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SUSTAINABLE HOSPITALS: CRITICAL ITEMS FOR THEIR CONSTRUCTION AND THE ROLE OF TECHNICAL INSPECTION

HOSPITALES SUSTENTABLES: PARTIDAS CRÍTICAS PARA SU CONSTRUCCIÓN Y EL ROL DE LA INSPECCIÓN TÉCNICA

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RESUMEN

Actualmente, la infraestructura de salud pública en Chile, en sus distintas escalas, presenta avances significativos en la determinación de criterios de diseño en sustentabilidad. Sin embargo, es posible observar que durante su construcción no existen procesos de verificación estandarizados sobre aspectos de sustentabilidad y que la labor de la inspección técnica se centra en el cumplimiento administrativo de los contratos de construcción, más que en la verificación de los aspectos técnicos. La presente investigación propone una lista de partidas y actividades críticas a fiscalizar en la construcción de hospitales para asegurar criterios sustentables en su operación. Luego, se realiza una encuesta a profesionales que participan en el diseño, construcción y fiscalización de obras hospitalarias. Los resultados se jerarquizan con una metodología multicriterio (AHP), a partir de la cual se evidencia una preferencia en la envolvente térmica (20%) e instalaciones térmicas y de ventilación (17%). Finalmente, en base a las debilidades señaladas por los profesionales, se propone un proceso de control y seguimiento a estas partidas y actividades con un rediseño de la labor del Inspector Técnico de Obras.

Palabras clave
infraestructura sanitaria, inspección, sustentabilidad, metodología multicriterio (AHP)

ABSTRACT

Currently, the public health infrastructure in Chile, at its different scales, has made important advances in determining sustainability design criteria. However, it is possible to see that, during its construction, there are no standardized verification processes on sustainability aspects, and that the work of technical inspection focuses on the administrative compliance of construction contracts, rather than on checking technical aspects. This research proposes a list of critical items and activities to supervise hospital construction, to guarantee sustainable criteria in their operation. A survey was also made to professionals involved in the design, construction, and supervision of hospital construction, ranking the results with a multi-criteria methodology (AHP), which showed a preference in the thermal envelope (20%) and thermal and ventilation installations (17%). Finally, based on the weaknesses stated by the professionals, a control and monitoring process of these items and activities is proposed, redesigning the work of the Worksite' Technical Inspector.

Keywords
Health infrastructure, inspection, sustainability, AHP methodology

INTRODUCTION

Criteria related to the satisfaction or welfare of professional work teams, patients, and administrators, along with the efficiency of the building's resources, must be considered during all stages of a construction project, especially in hospital buildings (Rodríguez, Svensson & Wood, 2020; Soliman-Junior *et al.*, 2021). In this sense, sustainable standards have been developed in health buildings, through different certifications like LEED, WELL or LBC (Allen *et al.*, 2015), which have the so-called "commissioning" credit, understood as the set of processes which would allow them to carry out project inspection in all its stages (Lord, Noye, Ure, Tennant & Fisk, 2016). In addition, in their application, some authors have shown that a certified building has an additional productivity of 16% (Vasquez *et al.*, 2013), thanks to improvements in lighting, temperature control, improvements in indoor air quality (Xuan, 2015), and a 15% reduction of absenteeism (Vasquez *et al.*, 2013).

Despite this, during the operation of the building, it cannot be confirmed that hospitals certified with the highest score, manage to be more efficient than those that score lower (Golbazi & Aktas, 2016). Together with this, public health infrastructure buildings do not always comply with the sustainability criteria described in the design phase, and few studies further analyze the reasons for this (Balali & Valipour, 2021).

Likewise, during the construction phase of public health infrastructure, there are no standardized verification processes of the project's guidelines in sustainability aspects, which could affect the sustainable life cycle of these buildings. The errors in the execution of critical sections of health infrastructure have different consequences during the operation of a building (Castro, Mateus & Bragança, 2015), from excessive corrective maintenance and an increase of public expense due to the extra energy for energy systems (D'Amanzo, Mercado & Ganem Karlen, 2020), to environmental discomfort for the people who use the building, whether due to overheating, overcooling or poor air quality In constructive terms, said errors can lead to an increase of after-sales costs due to humidity or incorrect waterproofing issues, the incorrect implementation of insulation, or errors in restroom facilities (Carretero-Ayuso & García, 2018).

