

Article

Design and Implementation of Adaptable Self-Protection Plans for Public Buildings: A Nursing Home Case in Spain

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Featured Application: Model for designing and implementing self-protection plans for public buildings. Adaptability of self-protection plans for elderly residences.

Abstract: COVID-19 is reflecting the importance of self-protection plans in nursing homes, especially when it concerns persons of older age. Self-protection plans intend to prevent and control the risks of residential buildings. The goal of this research is to develop a design process for self-protection plans of public buildings, and specifically a nursing home. In this regard, it is key for the viability of the nursing home operations to be capable of adapting to any potential future event. Starting from some initial hypotheses that establish the need for adaptability, a self-protection plan model is developed for public buildings based on a new approach consisting of four elements and three steps. It was applied to an elderly residence which is currently under construction. The methodology followed has consisted of a process by stages, to design and implement a novel self-protection plan for public buildings. Subsequently, it has been applied to the specific case study, using the most common tools and applications available for later analysis of the result obtained with the starting hypotheses. The results show how the research allows an increase in the adaptability of self-protection plans for any publicly owned building, although there is an extensive and precise subsequent work of adaptation to specific cases considering the different legal frameworks which makes the work challenging. Finally, the research on adaptability and its application for elderly residences enabled the derivation of recommendations regarding self-protection plans in general and specifically in homes for the elderly.

Keywords: occupational health and safety; risk assessment; public building; self-protection plan; adaptability elements; case study



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1. Introduction

Self-protection plans arise with the purpose of protecting people and property through the design, implementation, and maintenance of these plans for the different public or private buildings in which their application is necessary. The challenge in this matter has been severely exposed globally by the COVID-19 crisis, in which residences and especially the elderly, were strongly impacted. The relevance of this paper is derived from this fact. Adaptability to overcome unexpected situations such as COVID-19 is fundamental for the safety and life quality of people. Thus, it is key to reduce the risks generated by internal and external factors for the future by securing the viability of the public buildings' operations for users and employees, the building, and installations within it, as well as for the related building environment.

In this context, the self-protection measures consist of a set of rules to be adopted during the lifetime of buildings. The self-protection measures foresee preventive measures, actions in case of an emergency, safety records, training and awareness on fire safety and

evacuation exercises [1]. As reported in the literature, issues related to security cannot be limited to a mere list of rules, protocols, and administrative prescriptions [2]. It should be linked to the organizational culture by promoting a preventive culture that provides solutions to existing security problems. For this reason, self-protection plans must serve for two purposes. First, as an essential tool in complying with civil protection regulations, and secondly, as tools to promote prevention and action guidelines in case of emergency [2]. Hospitals are, among public buildings, those which generate more doubts when implementing self-protection plans due to the specific nature of the occupants: both, hospitalized patients who are incapable of auto-evacuation, accompanied outpatients and hospital staff. Therefore, there is a need for a global plan which accommodates current regulations, risk management and experience in the field [3].

A high degree of unpreparedness of both countries and citizens for disasters, has been evidenced. The latest fire prevention and extinguishing devices can be installed in a building. However, suppose occupants ignore the warning signals, have no technical knowledge, etc. In that case, even the latest technology will not be helpful or valuable in fire situations. The elderly is most at risk due to poor mobility, rapid fatigue, confusion, impaired vision, or hearing [4].

The environment for healthcare emergencies is also continually changing. Indeed, during 2010–2011, changes to healthcare emergency planning arrangements in England, and uncertainty about their exact nature and timing, and the level of commitment to emergency planning, were of great concern. Effective national health systems and health service coverage depend on the availability, accessibility, acceptability, and quality of health workers. The COVID-19 pandemic highlighted that responding to acute and chronic health needs from disasters and emergencies could result in significant infrastructure and service disruption, even in well-established health systems. Therefore, in order for a country to establish, or scale up health workforce quality and availability during emergencies, there is a strong need for national governments to develop or revise the national health and multisectoral plans and health workforce strategies [5].

The U.K. research studies typically indicated shortfalls in the emergency preparedness of health-care services [6]. There are differences between the U.K. and U.S. contexts. Among other things, the United States has a greater incidence of extreme weather and a more complex legal situation, with both federal and state laws. Nevertheless, many of the research gaps identified by previous U.S. focused scoping studies are also relevant to the U.K. [6]. Although numerous researchers have recognized the pivotal role of resilient hospitals in a disaster response, there has been little research devoted to the vulnerability of hospitals to providing reliable healthcare services to the community during disasters [7]. Moreover, the lack of access to emergency and surgical care in developing countries has been identified as a critical gap in the development of health systems. While human resource challenges receive most attention from governments, efforts to address these should be implemented in tandem with systems-level changes like investment in facilities, establishment of quality systems and determination of processes of care [8].

The novelty of this research paper is the methodology, based on a new approach for developing self-protection plans, the 4-Elements-Model (the 4M) for adaptable self-protection plans, as it considers the users, the activities, the inventory of objects, as well as the human resources working in a given building. The approach was applied in a Spanish case study as an implementation example using the methodology. This paper attempts to show how the generic model can be applied and how the specific factors such as the region-related regulation are important elements when designing a self-protection plan. The criteria considered in the paper depends on the one side, a general methodological approach, the 4EM, and on the other side a specific approach for any given object intending to develop a self-protection plan. This specific approach is highly dependent on the region-related regulation. Given that the goal of this research is to develop a design process for self-protection plans for public buildings, and specifically a nursing home, it is of great interest for the technician to start from the study of the development throughout the time

that this type of center has existed. In this context, according to Pía (1992), the origin of residences in Spain stem from the need to provide society with institutions that fulfill the functions of sheltering, guarding, or reclusing certain individuals with different purposes, among which we could find relief, prevention, cure, or punishment, all for the sake of social welfare [9]. These institutions at first initiated from religious charity. Then, after the advent of the industrial revolution, a process of sensitization of society and an interest in social welfare developed, maintained by the state, or by related public administrations. These institutions did not begin a criterion of medicalization until World War II (WWII) was over. These homes for the indigent elderly are the germ that evolves in the current residences for the elderly, which are directed and attended by personnel who may be religious, or belong to Public or Private Administrations [9].

According to Elizari, Furiel and Aizpiru (1997), in the 1970s there was a turning point when residences for retired people were created in Spain, supported by Social Security funds [10]. With this, article 41 of the Spanish Constitution (CE) is applied, which indicates “the public powers will maintain a public Social Security regime for all citizens, which guarantees assistance and sufficient social benefits in situations of need. . . .” [11], through the creation of the National Institute of Social Services in 1978 and the process of transfers to the Autonomous Communities (CCAA) [12]. At present, and according to the Basic Model of Care in Residences for the Elderly of the Ministry of Health and Social Welfare of Castilla la Mancha (2012), residences have evolved to “a model aimed at meeting the new needs of older people, offering comprehensive care with professional criteria and understanding of the person and the social environment in which they reside” [13]. It is also necessary to indicate that home-type accommodation currently coexists with residences, although the majority alternative to the home is the residence [14].

