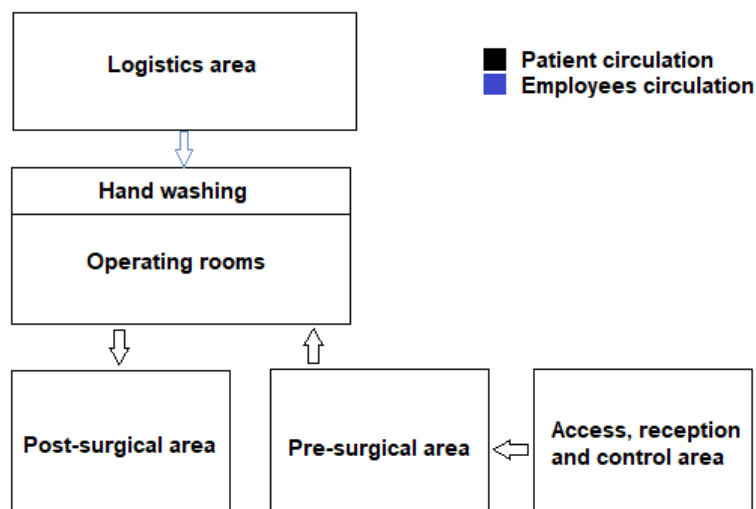

Figure 36 Distribution model for the surgical unit

Once the coordinates have been established, you can then dump the recommender to Dynamo in Revit.

As the code is written, you can choose which unit to size, the surgical unit or the emergency unit, as well as whether you want to obtain the results by entering the town or the name of the locality.
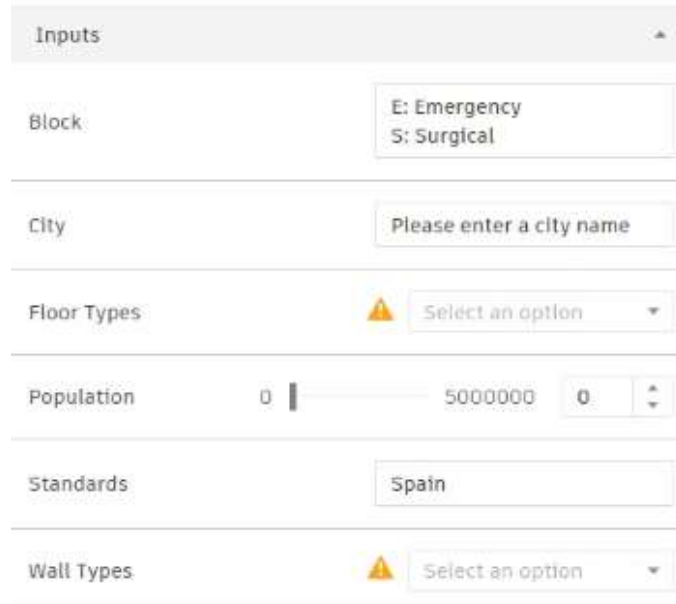

Figure 37 Inputs in Dynamo

If we take the surgical unit as an example, if we set the population at 120000 inhabitants and choose a floor and walls, we get the design proposal. In this case, some rooms of each area have been plotted, not all of them, in order to adapt the project to the amount of time required.
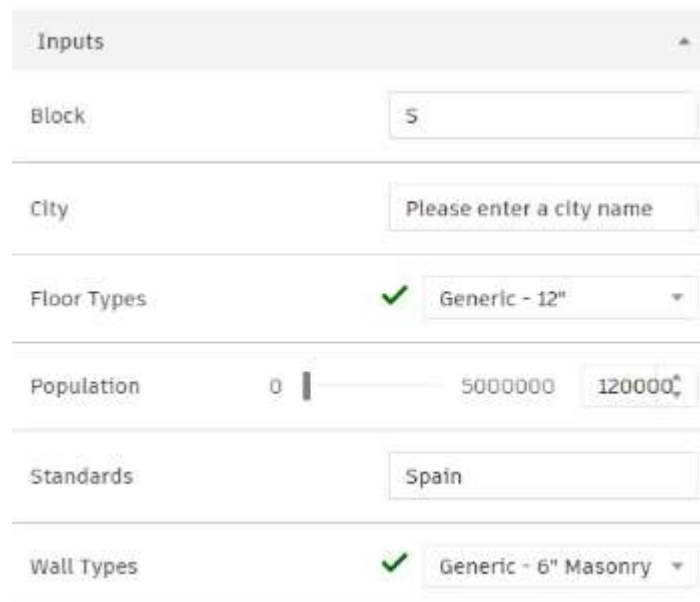

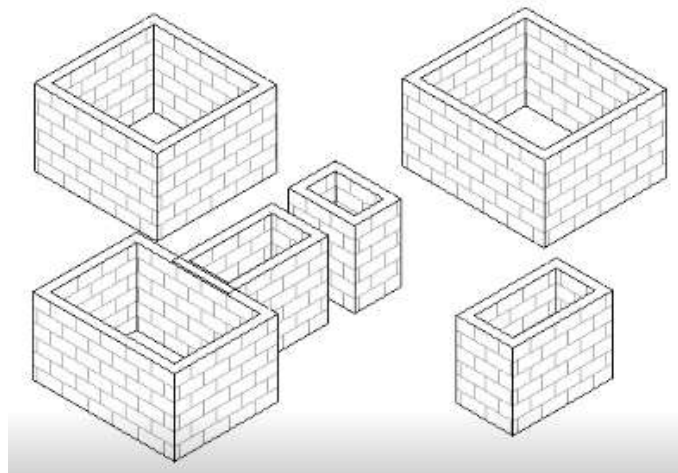*Figure 38 Surgical unit in Dynamo per number of inhabitants*

Figure 39 Example of surgical unit areas

If we select it by the name of the locality and select again the typology of walls and floor, we also obtain the model of the areas of the surgical block.