In this way, the work of the Technical Inspection or the State Inspection of public works in Chile is key to check that what is stipulated in the project is complied with, once implemented. Specifically, the Technical Inspection has two main goals: 1) inspecting the administrative conditions, referring to financial aspects, deadlines, and legal regulations; and 2) inspecting the technical conditions, regarding the execution of the project to safeguard contractual compliance between design and implementation, and thus guarantee the stability, durability, and habitability of the project (Ministry of Housing and Urbanism [MINVU, in Spanish], 2007). However, their work is focused on the administrative compliance of the construction contracts, more than on checking the technical aspects of the projects. The main issues, in this context, are associated with the incompatibility of the blueprints of different areas, differences in criteria between the office and on-site personnel, and the limited feedback about the work methods (Santelices, Herrera & Muñoz, 2019).

A study made by the Chilean General Comptroller of the Republic (Moscoso, 2017) indicates that the most relevant observation in public works contracts for the health area is the non-compliance of technical aspects, while other academic studies confirm that the shortcomings in the design processes are the main factor that influences the problems unleashed on the worksites (Montiel-Santiago, Hermoso-Orzáez & Terrados-Cepeda, 2020). This reflects the need of having construction protocols and standards that are incorporated from the start of the design, and that is accompanied by an effective works technical inspection, focused on the correct operation of the characteristics of the systems and facilities in hospital buildings.

This study identifies the critical sections -set of activities or works of the construction stages of a project (National Standardization Institute [INN, in Spanish], 1999a) – which must be inspected during the execution of a health construction project, and that affect its sustainable life cycle, including, the quality of the indoor environment and the efficiency of water and energy consumption during the operation. In this framework, an analysis of the critical activities of a section was made, to identify sustainable design criteria that should be guaranteed for the operation phase. On the other hand, the information was validated through a survey made to professionals who take part in the design, construction, and supervision of hospital constructions. The results were analyzed with the AHP Prioritization Method to rank the critical sections and activities, and to detect the possible weaknesses that these professionals see in their work. Finally, based on the open questions of the survey, a simplified follow-up process of critical sections and activities was proposed, that could be used throughout the cycle of a public health infrastructure project, with emphasis on the execution stage.

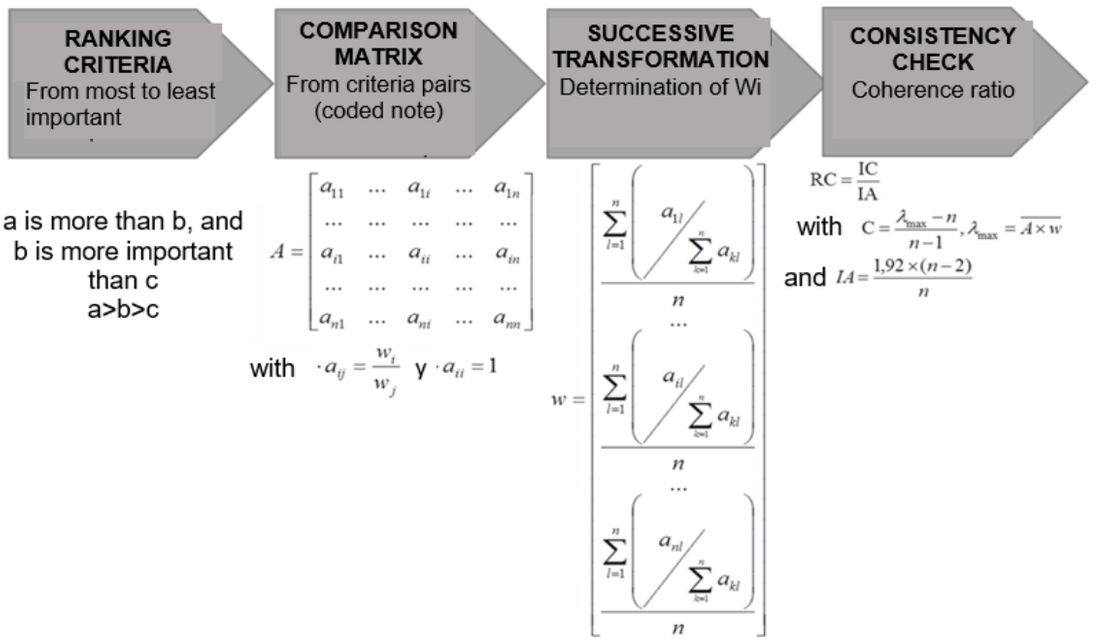

Figure 1. AHP method stages. Source: Preparation by the authors using Saaty (1977; 2008).