The Higher Center for Scientific Research (CSIC) publishes, through the Ministry of Economy and Competitiveness (2021), statistics on the evolution of the number of places and centers in the last 10 years. From its analysis, a non-linear growth in places and total centers is observed, with a point of decrease in 2013 [15]. Despite the fluctuations in the economy on the national or international scene, the future of nursing homes in Spain indicates that they will have an increasing weight in the social order, fundamentally since it is estimated that in the next 40 years, the group of citizens over 65 years of age will double from 7.6 million in 2010 to a level close to 15.3 million, which means almost 32% of the Spanish population [14]. Due to the clear increase in the population in most of the Spanish territory and the increase in life expectancy, the growing need for and importance of nursing homes in the current and future social order is becoming more evident. Given the specialization of the attention and care of the residents, and the varied types of activities that are carried out in them, it is a challenge for the preventive technicians to be able to develop self-protection plans adapted to these centers and that can comply with the criteria established in current and future regulations.

Carrying out a self-Protection plan is presented as a mandatory procedure for certain work centers according to self-protection law in the Spanish regulations, among which are public buildings with residence functions for the elderly. Another point to consider is that the self-protection plans are governed by national regulation, but since the CCAA are assigned with certain powers, there may be differences or peculiarities in the requirements depending on the area where it is located the work center. For this reason, it is of great interest to develop generic guidelines to assist technicians that can follow it to obtain a self-protection plan valid for the entire Spanish territory and for the most common activities that take place in any public building. Starting from the characteristics of a public building and the risk-generating activities, the specific case of application is a residence for the elderly, considering its constitutive, functional, and environmental characteristics. For this, the study can focus on the hypotheses that the Self-Protection Plan applied to a residence for the elderly varies very little from that focused on another use of public ownership, and that a model to design a plan for a public residence can be applied without great variation, to other uses of public buildings.

2. Background, Methodology, and Materials

2.1. Scope and Fundamental Definitions

To define what a building for public use consists of, one can go to the current applicable regulations. Among the current legal texts in Spain, the Technical Building Code (CTE) [16] distinguishes different uses for a building, such as administrative, parking, commercial, educational, hospital, public attendance, public residential and residential housing or private. As can be seen within these uses, there is great versatility among those that could be defined as public or open to the public, especially considering that there are other types of buildings that could be added to this classification, such as religious, transport infrastructures or sports facilities.

Another legal text that defines what a building for public use is Decree 158/1997, of the Accessibility Code in Castilla-La Mancha [17], where buildings for public use are considered as independent architectural units, whose exterior and interior spaces and dependencies are entirely for collective use or public attendance or constitute a work center. It is also considered a building for public use even if it has dependencies for private use or housing for functions such as surveillance or maintenance of the building. Establishments for public use are located inside buildings or facilities, whether public or private, for commercial, administrative, cultural, sports, work centers, entertainment, or meeting venues, etc. Law 8/1997, of June 18, on the Promotion of Accessibility in Extremadura [18]. The law includes an extensive list with the types of public utility buildings such as: public and services of the Public Administrations; health and care centers; rail and bus service stations; airports and heliports; educational centers, garages and collective parking lots; libraries, museums and exhibition halls; theaters, movie theaters and shows; recreational sports facilities and campsites; large commercial surfaces; religious centers, hotel facilities; bars and restaurants; banking establishments; work centers; union centers; business centers. Within these uses, buildings for public use must comply with the functions that are established for service to citizens, without forgetting that the adjoining border areas that are established to give them access or auxiliary services are also part of them. Within the cluster of public buildings, elderly residences are included. In this context, according to a report by the Institute for the Elderly and Social Services (IMSERSO), residential accommodation for people in situations of dependency can be classified according to the following criteria [19]:

- Ownership: centers can be publicly or privately owned.
- Type of center: aimed at people who require assistance for their daily life (assisted) or not (valid), or both types of users (mixed centers).
- Type of accommodation: supervised housing, apartment blocks, residential complexes, residences, socio-sanitary and psychogeriatric.
- Number of places: classified into 3 categories: less than 50 places, between 50 and 100 places and those that have more than 100 places.
- Minimum price per place: 5 categories depending on the price charged by the institution (price per month): less than 400 euros, between 400 and 800 euros, from 800 to 1200 euros, from 1200 to 1600 euros and more than 1600 euros.

2.2. Methodology and Materials

Once the objective of the use of the public building has been established, the self-protection plan must set as the first objective, to comply with the requirements of the Law on Prevention of Occupational Risks to the employer. These obligations include analyzing possible emergency situations, adopting the necessary first aid, firefighting, or evacuation measures, appointing responsible personnel and periodically checking their operation or coordinating with external services in relation to with first aid, emergency medical assistance, rescue, or firefighting. For this, the Self-Protection Plan must establish the organic and functional framework planned for the building, in order to prevent and control the risks to people and property and provide an adequate response to possible emergency situations, in the area under the responsibility of the owner of the activity, guaranteeing the integration of these actions with the public civil protection system. For this purpose,

this research deals with the identification and evaluation of risks, actions, and measures necessary for the prevention and control of risks, as well as the protection measures and other actions to be taken in the event of an emergency.

The legal framework must comply with Spanish regulations regarding the Self-Protection Plan for a generic building for public use and therefore must be structured in accordance with the provisions of Annex II of the Basic Self-Protection Standard (NBA) [20]. Considering this, and adding other aspects pursuing a greater adaptability, the steps followed are shown in Figure 1, such as the literature review, that includes the search of articles, documents, etc. based on keyword searches: “self-protection plans” alone and with other keywords “challenges”, “regulations”, “conceptual models”, “public buildings”, “COVID-19”, “elderly residences”, “nursing homes”:

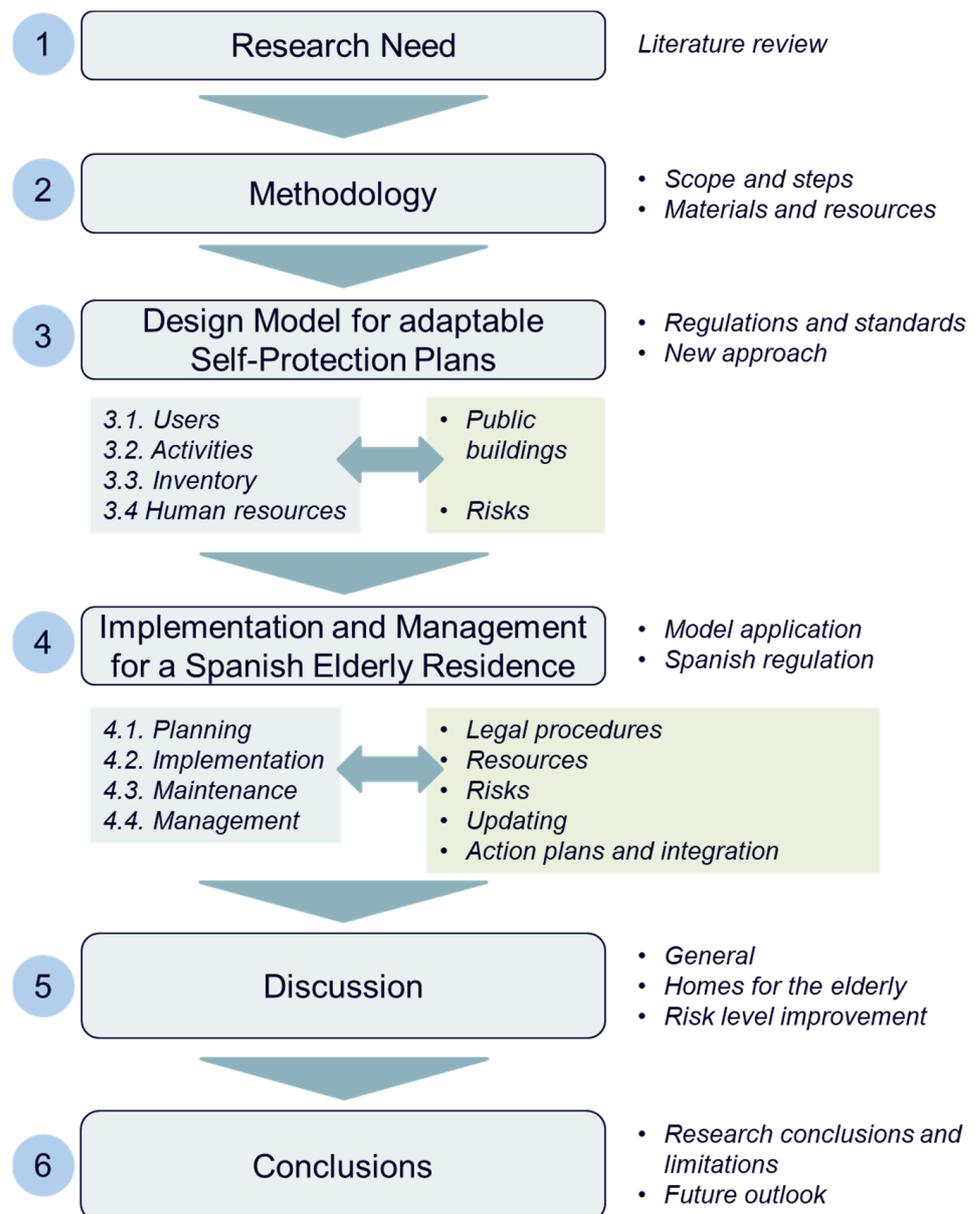


Figure 1. Research methodological steps (own elaboration).

3. Design of an Adaptable Self-Protection Plan Framework for Public Buildings

With the goal of adaptation of self-protection plans for public buildings, the following four key elements are to be considered, as shown in Figure 2:

1. Users—who is the model protecting?—the customers, users of the building. This element defines the user as the first key element, the mindset is to think in the user, i.e., what are their needs along the working journey for employees and for the service provision journey for the customers.
2. Activities—What and where is the action consisting of?—describes the activities and the related environment where they take place.
3. Inventory—With what is the action performed?—Identify the buildings and installations and any other assets used and/or enabling the realization of activities.
4. Human resources—By whom are the activities performed?—it consists of the organizational structure, managerial levels, and other staff levels.

Given that the use or uses to which the public building is intended can be found within a varied typology, when the Self-Protection Plan is designed, it must be adapted to the needs that arise from the different activities that are carried out in the building, but always fulfilling the minimum content reflected in the Spanish self-protection regulation, the NBA. However, it is the aim of the research study to develop these four areas in order to develop self-protection plans with the goal of adaptability that would lead to a risk mitigation.



Figure 2. The 4-Elements-Model for adaptable self-protection plans (own elaboration).

3.1. Classification and Description of Users

Given that the building will be used by the staff who carry out their work there, and that this is focused on serving the public, we will also find users of the facilities. Throughout the hours of the day, the number of people inside the building may vary, so it is necessary to indicate the type of personnel, the affiliation to the department in which they are located, and the approximate hours in which they are located when carrying out their professional tasks. In turn, it will be necessary to indicate the opening hours to the public and the distribution of influx throughout this. For better understanding of users, all their needs and services expected should be analyzed.

3.2. Activities and Physical Environment

The self-protection plan must include all of the different activities that are carried out in the building, making a detailed description of the composition and volume of all the dependencies that are found in it. This can be performed by means of process mapping methodologies and tools such as business process reengineering methods. The input, process, and output of every task within an activity is to be detailed while considering the needed areas and systems involved.

It is also essential to correctly define the environment in which these activities are carried out. To do this, the interior architecture of the building must be defined, detailing the dependencies and installations in view of a possible emergency and the necessary action of the emergency teams. In relation to the physical environment, it will begin with a description of the characteristics of the accesses to the building from the outside, as well as distribution and architectural characteristics. In addition, the total constructed area and floors of the building, its total height, the year of construction and all the data available in terms of structural and constructive typology that may vary the action in the event of an emergency, will be indicated. Therefore, it will be necessary to provide data about the characteristics of the structure, exterior enclosures, roof, interior divisions, carpentry, etc.

Moreover, it is to be considered if fire resistance equipment is required according to the location’s regulations [16], and if the existing constructive sets in the building are already compliant with it.

All activities will have an average number of workers who will carry them out in the described facilities, as well as an average number of users of the services they are capable of offering. Also, in accordance with the regulation regarding the evacuation of occupants [16], the average occupancy of each zone of the building should be determined, considering the simultaneous or alternative use nature, as well as considering the regime of activity and use planned for it. Based on this information, and if updated and accessible, the expected maximum occupancy can be used for optimization of the design, and construction of the building according to real needs. To present it, a standard table can be used that contains detailed information on uses, surfaces and associated occupation for each of the floors. To complete the information indicated in this section, the necessary graphic documentation must be included in the Self-Protection Plan Plans Annex, incorporating plans of all the floors of the building, and locating the facilities and areas where the activity is carried out.

Both the activity-oriented analysis and the activity environment-oriented analysis join in the global situation analysis which represents the first step in the development of a self-protection plan for any given building as shown in Figure 3:

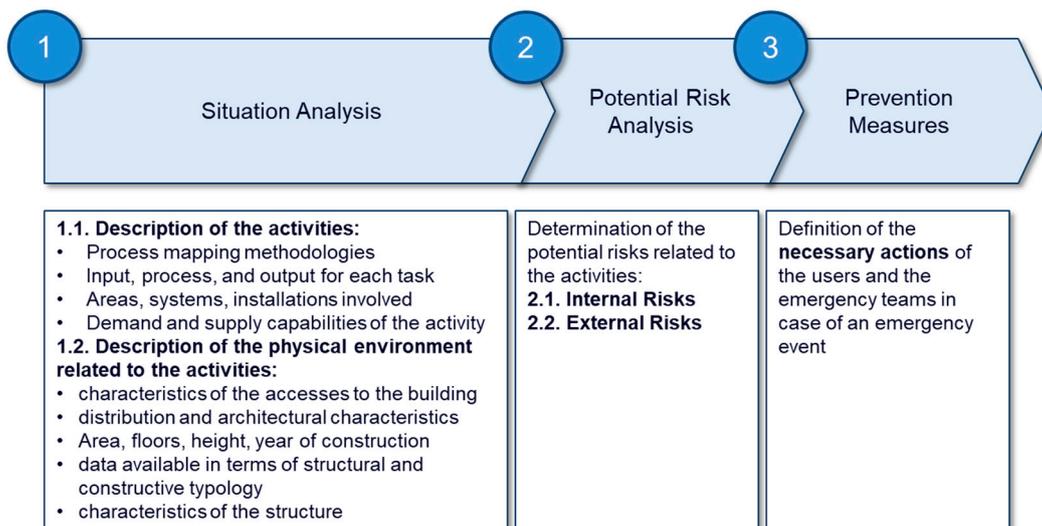


Figure 3. The 3-Steps Model for Developing Self-Protection Plans (own elaboration).