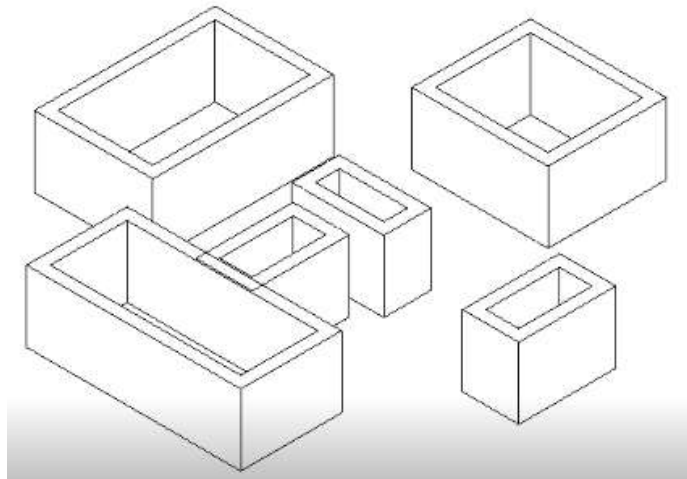*Figure 40 Surgical unit in Dynamo per name of the locality*

Figure 41 Example of surgical unit areas by location

9   Continuity plan

This project is extensive, but the overall hospital project is even more so. Given that this project has worked with the surgical and the emergency unit of a hospital, the study and sizing of the rest of the hospital units, listed in point 4 of this report, should continue to be carried out.

Once this study and sizing has been carried out, they can be integrated into the same code used in this project for the subsequent design proposal in BIM, after defining the coordinates of each of the new units.

Once the BIM design proposal has been made for the entire hospital based on the defined inputs, the necessary material for each room could be studied, a database could be created and the recommender could also list the necessary equipment and material. In this way, any new unit could be fully dimensioned and have an equipment plan automatically.

Another point of continuation would be to link the BIM design to the design of other facilities, such as electrical, water or fire protection, among others.

Once all these points have been reached, an automatic recommender could be obtained, which would be very useful for the creation and improvement of new hospital centres.

10 Budget summary

The detailed budget is in the *Budget* document and amounts to 11.550 €

11 Analysis and assessment social implications

11.1. Project scope

The aim of the project is to create a recommender that allows the sizing of the surgical and the emergency unit of a hospital according to the inputs studied, for subsequent design in BIM. The study does not contemplate the construction or the furniture or equipment that each room may have, and is designed according to the standards and recommendations of the Ministry of Health, that is why it is not the environmental implications that will be studied, but the social implications.

11.2. Social implications

Every country in the world is exposed to different social and environmental factors that can affect the physical and psychological health of any citizen. These factors are different depending on the geographical location of the country, so hospitals cannot be expected to be identical everywhere. This project studies the relationships between the different rooms in the surgical and emergency blocks according to both frequency of use. This frequentation is variable in the different Spanish communities, so it will also be variable in different parts of the world. The project allows the establishment of a model that can be extended to different countries, thus facilitating and improving the sizing of hospitals and even extending it to other types of health facilities in the future.

The implications of this project are positive, as in the end it quickly proposes a model that will be viable and suitable for the location of the hospital, thus facilitating studies and subsequent construction.

12 Conclusions

The objective of this project was to carry out the conceptual design of a hospital in BIM. To do this, it was necessary to study the hospital's care units, their relationship with each other and the rooms that were part of each one. Carrying out this part, it was observed that a hospital is made up of many care units, and that they have many wards, so studying the relationship between them was going to require a lot of study time. For this reason, the project was limited to two care units that could be related to each other: the surgical unit and the emergency unit.

The standards and recommendations of the Ministry of Health were studied for both units, and the relationships between them were established based on the statistical data on surgical and emergency frequentation, published on the Ministry's website. In order to limit the work, the populations were reduced to those belonging to Catalonia.

With this information, it was created an algorithm that determines the number of rooms and the dimensions of each in relation to the inputs. These inputs were the number of inhabitants to be treated at the hospital location and the frequentation. It was considered more useful for the user to choose whether the recommender would calculate the results using the number of inhabitants or the name of the locality, as well as giving the option to modify the frequentation manually.

In order to visualise these results correctly and to be able to work better with them, a web environment was created, in which these data could be obtained. Finally, a physical situation of each room for the surgical unit and its results in BIM were proposed.

This project has been completed satisfactorily, achieving the objective set despite the constraints imposed in order to respect the time required.

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