METHODOLOGY

This research lays out a simplified hospital inspection process, with emphasis on execution. To present it, the article has been divided into three stages.

In the first phase, a description and analysis of the context of hospital establishments in Chile are presented, for the sake of understanding how their management works and to go further into the technical inspection of the works.

In the second stage, the critical sections and activities that must be supervised in the hospital's construction process are determined. This is a task fed by the requirements that make up the Hospitals Sustainable Building Certification [CES, in Spanish] (Construction Institute [IC, in Spanish], 2017). After this, the critical sections and activities are ranked using a survey applied to professionals who take part in the design, construction, and supervision of hospital works.

The group of professionals was chosen considering experience of at least 5 years in design, monitoring, and direct inspection of health projects. The professionals consulted were 9 architects and 7 engineers, as well as 10 technical inspectors.

The survey was made in three parts. First, the question, "which sections/activities are most important to inspect during the construction of a hospital to ensure that the occupation/operation of the building complies with sustainable standards?" had to be answered. To answer, they were asked to choose, from pairs, the most important critical sections to be evaluated in the execution of hospital projects, and after that, to choose among each critical activity of each section. Second, opinions were sought regarding inspection processes, such as "what difficulties arise on-site to supervise the aforementioned sections or activities? and "what measures could be implemented on-site to guarantee the correct execution of the sections and activities? Finally, they were asked to give their opinion on the need of supporting the technical inspection task with the inclusion of another professional, and they were asked to describe and/or comment on the task the technical inspector performs. The second and third parts of the survey allowed proposing a new monitoring and control process during the construction phase, aiming at guaranteeing the achievement of the sustainable standards defined during the design phase.

The results of the paired comparison of the sections and activities alternatives were prioritized through a multi-criteria prioritization method, where a weight (w_i) is calculated for each alternative presented, making a two-by-two comparison of all the criteria. The method chosen was the Analytic Hierarchy Process (AHP) by Saaty (2008), due to its great popularity to determine priorities in very varied issues like politics, social aspects, personal wishes, education, industry, or engineering (Valderrama-Ulloa & Puiggali, 2014; Darko *et al.*, 2019; Emrouznejad & Marra 2017). The different AHP priority stages are shown in Figure 1.

Here, each alternative is compared with a pair, through 5 levels. For example, it can be seen whether the envelope section is "much more important", "important", "equally important", "less important", or "much less important"

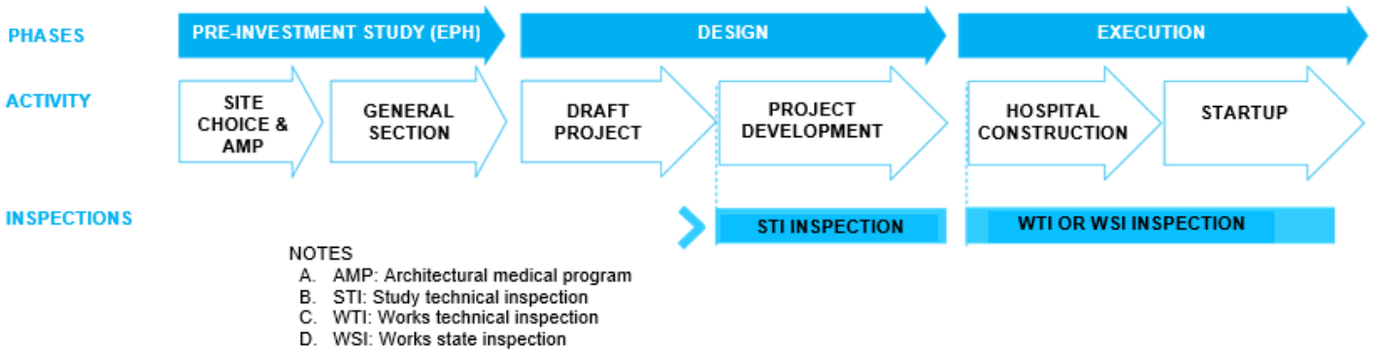

Figure 2. Workflow of a hospital construction process Source: Preparation by the authors.

than the fittings section. The results of the vote lead to the A matrix of paired comparisons of *n* alternatives. Then, successive transformations are made to determine w_i, which will be the prioritization percentage. After this, the consistency level (RC) is determined to confirm whether the result is "rational" or not, with values of between 0.20 and 0.10.

In the third and final stage, based on the comments received in the survey, a simplified hospital inspection process is proposed, with emphasis on the minimum sustainability criteria to be inspected in the sections and activities that are related to these criteria during the construction of the hospital facilities.