3.3. Inventory, Analysis and Risk Assessment

Once the activities and the physical environment in which they are carried out, as well as the possible occupants, have been detailed, an inventory, analysis and evaluation of the risks that are present in the building must be carried out due to the elements and facilities necessary to carry out the different activities.

For this, all the elements and installations with associated risks, risk installations, that are in the building will be listed, among which it can mentioned examples such as electric generators, electrical installations, power supply systems, the gas distribution installations, gas or fuel tanks, air conditioning installations, the water supply installations, the lifting devices and the installation of photovoltaic solar panels or the production of domestic hot water.

Moreover, it is also required to indicate its location in the building, as well as the technical characteristics that define each installation, being able to collect this information in a standard table. Based on this, the next step will consist of applying a risk assessment methodology to determine the risk level for the different areas, installations, and related activities.

3.4. Organizational Structure: Managers and Main Activity

In order to try to unravel common lines in the general uses of public buildings and considering the different activities that take place within them, we will proceed to study the scheme of activities by departments that are carried out in different types of buildings, all belonging to the public sector.

The Basic Model of Care in Residences for the Elderly, published by the Ministry of Health and Social Welfare of Castilla-La Mancha [13], describes the functional areas for a typical residence for the elderly. There, four main areas depend on the Center's Management, corresponding to Administration, Social and Psychosocial Care, Health Care and General Services. In turn, all these main areas will depend on the different services offered in the type of residence for the elderly. The internal organization of a hospital, published by the Community of Madrid [21] for a specific case, is organized into a direction managerial level with four management areas: management, medical, nursing and continuity. As in the case indicated above of a typical residence, the different sub-management areas will depend. In this case, several services also depend directly on the direction management, such as quality, legal, patient care, risk prevention, communication, admission and clinical documentation, and the library. Finally, the organization chart with the distribution of workers in the different departments of a public school is considered [22].

As can be seen in the three examples described, there is a marked hierarchy that differentiates the managerial departments from the execution or production departments. Also, in all uses, a top management person in charge is presented, as well as directors, deputy directors or coordinators in their internal operating bodies. The different departments and services where the rest of the workers work depend on all of them. All these bodies serve at the same time to provide a service to the citizen, who is the end user of the building.

The workers of any public center will be ranked, being able to identify the owner of the activity, and it will be necessary to appoint the Director of the Self-Protection Plan and the Director of the Action Plan in case of Emergency. This information is to be included in the Self-Protection Plans with standard tables consisting of:

- Building data
- Data of the owner of the activity
- Data of the representative
- Data of the Director of the Self-Protection Plan
- Data of the Director of the Emergency Plan

Likewise, in another table, the type of generic activity of the building and its use or uses must be specified, and if it has civil liability or fire insurance.

4. Implementation and Management for a Spanish Elderly Residence

4.1. Planning for the Case Study

4.1.1. Classification and Description of Users

A classification of employees and users according to the quantity of persons and timetable of the activity can be shown in Table 1. The users of the elderly residence can be classified into:

- Workers of the 24-h service staff center, with a greater number in the hours between 06:00 and 22:00. Their number varies between five and ten people.
- Staff workers during daytime hours, with a timetable between 08:00 and 20:00. A total of between 10 and 20 people are counted.
- Personnel from service contracts such as cleaning, maintenance, supplies, etc., with variable hours between 08:00 and 20:00. Their number can vary depending on the time of day and needs, but an average number of three to four people can be estimated.
- Residents in the residence. Its maximum number will be 99 people.
- Visits to residents between 10:00 a.m. and 6:00 p.m. Its number will vary depending on the hours and whether the day is a weekend or a holiday. It is estimated a number between 15 and 20 people.

Table 1. Classification and timetables of the employees and users.

No.	Classification and Timetables of the Employees and Users			
	Classification	Description	Timetable	Persons per Day
1	Employees	All-day shift	From 00:00 to 24:00	From 5 to 10
		Day-shift	From 00:00 to 20:00	From 10 to 20
		Outsourcing	From 00:00 to 20:00	From 3 to 4
2	Users	Residents	From 00:00 to 24:00	Up to 99
		Visitors	From 10:00 to 18:00	From 15 to 20

4.1.2. Activities and Physical Environment

This sub-chapter describes the urban, industrial, or natural environment in which the buildings, facilities, and areas where the activity is carried out. In the building that is the object of the Self-Protection Plan, the activity of the Nursing Home (geriatric) is mainly carried out, with a total of almost 100 beds distributed with a higher percentage of double bedrooms than single bedrooms. The characteristic use of the building is the Hospital. The building is developed on a ground floor without a basement, with a total useful area of almost 4000 square meters and a total built area near to 4500 square meters, as shown in Table 2:

Table 2. Data on uses and occupation of the residence based on legal regulation.

No.	Data on Uses and Occupation of the Residence			
	Floor	Use	Area (m ²)	Occupancy
1	Ground Floor	Common	1400	66
		Dormitories	2300	109
		Exteriors annexes	300	12

The different areas and activities in which the residence is divided are the following:

- Services area
- Area of usual common uses
- Occasional common use area
- Administrative area and reception
- Geriatric care area

- Multipurpose area
- Exterior annexes

Access to the building is pending paving, although it is very wide. This street communicates at a distance of 50 m with a road that connects the municipality to a main city. A few meters away is the intersection, a highway that connects the residence to other cities and highways. All roads allow the passage of large emergency vehicles without problems. The closest hospital and fire station are located at a distance of 20 km with almost 20 min driving time.

4.1.3. Inventory, Analysis, and Risk Assessment

This sub-chapter describes the location of the elements, facilities, production processes, etc., that may lead to an emergency or adversely affect its development. These are classified into constructive characteristics of the building including fire protection, the occupation and uses, the risk installations and services. Later, this sub-chapter will describe the measures and means, human and material, available in application of specific provisions on security as well as a comparison of the available inventory of the technical and technical means in the residence with the level required in the regulations.

1. First, the constructive characteristics of the building, based on the materials used, are the following:
 - Structure: foundation by means of reinforced concrete.
 - Exterior cladding: 1-foot-thick brickwork.
 - Roof: it is made with an inverted flat roof and gravel coverage.
 - Interior divisions: double hollow brick wall covered with plaster or partition walls with metal structure and plasterboard plates.
 - Carpentry: in white lacquered aluminum.
 - Vertical facing finishes: vertical facings are generally finished with plaster and paint in office and retail areas, water-repellent in toilets and wet rooms, and painted in living areas.
 - Floor finishes: the general flooring is non-slip ceramic tile in common areas, services and bedrooms, and polished concrete in storage areas and auxiliary elements.

In relation to the fire resistance required [16], according to the materials used, it is fulfilled that for hospital use, and situations above ground with an evacuation height of less than 15 m, they have a fire resistance of EI 90. In turn, it is fulfilled that the constructed area of each fire sector does not exceed 2500 square meters, nor does the descending evacuation height exceed 10 m, nor does the ascending exceed 4 m, since there are no underground floors.

2. According to the information indicated in Section 4.1.1. Classification and description of users, the maximum expected personnel do not exceed the maximum ratios obtained according to the calculation established in the regulations for the use of the residence.
3. The existing technical risk facilities and services and their location in the building, in an adjoining building, or next to the building are the following:
 - Transformation center: in the attached building.
 - Electricity facility: on the ground floor in the general low voltage panel.
 - Generator set: on the ground floor in the electrical room.
 - Air conditioning: in the building cover.
 - Water supply from the general urban network through pressure equipment: on the ground floor.
 - Detection system against fires: in the whole building.
 - Lightning conductor: In the building cover.
 - Gas installation: network inside the building.
 - LPG tank: next to the building.
 - Treatment plant: ground floor in a room next to the pool.

4. After having described the construction characteristics, the uses and occupancy level, as well as the risk installations and services, it is required to develop an inventory with a description of the measures and means, human and material, available to control the risks detected, as well as to deal with emergencies and to facilitate the intervention of External Emergency Services. Active fire protection includes all means and installations provided for fire detection, alarm, and extinction. Passive fire protection includes the construction conditions and design specifications of the building itself to minimize the consequences of any fire:
 1. Technical means of active fire protection:
 - Equipped fire hydrants
 - Portable fire extinguishers
 - Automatic fire detection and alarm system
 - Emergency lighting
 - Emergency signage
 - Communication system
 - Other systems
 2. Human means of fire protection: the staff who are working at the residence at that time must collaborate in one way or another to mitigate the consequences in the event of an emergency occurring in their facilities that require, due to their level of danger, based on the activation of the Self-Protection Plan. The training of these human resources will depend mainly on their professional category and their specific training for emergencies.
5. Comparison of the available inventory of the technical and technical means in the residence with what is required in the regulations [16], the provision of the fire protection installations must be:
 - (a) Equipped fire hydrants: the six existing units meet the parameter.
 - (b) Portable fire extinguishers: in special high-risk areas, in accordance with the regulation, whose built surface exceeds 500 square meters, it is required that a mobile fire extinguisher of 25 kg of powder or CO₂ for every 2500 square meters of surface. These parameters are widely met, given that the surface of the residence, as it has two fire extinguishers of 25 kg of powder or CO₂, one of these elements located in each wing of the building, as well as 22 units of 6-kg ABC powder fire extinguishers and 9 units of 5-kg CO₂ fire extinguishers distributed throughout the residence.
 - (c) Dry column: it is only necessary if the evacuation height exceeds 15 m, which is not the case in the residence.
 - (d) Fire detection and alarm system: the system has detectors and manual buttons and must allow the transmission of local alarms, general alarms, and verbal instructions. To this end, an automatic fire detection and alarm system has been arranged with buttons, sirens, detectors, and a switchboard. If the building has more than 100 beds, it must have direct telephone communication with the fire service, which is not the case with the residence.
 - (e) Emergency elevator: In the areas of hospitalization and intensive treatment whose evacuation height is greater than 15 m, it is not the case in the application of the residence.
 - (f) External hydrants: A total of one, if the total built area is between 2000 and 10,000 square meters. An extra one more for each additional 10,000 square meters or fraction thereof. Given the total constructed area, an external hydrant is installed.

In relation to technical human resources, once the Director of the Self-Protection Plan, the Director of the Action Plan in the event of an emergency and the rest of the components of the emergency teams have been appointed, regulation requirements are met.

4.1.4. Organizational Structure: Managers and Main Activity

Moreover, measures available in the application of specific provisions on security, consists of the emergency personnel of the establishment object of this Plan, constitutes the set of people specially organized and trained for the prevention and action in case of accidents that produce any type of emergency, that may affect the establishment. For this, the teams with this function must:

- Detect anomalies causing accidents.
- Be informed of the particular and general risk of the place where they carry out their activity.
- Know the material means of protection available to them, as well as their use and management.
- Know the sequence of actions to be carried out in an emergency.

In terms of protection, whenever the emergency has occurred, they must make use of the equipment and facilities provided to control the incident, or failing that, control it until the arrival of the External Emergency Services, ensuring in all cases that the cost in human damage is zero or as low as possible. On the other hand, the rest of the occupants of the center must:

- Know the existence of the Emergency Plan.
- The basic guidelines for action.
- Detect anomalies causing accidents.

The Emergency team will be made up of at least the following components [23]:

- Chief of Emergency (JE)
- Chief of Intervention (JI)
- Intervention Team (EI)
- Alarm and Evacuation Team (EAE)
- Responsible for the Command Post (RPM)

4.2. Implementation for the Case Study

4.2.1. The Environment

The municipal term in which the building is located must be indicated, as well as the main characteristics of the environment or neighborhood in which it is located. To synthesize this information, standard tables can be filled in with information on access to the site and the building and the spaces intended for maneuvers by foreign aid teams. Also, it is necessary to differentiate if it is an urban or industrial environment, or if it is a natural area [16]. To do this, a table can be used that contains information on the name, type, location, area, and level of risk according to regulations of each of the hazardous installations in the environment.

4.2.2. Identification, Analysis, and Evaluation of External Risks

Depending on the building's environment, the building will be subject to factors that produce potentially dangerous situations that can lead to an emergency. The different situations that trigger an emergency and a probable evacuation are as follows:

1. Flood: in the evaluation of this risk, the existing data on the existing rivers and the flood zones in the surroundings of the building is compiled. To do this, the information published by official bodies and by Public Administrations, such as Civil Protection, Autonomous Communities, City Councils, etc., is used.
2. Earthquake: The basis of the information used for the zoning of earthquake hazard levels is the Basic Civil Protection Planning Guideline for seismic risk [24] and the Seismic Risk Maps updated by the National Geographic Institute [25]. Based on the information obtained, the level of earthquake risk can be identified and established.
3. Nearby risk facilities: Public or private installations located in the surroundings of the building which, due to their own characteristics, and in the event of an emergency

occurring in them, may pose a risk to the building in question. Among the many that can be mentioned are energy-producing facilities such as thermal or nuclear power plants, civil works such as dams, chemical or fertilizer factories, power grid transformation stations, etc. Depending on the characteristics of each of them, the risk may be to a greater or lesser degree depending on the distance they are located, as well as their type.

4. Bomb Threat: For the evaluation of this risk, the methodology proposed by the National Institute of Safety and Health at Work (INSST) [26] can be used for the risk assessment method, based on the product of the probability factors of the risk occurring and the consequences that would appear if it did occur.
5. Changes in regulations: The successive changes in the current regulations that affect both the building itself and the nearby facilities can generate situations of vulnerability. If they are not treated properly, modifying the facilities, and adapting the Self-Protection Plan, they may generate risks that could lead to an emergency. For this, it is essential to periodically maintain and update the Plan whenever situations arise that require it.

4.2.3. Identification, Analysis, and Evaluation of Internal Risks

The internal risks will be closely related to the general use of the building and the various specific uses that can complement the previous one. In a generic way, we proceed to cite the fire risk assessment due to the use and existing facilities, for which the Simplified Risk Analysis Method indicated by the INSST through NTP 330 can be used for its assessment: System simplified accident risk assessment [27]. This methodology makes it possible to determine the probability that certain risk factors materialize in damage, and the magnitude of the damage (consequences). With this, it will be possible to establish a scale in the magnitude of the different risks and prioritize their correction priority.