BACKGROUND

HOSPITAL ESTABLISHMENTS

The Chilean Ministry of Health (MINSAL, in Spanish) has, among its roles, the setting of the investment regulations and policies in infrastructure and equipment of the public establishments that are part of the healthcare network (MINSAL, 2017). For this purpose, the Undersecretary of Healthcare Networks is in charge of regulating and supervising the operation of the healthcare networks through the design of policies, standards, plans, and programs for their coordination and articulation. In this framework, each project must comply with all the regulatory requirements from MINSAL, regarding healthcare regulations, user satisfaction, and attention quality, as well as the criteria and guidelines the designs will be developed under. In general, the development of hospital projects is divided into the phases of pre-investment or pre-design, design (Figure 2), and execution. Currently, the inspection tasks begin in the design phase, together with the project development by technical studies inspection teams, and once in the execution phase, the works technical inspection takes place.

Hospitals in Chile are closed attention facilities, that provide health care under a continuous attention system, and that must have organized resources of infrastructure, equipment, and personnel necessary for their permanent operation. Currently, these have an outpatient attention area (clinics, outpatient minor surgery rooms, therapeutic and emergency diagnostic support units), that is annexed and complementary to the closed attention where the hospital admissions are mainly found.

In Chile, hospitals are truly relevant to cover the healthcare needs of the population. However, in terms of health infrastructure, the country has shortcomings, which is seen in the lack of hospital beds per number of inhabitants. The average number of hospital beds of member countries of the Organization of Economic Development and Cooperation, OECD, was 5.045 beds per one thousand inhabitants in 2013. In the case of Chile, this is only 2.18 beds per thousand inhabitants (Goyenechea, 2016). This has generated, in the last decade, the preparation of investment plans in hospital infrastructure that manage to strengthen the existing healthcare network. Despite the efforts made, a diagnostic made in 2018 indicates that 80% of hospitals still do not comply with the current infrastructure quality standard, due to the age of their buildings, and that 63% of the premises have buildings from before the 1980s (Sandoval & Leiva, 2018).

In issues related to sustainability, since the mid-2000s, the Chilean Ministry of Health has incorporated sustainability criteria in the designs of health establishments. The first efforts focused on energy efficiency, establishing envelope specifications (walls and windows) with better thermal behavior, which allowed reducing energy demands for the thermal conditioning of premises, as well as the

incorporation of more efficient active systems (air-conditioning and lighting systems).

In 2017, the Hospitals CES Certification, a voluntary national energy efficiency and environmental quality certification for hospital buildings, came into force. Its purpose is to evaluate, qualify, and certify the capacity of a building to achieve suitable indoor environmental quality, with the efficient use of resources, and low generation of waste and emissions (IC, 2017). The CES certification system is based on the compliance of obligatory requirements, the obtaining of a score, the compliance of each voluntary requirement that it comprises, and verification of the works in the final stage of the evaluation process, which consists of collecting some background information, and at least, making one inspection visit made by an Evaluation Entity. Currently, its use is encouraged as a work method to choose the sustainable criteria that hospital buildings must comply with (MINSAL, 2017).

INSPECTION OF HOSPITAL WORKS

In Chile, there is no detailed procedure to inspect hospital works. Although there is a Works Technical Inspection Manual (Ministry of Housing and Urbanism, 2007), its scope is based on the inspection of social housing, which, as time has gone by, has been extended to paving and green area projects (Moscoso, 2017).

A study on comments and recommendations in the execution of public work contracts, made by the General Comptroller of the Republic between 2012 and 2015, concluded that a large part of these observations is directly related to the role the works technical inspection fulfills, highlighting the non-compliance of the technical standards, which represented 27% of the cases (Moscoso, 2017). It also revealed that 51% of the negative comments were linked to health establishments and that this type of project did not consider a technical inspector in the early design stages, which is why two main problems appeared: 1) Deficient use of time, given that the technical inspector was hired or assigned only at the start of the works, having to invest time in studying the project and all the administrative documents that were part of it; and 2) Not making use of the contribution and experience of the works technical inspector in the early stages of the project, where all modifications have less of an impact on its costs.