4.2.4. Implementation of Maintenance Programs for Installations

After having identified the associated risks, as a first step, it follows with the description of the preventive maintenance of the risk installations, which guarantees their control. The maintenance strategy for risk facilities must be based on preventive-predictive and punctually corrective maintenance. The risk installations, present in the residence, susceptible to maintenance are the following:

- Low voltage electrical installation
- High voltage electrical installation
- Generator set
- Lightning rod
- Pressure group
- Gas supply installation
- Air conditioners

According to what is stipulated in the specific regulations, for each of the installations, including their devices, equipment, systems, and components, they will be subjected to periodic revisions and always after a fire, thus establishing preventive maintenance. A certificate will be issued from the completion of these reviews to be carried out by companies authorized and registered by the competent body of the corresponding Autonomous Community, in which the name, seal and corresponding registration number must appear, as well as the signature of the technician who carried them out, and must be available to the competent fire prevention inspection services for at least five years from the date of issue. Likewise, in each type of installation, faulty components must be replaced or repaired whenever they are detected, these works being part of corrective maintenance. The maintenance records of the facilities will always be available to be consulted or reviewed at the request of an inspector. The maintenance program will be designed in accordance with the current regulations that regulate the installation in question. Tables of chronological programs are monitored with the inspections and reviews to be carried out in the different

facilities, their frequency, the responsible body, the indication of whether it is mandatory or not and the applicable regulations.

Later, in a second step, a description of the preventive maintenance of the protection facilities, which guarantees their operability is to be developed, mainly consisting of the maintenance of fire protection installations as is established in the R.D. 1942/93 “Regulation of Fire Protection Installations” [28]. According to the RD, the material means of protection against fires will be subject to the minimum maintenance program:

- Maintenance operations for level 1 may be carried out by the personnel of an authorized installer or maintainer, or by the personnel of the user or owner of the installation.
- Maintenance operations for level 2 will be carried out by authorized manufacturer, installer, or maintainer personnel for the types of devices, equipment, or systems in question, or by user personnel, if they have acquired the status of maintainer. For having adequate technical means, in the opinion of the competent services in matters of industry of the Autonomous Community.

In all cases, both the maintainer and the user or owner of the installation will keep documentary evidence of compliance with the preventive maintenance program, indicating at least: the operations carried out, the results of the verifications and tests and the replacement of elements’ defects that have been made. The annotations must be kept up to date and will be available to the inspection services of the Autonomous Community. Regardless of what is established in the maintenance program, the designated persons will periodically visually review the good state of conservation of the assets, communicating any deficiency observed. The preventive maintenance of these installations must be carried out by an authorized company. The chronological programs for the maintenance of the existing protection facilities in the residence are monitored in tables with their respective activities.

In a third group, the performance of safety inspections in accordance with current regulations is performed. Both the maintainer and the user or owner of the installation will keep documentary evidence of compliance with the preventive maintenance program, indicating, at a minimum, the operations carried out, the results of the verifications and tests and the replacement of defective elements that have been done. The annotations must be kept up to date and will be available to the inspection services of the Autonomous Community. All technical installations likely to cause or spread a fire in the residence (especially electricity supply and distribution, gas installation and air conditioning) will be subject to the conditions of maintenance and use established in current legislation. The periodic reviews and inspections to be carried out in the different facilities will be recorded in accordance with the regulations of the current installation regulations. The establishment will provide, through the Director of the Self-Protection Plan, all the information regarding this point that is requested by the Administration.

In a fourth step, it is to be defined the timeline distribution of maintenance tasks for risk and protection facilities, as certain tasks of inspection and maintenance of the facilities must be carried out by Authorized Control Organizations (OCA) as indicated in the current applicable regulations. For the rest of the tasks, it is recommended to hire a specialized and authorized maintenance company, in such a way that specialized personnel are available whenever necessary. Based on these considerations, a maintenance schedule is developed for the following ten years from the date of opening and commissioning of the residence in 2022. For optimization purposes, a smoothing of maintenance requirements has been realized to distribute the working load throughout the quarters of the year, trying to level the activities to be realized enabling an improvement in maintenance quality, resources needed, and implying a reduction in associated risks.

4.2.5. Resource Planning

Among the resources that must be present in the building and prepared to be used in the event of an emergency are material resources and human resources. The material

resources will be made up of the different protection means and installations available in the building, including the inventory of active fire protection means and passive fire protection means.

Active fire protection includes all means and installations provided for fire detection, alarm, and extinction. The most common installations and elements that can currently be found in buildings for public use are the following: equipped fire hydrants (BIEs), portable fire extinguishers, automatic fire detection and alarm system, emergency lighting, emergency signaling, communication systems and other installations such as closed circuit television or precise systems for specific uses, such as the halon gas fire extinguishing system in highly relevant archives or warehouses and where they are not usually present, personal.

Passive fire protection includes the design conditions and specifications of the building itself, to minimize the consequences of any fire. It is especially important to consider the sectorization conditions, which allow the confinement of the fire within a fire sector, and the evacuation conditions that allow the partial evacuation of an area or the total evacuation of the building.

In relation to human resources, a group of people chosen from among the building's workers will be established who will form part of the emergency personnel. They will be specially organized and trained for the prevention and action in case of accidents that produce any type of emergency, and that may affect the building. For this, they must detect anomalies that cause accidents, be informed of the particular and general risk of the place where they carry out their activity, know the material means of protection available to them, their use and handling, and know the sequence of actions that must be carried out in the event of emergency.

On the other hand, the rest of the occupants of the center must know the existence of the Emergency Plan, the basic instructions for action and know how to detect anomalies that cause accidents.

The Emergency team will be made up of at least the following components [23]: Head of Emergency (JE), Head of Intervention (JI), Intervention Team (EI), Alarm and Evacuation Team (EAE) and Responsible for the Command Post (RPM).

4.2.6. Legal Procedures Planning

The maintenance of fire protection installations is established in RD 1942/93 "Regulation of Fire Protection Installations" [28]. This regulation establishes the minimum maintenance of fire protection installations. According to the RD, the material means of fire protection will be subject to the minimum maintenance program divided into level 1 or 2 operations, depending on who is authorized to carry them out.

In all cases, both the maintainer and the user or owner of the installation will keep documentary evidence of compliance with the preventive maintenance program, indicating at least: the operations carried out, the results of the verifications and tests and the replacement of elements defects that have been made. The annotations must be kept up to date and will be available to the inspection services of the Autonomous Community. The establishment will provide, through the Director of the Self-Protection Plan, all the information regarding this point that is requested by the Administration.

Regardless of what is established in the maintenance program, the designated persons will periodically visually review the good state of conservation of said means, communicating any deficiency observed. The preventive maintenance of these installations must be carried out by an authorized company.

In accordance with what is indicated, certain inspection and maintenance tasks must be carried out by Authorized Control Organizations (OCA) as indicated in the current applicable regulations. For the rest of the tasks, it is recommended to hire a specialized and authorized maintenance company, in such a way that specialized personnel are available whenever necessary.

In relation to human resources, the personnel belonging to the Emergency Teams will receive adequate and sufficient theoretical and practical training, in order to improve their knowledge and be able to perform the functions assigned to them. For this, the training will consist of a theoretical and a practical phase, where extinguishing exercises will be carried out on arson and controlled fires, with the use of manual fire extinguishers of the types and extinguishing agents present in the building, as well as with hoses and individual protection equipment, appropriate to their missions.

In turn, a recycling schedule will be established aimed at maintaining and updating the information acquired by the components of the teams involved in emergency situations. Likewise, it should be considered that the new staff of the organization will have to be trained.

For the information systems, communication channels will be kept in perfect condition, both with the outside and inside, keeping the communication directories and emergency management forms up to date.

Finally, by carrying out drills, the correct functioning of the organization and the defined action procedures will be verified. These must be carried out periodically and, at least, once a year as established by the NBA. The Director of the Action Plan will write a report that collects the incidents that have occurred, alterations in the planned plans, difficulties that have arisen, behavior of people, etc., making the appropriate corrections and incorporating the information into the Self-Protection Plan.

4.3. Maintenance of the Effectiveness and Updating of the Self-Protection Plan

The maintenance of the effectiveness and corresponding updating of the Self-Protection Plan will be based on the execution of the following programs:

1. Training and information recycling programs.
2. Means and resources substitution program.
3. Program for carrying out exercises and simulations.
4. Program to review and update all the documentation that is part of the Self-Protection Plan.
5. Audit and inspection program.

Through its execution and monitoring, the implementation of the material and human resources is achieved, as well as the verification of its effectiveness and its subsequent improvement, following cycle of continuous improvement based on Plan-Do-Verify-Act (PDCA) systematic.

4.4. Management for the Application Case

For the management of the Self-Protection Plan, an action protocol must be established in the form of an Emergency Action Plan, where both the different emergencies that can be dealt with and the mechanisms proposed to deal with them are classified.

4.4.1. Emergency Action Plan

Emergencies that can be classified according to the type of risk, including fire, bomb threat, vandalism, flooding, or earthquake. In turn, they can be classified according to their severity, where they would be divided into near misses, partial emergencies, and general emergencies. A final classification would be based on human resources and occupation, differentiating between emergencies occurring during the working day of the daytime staff and visiting hours or outside.

In any case, the action procedure in the event of an emergency will always be the same. The first step will be to quickly detect the event and transmit the alarm. From that moment on, intervention personnel are immediately mobilized from the Command Post and, if necessary due to the seriousness of the emergency, Foreign Aid is requested through 112. Carry out an effective intervention knowing at all times what needs to be done and, if necessary, the occupants are evacuated preventively, to ensure their physical integrity. This evacuation can be carried out without urgency or urgently depending on the time

available, and it can be total or partial depending on whether it affects the entire residence or only part of it. Finally, the services will be safely restored.

The evacuation plan must be included in the Emergency Action Plan, which consists of a procedure that establishes the necessary steps to respond to the different emergencies that may occur in the building. It will also include the orders and processes for the evacuation of personnel and visitors, and their centralization at the external meeting point, as well as the identification and functions of the people who are included in the emergency teams and the means and equipment with which they are empowered.

Finally, the person responsible for the implementation of the Emergency Action Plan must be identified, who will be part of the staff present at the facilities during work shifts.

4.4.2. Integration of the Self-Protection Plan in Others of a Higher Scope

For the correct integration of the Plan, communication protocols must be established with the External Emergency Services, which will be carried out by telephone by the Director of the Emergency Action Plan or the Head of Emergencies from the Command Post through the 112.

The Self-Protection Plans should normally be integrated into the Civil Protection Plans at a local or regional level or in the Special Plans [29]. For this, the Self-Protection Plan will be integrated into the Civil Protection Plan at the local level of the municipality where the building is located. In the event of an emergency, once the help of the External Emergency Services has been requested, when they arrive and are informed by the Head of Intervention, they will take charge of resolving the emergency. Depending on the evolution of the emergency, if necessary, the Head of Intervention of the Foreign Aid Service may propose to the Political Authority the activation of the Civil Protection Plan at the local level.

Collaboration between the establishment's Self-Protection Organization and the public Civil Protection system must consist of a fluid and bidirectional relationship, in order to guarantee the full effectiveness of their joint actions in the event of a situation of serious risk or catastrophe. For this, activities can be established in order to achieve a closer collaboration and an improvement in the results, such as joint inspections of the residence and knowledge of the characteristics of the facilities or participation of both parties in the simulations to get better coordination.

4.4.3. Implementation of the Self-Protection Plan

The person responsible for the implementation of the Self-Protection Plan will be the owner of the activity. If it were a legal person, the most convenient thing would be to designate the Director of the Self-Protection Plan. To carry out the implementation of the Self-Protection Plan, it is necessary, at least to have, the education and training of personnel, the establishment of public information mechanisms and the provision of the necessary means and resources. For this, all the personnel belonging to the Emergency Teams must receive both theoretical and practical training that is sufficient and appropriate according to the functions assigned to them. Theoretical training should be based on the methods of intervention in emergency situations, available means, first aid and possible responses of users in times of crisis. In turn, one must know how to apply what is established in the Self-Protection Plan. The practical training will be based on exercises in the use of the means available in the residence and in the evacuation of its occupants.

In relation to the rest of the building's personnel, periodic generic information sessions must be given where the fundamental aspects and the general instructions included in the Self-Protection Plan are exposed. Likewise, users and visitors will have posters with information on instructions and security measures. Photoluminescent signage must be installed in relation to the means of alarm and extinction, evacuation routes, exit points to the outside and meeting point. There will also be "you are here" signs so that the visitor can locate himself inside the building.

The provision of material means, and human resources will be those that are part of the inventory and description of the measures and means of self-protection. The personnel of the Emergency Teams and the Intervention Team must have a yellow reflective vest and an orange reflective vest, respectively.

Finally, a copy of the Self-Protection Plan, a complete set of keys for all the doors, a directory of telephone numbers for foreign assistance and a message model, and a logbook must be available at the Control Point, in a controlled place.

5. Discussion

5.1. Self-Protection Plans in General

When starting to develop a Self-Protection Plan, the technician must know the building perfectly, both constructively and functionally. In addition, the technician must be able to know both internal and external risk factors, and to foresee possible emergency situations that may arise. Given the infinity of combinations that can occur in the characteristic and secondary uses within a building or facility, as well as in its own characteristics, this makes each plan different from the others, which represents a challenging task.

This difficulty can be aggravated by the multiple legal texts published in national and other regional communities' regulations. These documents specify, adjust, or expand the minimum parameters established by the national regulation for Self-Protection Plans. In addition, there are technical and preventive standards that must be considered when developing the plans. Although these standards are not of obligatory application, they do have to be studied when designing certain construction elements or facilities, as well as in the definition of preventive measures to deal with risks.

5.2. Self-Protection Plans Applied to Homes for the Elderly

In the specific case of a public building used as a residence for the elderly, whose main use according to what is indicated in the CTE is as a hospital, the Self-Protection Plan must be able to cover all the risks inherent to this activity. This can be made difficult by the complementary uses of the main use that arise from the multiple needs that a residence must cover with respect to its residents. These secondary uses can be as varied as accommodation, restaurants, sports, or teaching. Likewise, the particularity of finding users in the building during the entire day must be observed in the Plan, which in turn entails the availability of personnel assigned to the intervention and emergency teams without great difficulty, during all the hours. Finally, it should be pointed out, that as it is a public building and it provides continuous service to a group, the regulations that regulate it are very broad and varied and may present differences depending on the different regions where the facility is located. All this must be considered both when generating any Self-Protection Plan for elderly residences and during the useful life of the building.

5.3. Risk Level Improvement Based on Continuous Monitoring

As shown in Figure 4, the conceptual model can be expanded with the analysis of deviations and the learning from experience based on past events, the values of Key Performance Indicators (KPIs), and the impact and success level of measures. Consideration of learning processes is important, as it provides a syndication of the impact of self-protection plans as well as supports the identification of needed changes and adjustments that will enable the continuous improvement of the effectiveness and efficiency of the plan. Thus, it is key to research and integrate the learning process to reduce the risks for any given building.