Another study on Works Technical Inspection (WTI) indicates that there is an important number of events and situations that lead to conflicts and doubts, not always attributable to a wrong decision by the principal or to the deficient management of the Contractor (Technological Development Corporation [CDT, in Spanish], 2011). These conflicts tend to come from some of the following causes: Projects that do not have a suitable level of detail, which impedes defining, accurately and with objectivity, the demands and standards that must be checked by the WTI; projects that do not have efficient coordination within themselves, or even with the specialties; the roles and responsibilities that the different professionals of the construction processes must take on in their participation in the different stages of the projects, are not seen; both the analyses and the evaluations are based on uncoordinated and almost unreliable background information; and, the lack of definitions, the omissions, and errors that the administrative terms and conditions of the contracts have, lead to an important number of conflicts in the relationship between the parties.

Based on what has been described, a list of relevant critical sections to comply with and check in the construction process (execution phase, construction stage of Figure 2) of hospitals is proposed, to ensure sustainability in their operation.

RESULTS AND DISCUSSION

The main results of the study, including the list and definition of the critical sections and activities that are relevant for the construction of sustainable hospitals, the ranking made by the surveyed professionals, together with recommendations to strengthen technical inspection, and a streamlined control and monitoring process with emphasis on the execution stage, which allows guaranteeing sustainable criteria and variables during the operation, are presented below.

RELEVANT CRITICAL SECTIONS AND ACTIVITIES FOR THE SUSTAINABLE CONSTRUCTION OF PUBLIC HOSPITALS

For the choice of the selected sections, first, each one of the CES variables that had a relationship with the structural or finishings work of a construction project was analyzed (INN, 199b) and, then, the sections where the associated CES variable had the highest scores in the certification were chosen. Finally, each chosen section was subdivided into activities, so that the Works Technical Inspector, during the construction stage, can inspect each section in more detail. Thus, Table 1 shows the CES variable relationship with the associated work section, the list of the selected sections, and the activities that were analyzed in this research.

CES Variable	Associated Works Sections	Chosen sections	Activities involved
Visual comfort - passive	Thermal envelope	Envelope	- verification of the type of material and thickness of the insulation of the: ceiling-roof group, of the envelope wall, of the ventilated floors -verification of the type of glazing and frames in windows - verification of the type of material and continuity of insulation to avoid thermal bridges - verification of the type of material and execution of solar protections - verification of the types of materials of the vapor and humidity barrier
Energy demand	Thermal envelope		
Watertightness of the envelope	Thermal envelope		
Acoustic comfort	Acoustic insulation	Acoustic insulation	- verification of the type of material and thickness of the vertical and horizontal dividing elements - verification of the water-tightness of joints of: vertical and horizontal dividing elements - controlling noise and vibration of: equipment, air injection/extraction ducts of elevators and freight elevators - verification of the acoustic insulation in the sewer network
Equipment noise	Acoustic insulation		
Air quality – passive	Indoor finishings	Finishings	- verification that the vertical indoor covers, ceilings, pavements and paintwork, and varnishing are those specified
Visual comfort – active	Lighting and electrical installations (visual comfort)	Lighting and electrical installations	- verification that the lights are those specified - verification that the lighting sensors and switches are those specified
Energy consumption	Lighting and electrical installations		
Thermal comfort – active	Thermal and ventilation installations (thermal and ventilation comfort)	Thermal and ventilation installations	- verification of the type, characteristics, and operation of the air-conditioning and domestic hot water (DHW) system -verification of the insulation of the air-conditioning and DHW distribution network - verification of the correct installation and operation of the air-conditioning thermostats, of the ventilation airflow, of the type of ventilation and/or forced extraction filters - verification of the location and number of CO2 sensors
Air quality – active	Thermal and ventilation installations		
Energy consumption	Thermal and ventilation installations		
Energy consumption	Non-Conventional Renewable Energy Systems	Non-Conventional Renewable Energy Systems	- verification of the correct installation and operation of photovoltaic panels or thermal solar collectors
NCRE	Non-Conventional Renewable Energy Systems		
Drinking water systems	Sanitary installations	Sanitary installations	-verification of the correct installation of basin and scrub station faucets according to TS - verification of the time in the basin tap timers - verification of the correct installation of WCs - verification of the correct installation of bath and shower taps, as per TS - verification of the type and characteristics of the hard-water treatment system

Waste management	Waste management	Management of operation waste	- verification of a suitable space to guarantee waste management
Watering	Landscaping	Landscaping	- verification of its existence, and that it has a low water consumption
Landscaping	Landscaping		
Incorporated energy	Structural Works	Structural Works	- verification that the structural materials have an environmental label
Incorporated water	Structural Works	Structural Works	- verification that the structural materials have an environmental label
Comprehensive draft design	-	-	-

Table 1. Detail of sustainable variables and their relationship with the work's sections associated with the chosen sections and activities Source: Preparation by the authors.