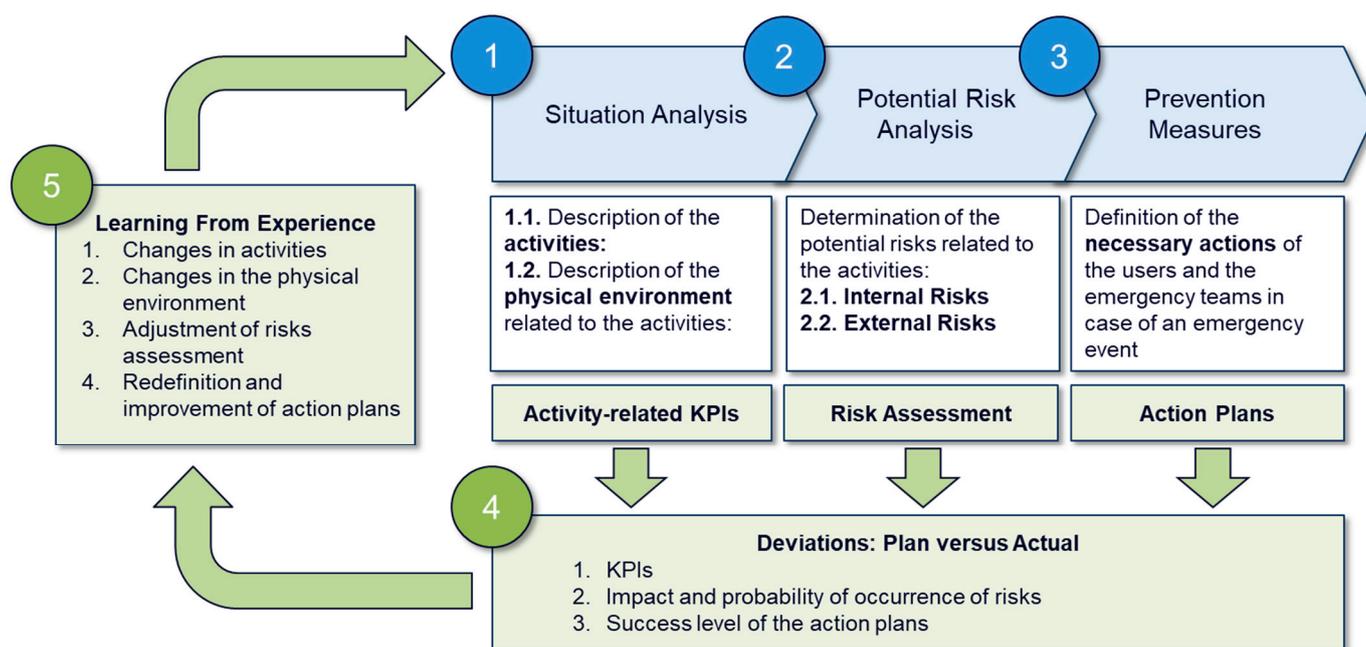


Figure 4. From Deviations to the Improvement of Self-Protection Plans based on Experience (own elaboration).

6. Conclusions

To carry out the correct design of a conceptual model of a self-protection plan applicable to any public building, first, it must be based on the minimum contents indicated in the existing regulation such as the NBA for the Spanish territory, or any other regulation applicable to any other location. However, to meet current and future challenges for adaptability and resilience, public buildings are required to evolve considering other aspects and improvements. Therefore, this paper provides a framework with four key elements how to improve the elements and interrelationships of the self-protection plan for becoming a robust system against any potential event and disturbance. The transformation process for the self-protection plan of a residence for the elderly was carried out, applying the model. As a result, the contributions of the paper are the identification of the research need, the development of a design process with four key elements and three different steps, and its application in a case study under a specific regulation. Based on the research key findings are discussed providing insights for an optimized management and improvement of self-protection plans.

The first of the hypotheses proposed indicated that the structure and the steps to follow in the process when developing a Self-Protection Plan is the same for any publicly owned building. As has been verified, the process of developing a Self-Protection Plan is applicable for public buildings with different uses. The information to be collected must only be compiled and expanded on certain aspects due to the typology and characteristic use of the building under study.

The second hypothesis mentioned that the regulations governing planning and intervention instruments in the event of an emergency are very similar between different Autonomous Communities. Throughout the text, it has been indicated that it is the Autonomous Communities that have the powers assigned in accordance with their Statutes of Autonomy that have published regulations regarding Self-Protection Plans. These legal texts focus exclusively on specifying certain aspects of the NBA, such as the minimum characteristics of the building or facility for which it is necessary to carry out the Self-Protection Plan.

The following hypothesis indicated that there is a need for a polyvalent qualification among the technicians who are competent to perform a Self-Protection Plan for a public building. At this point, differences are observed between certain Autonomous

Communities, varying the category or qualification of the responsible technician, and therefore, not clearly specifying a technical figure for such a task. In addition, in some Autonomous Communities, the completion of specific courses for Self-Protection Plans is an enabling condition.

Next, another hypothesis indicated that a Self-Protection Plan applied to a residence for the elderly varies very little from that focused on another use of public ownership. Once the application has been made to the specific case under study, it has been verified that there are multiple factors to consider when developing a plan. In turn, and due to the constructive typology of the building, its characteristic use or uses, or the environment in which it is located, the Self-Protection Plan will vary significantly between different publicly owned buildings. Therefore, and although the structure of the plans is the same, the contents, the risks, the analysis, and the means proposed to deal with them will mean that the created Self-Protection Plans may vary substantially between different public buildings.

The last hypothesis proposed that a model can be generated with which to design a Self-Protection Plan for a public residence that can be applied without great variations to other uses of public buildings. As it has been verified during the completion of this research, a conceptual model, the 4-Elements-Model for adaptable self-protection plans can be applied to any public building reducing the risks of operations. But as mentioned in the previous paragraph, this model must be complemented, expanded, and specified to ensure that it adapts and includes all the specific needs of each building.

In conclusion, the research performed provides a scientific contribution to the existing body of knowledge as it develops a design process of self-protection plans that can be applied to any public buildings, and specifically a nursing home, which answers the research and practical needs for new approaches after the COVID-19 impacts on them.

From the theoretical perspective, this paper provides a clear picture of elements to be considered based on the four elements model for adaptable self-protection plans, as well as generating an implementation model consisting of the three steps for developing self-protection plans. Moreover, with regard to practical implications, this paper shows how to analyze the elements of any public building as well as how to apply the implementation steps showing how it is key to consider a continuous monitoring of relevant indicators to improve the risk level associated with the building, the activities performed, as well as the related environment. However, the research presents several limitations as it does not cover the differences between different activities and regulations for various case studies, as it aims to provide a generic model and its application in a specific case study. Therefore, a future research need would be to apply the model in different types of buildings, activities, and regulations, and based on the results, improve continuously the proposed model.

Given that the field of construction and installations, as well as preventive, and that its legal framework at the national or territorial level is too broad, it has not been the object of a detailed study in this work, carrying out an outline of the most important legal texts. Therefore, the investigation of the differences, similarities, and peculiarities between the regulations of different territorial areas that are related to self-protection could be a future research line. It could also be very interesting to design, develop and update applications that provide a specific service to the field of self-protection, which must be able to adapt to the different manuals and guides published by the CCAA for the generation of Self-Protection Plans.

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