Ranking	E>ITV>T=EnR>IIE>IS>P>AA>R								
Sections	E	AA	T	IS	IIE	ITV	EnR	P	R
wi (%)	20	6	13	10	11	17	13	7	5
λmáx	11.47	IC	0.31	IA	1.54	RC	0.20		

Table 2. Ranking of each section to be supervised in the construction stage, to guarantee that the occupation/operation of the building complies with sustainable standards Source: Preparation by the authors.

RANKING OF CRITICAL SECTIONS AND ACTIVITIES

Regarding the question, "which of the sections is the most important to inspect during the construction of a hospital, to guarantee that the occupation/operation of the building complies with sustainable standards?", a preference of 20% is seen (Table 2) for the Envelope (E), followed by the Thermal and Ventilation Installation (TVI) with 17%, and Finishings (F) and Non-Conventional Renewable Energy Systems (NCRE), with 13%. It is from this that the consistency was 0.20. Finally, the three least voted sections with Landscaping (L), Acoustic Insulation (AI), and Waste Management (W), with 7%, 6%, and 5%, respectively. Sanitary Installations (SI) and Lighting and Electric Installations (LEI) had a very similar valuation, of 10% and 11%, respectively.

Although the AHP method was applied to all sections, here the two most voted sections are graphed. The responses referring to the prioritization of the activities to be supervised on the envelope (the section with the highest priority, 20%) are broken down into two groups -that indicated by the architects, and that indicated by engineers and WTIs (Figure 3)-, as there is a great difference in the priorities indicated by each group, which did not happen in the voting of the other sections or activities. In this way, the 3 most voted activities by the group of engineers and WTIs were the correct installation of: insulation of the envelope wall (26%), vapor and humidity barrier (16%), and ventilated floors with ceiling-roof set insulation (15%). For the group

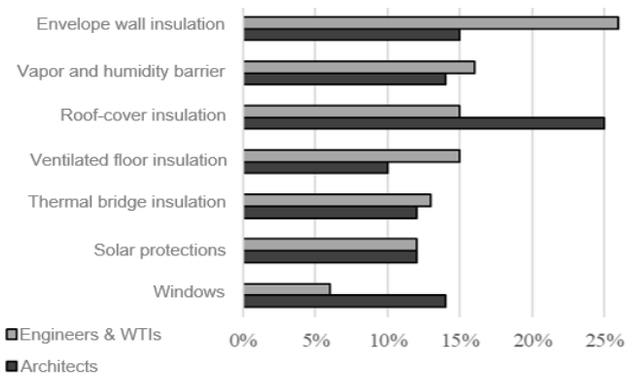

Figure 3. Prioritization by the groups of professionals for the envelope section activities. Source: Preparation by the authors.

of architects, the priorities were: ceiling-roof set insulation (25%), insulation of the envelope wall (15%), and window glazing and frames (14%).

In the case of the activities of the Thermal and Ventilation Installations section (the second most voted, 17%), the 3 most important activities for the professionals were: operation of the air-conditioning and domestic hot water (DHW) (26%), insulation of the air-conditioning and DHW network (22%), and the correct installation of air-conditioning thermostats (18%). The least important to inspect was: ventilation and/or forced extraction filters, with 8% of the responses (Figure 4).

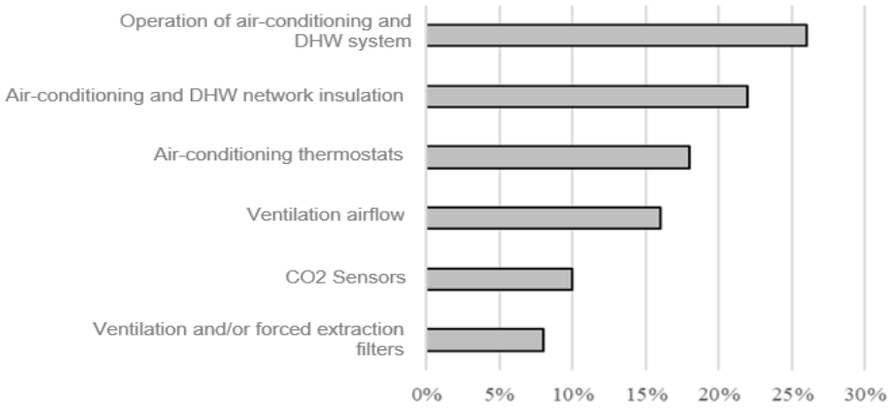

Figure 4. Prioritization by the group of professionals for the Thermal and Ventilation Installations section.
Source: Preparation by the authors.

Opinions were also asked about the technical inspection processes of hospital works. Regarding the difficulties that happen onsite, to inspect the previously prioritized activities or sections, the group of experts indicated that the main two difficulties found onsite are the lack of procedures (33%), and there not being regulatory bodies that provide indications (33%). In third place, a lack of technical knowledge (19%) is acknowledged. Other difficulties mentioned are related to the quality of the projects from the design, and the lack of self-control of the construction companies, sections with contradictory technical specifications, and a lack of coordination meetings; all with 4% of the preferences.

As for the main measures that could be implemented on-site to guarantee the correct execution of sections, creating onsite reception procedures was mentioned (46%), as was creating a regulatory body to provide indications (42%). Other responses indicate the need for having projects inspected by WTIs, standardizing the background information of projects, and having specialized technical support (all with 4%).

When asked about including a new specialized professional that would support the supervision, 100% of those surveyed answered in the affirmative. And some additional comments of the group of experts consulted with, pointed out three main issues that can be improved in the supervision of the sustainable aspects of hospital works, which are detailed below:

The role of the professionals:
- A new specialized professional must not only appear at the start of the work but must accompany even in the design process, coordinating the specialties and informing the principal.
- The collaborative running of the specialties by competent professionals is essential to achieve a high level of energy efficiency and sustainability for the building.
- It is necessary to guarantee, in the design, the incorporation of energy efficiency and sustainability aspects in the specialties.

Verification processes:
- Incorporating better technological tools to control the project and the specialties.
- Making verification processes of the compliance of what is specified a requirement, or previously checking the specified standards.
- Standardizing the checklists, which may be obligatory in the contract, so that the guidelines are not left to the will of the principal or the contractor.
- More frequent visits of the site visitor must take place.
- Checking the performance of the systems in the building startup.
- The installation of the energy systems must have its execution procedures, theoretical explanations, and acceptance checklist with acceptable tolerances.
- Once the works are executed, their compliance must be certified and evaluated through measurements that are part of the site reception process.

Regulatory context:
- there is a lack of a regulatory process that provides indications for the supervision procedures for these critical sustainability sections.
- There is a lack of domestic regulations, especially in the air-conditioning area.
- The international standards are not used, partly because of a language gap.

Based on the ranking of sections and activities presented here, the comments raised about the difficulties that arise on-site that are to be inspected, the measures that could be implemented on-site to guarantee a correct execution, and three topics highlighted in the open questions of the professionals (role of the professionals, verification processes, and regulatory context), a new monitoring and control process of the sections and activities is proposed in the following section, that would allow guaranteeing sustainable standards in the project execution phase (Figure 2), once defined during the design phase.

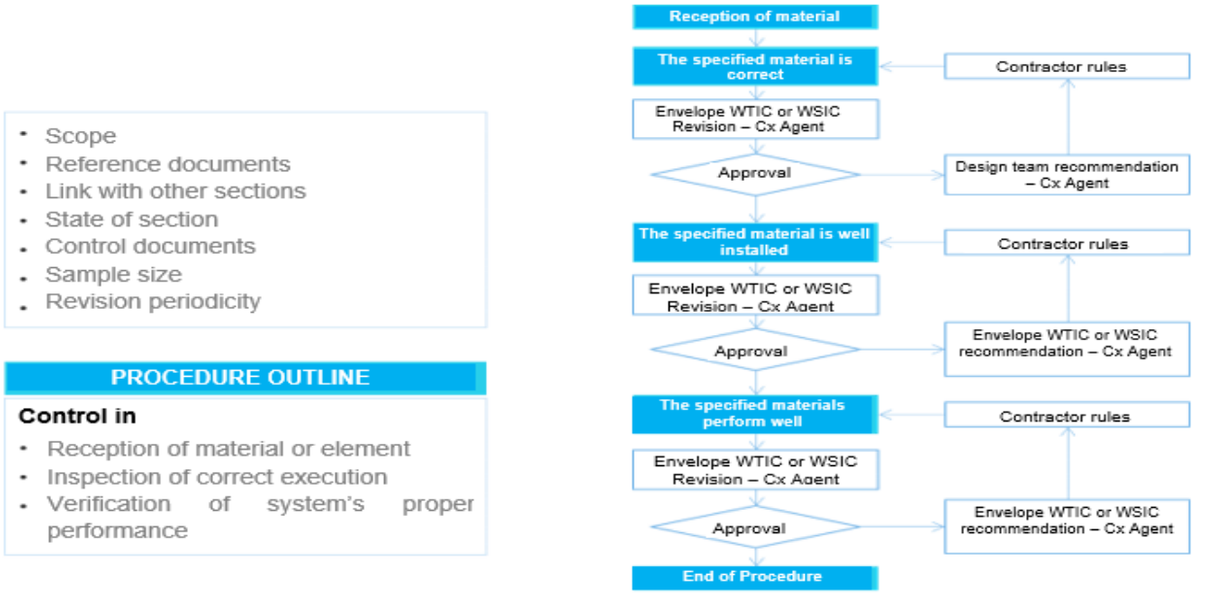

Figure 5. Flow diagram to monitor the execution. Source: Preparation by the authors.

TECHNICAL INSPECTION PROPOSAL

This proposal for a technical inspection control and monitoring process was developed considering any hospital works contract modality. It is recommended that, in these contracts, the technical or state inspection starts from the design and, in this way, facilitate the supervision, in the means that this is done from an early phase by the same specialized team.

This proposal for a monitoring and control process acknowledges the current tasks that the Works Technical Inspection (WTI) and the Works State Inspection (WSI) perform. However, thanks to the feedback from the open questions in the survey applied, it is possible to give new responsibilities and greater participation to these entities in more stages of the project. Likewise, it is foreseen that the teams of Consultants (WTIC or WSIC) would be comprised of specialists with specific knowledge and the capacity to perform support tasks for the monitoring and control process of a construction project since currently these only have the CES certification.

To carry out the aforementioned process, the figure of a coordinator, called Inspection Agent (Cx Agent), is required, who would be present throughout the project, from the pre-design phase to the operation phase, and who would be in charge of checking and documenting that the systems and installations have been planned, designed, installed, tested, operated, and maintained complying with the project requirements, and taking as a priority, the sections and activities revealed in the prioritization survey.

Figure 5 illustrates the flow of this new project control and monitoring process, with an emphasis on the execution phase (Figure 2) and in the checking of the performance and operation of the construction systems and installations. The flow is schematic, given that its specificity will be worked on in each of the sections and activities chosen in the multicriteria analysis. It also comprises a document chart that must be created for each project -or ideally, one that MINSAL uses in all its projects- and a procedure layout that highlights the controls in the execution of the section or activity. It ends with the diagram where the professionals that must be involved in the process are outlined.

CONCLUSIONS

Currently, MINSAL has an extensive plan of investments in health infrastructure, setting a great challenge for this sector, focused on building under sustainability parameters, and on suitably maintaining these new infrastructures during their operation.

Depending on the type of contract for the implementation of a hospital works, the flow of information between the different phases could be blocked, because there are different teams independently making the design, the construction, and the supervisions in each one of these phases, and without suitable monitoring. Because of the complexity that health establishments entail, ongoing verification processes are needed in all stages, which would guarantee the operation of the projected systems and installations.

On the other hand, the information collection process with the experts and, then, their weighting using the AHP method on the choice of critical sections and activities to be inspected in hospital works, allowed checking the relevance of each one. It was seen that the most relevant sections are the Thermal Envelope (20%) and the Thermal and Ventilated Installations (17%).

The results of the surveys show the need of having technical standards the provide system and installation supervision standards and procedures. The development of coordinated, better-quality projects is necessary from the design phase. The contribution of a specialist professional who aids in the supervision, and who is included from the early phases of the design, is acknowledged. In addition, many of the regulations to be applied on the systems and facilities are translations of foreign standards (due to the lack of domestic ones), and their supervision faces a language barrier. In this sense, it is not enough to translate the standards, but moreover, having an institution dedicated to their preparation, applied to the domestic context.

A control and monitoring process would also allow seeing the repercussions that the decisions made on-site, from the design, have, whether due to what is being demanded or to what the market offers. The early inclusion of an official control and monitoring process will lead to having a group of lessons learned in hospital works that could be used. The difficulty in its implementation would be focused both on the need for professional training and qualification for Cx Agents and in the regulations with specific protocols and procedures for each section, in a similar way to what the commissioning credit does in the international environmental certifications, including the energy systems and installations. Based on the systems there are in Chile, this process will likewise allow organizing, supervising, guaranteeing, and complying with the requirements of the current Hospitals CES certification.

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