ENVIRONMENTAL ASSESSMENT IN HEALTH CARE ORGANIZATIONS

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Abstract (10 to 15 lines)

The aim of this research is to design a multicriteria model for environmental assessment of Health Care Organizations. This is a model which guarantees the objectivity of the results obtained, is easy to apply, and incorporates a series of criteria, and their corresponding descriptors, relevant to the internal environmental auditing processes of the hospital. Furthermore, judgements were given by three experts from the areas of health, the environment, and multicriteria decision techniques. From the values assigned, geometric means were calculated, giving weightings for the criteria of the model. This innovative model is intended for application within a continuous improvement process. A practical case from a Spanish hospital in included at the end. Information contained in the sustainability report provided the data needed to apply the model. The example contains all the criteria previously defined in the model. The results obtained show that the best-satisfied criteria are those related to energy consumption, generation of hazardous waste, legal matters, environmental sensitivity of staff, patients and others, and the environmental management of suppliers. On the other hand, those areas returning poor results are control of atmospheric emissions, increase in consumption of renewable energies and the logistics of waste produced. It is recommended that steps be taken to correct these deficiencies, thus leading to an acceptable increase in the sustainability of the hospital.

Keywords (6 to 8 keywords)

Health care organization, Environment, Sustainability, Environmental management system, Environmental assessment, Analytical hierarchy process, Multi-criteria decision making.

INTRODUCTION

Concern about the environment is currently of great importance to European, nation and regional authorities, companies and organizations in general, and also with public opinion. Given the significance of the subject, it is useful for organizations to develop and introduce an environmental management system to assess the risks and environmental impact they have, and so control, reduce or improve outcomes. This reality is reflected in the strategies used by governments when designing policies and systems intended to build a society committed to sustainable development, eliminating or alleviating negative effects on the environment (Lee, Lee, Park, & Min, 2017).

There are in existence environmental audits as management tools, for performing assessments of the behaviour of organizations, of the management system and actions taken to protect the environment. The literature includes many contributions showing the importance of evaluating environmental activity, for example, with regard to sintering in the steel industry (Geldermann et al., 2000), in farming systems (Halberg et al., 2005) (Pishgar-Komlehv et al., 2017), in buildings (Ding, 2008), with assessment of risk to human health (Linkow et al., 2009), on agricultural land (Carballo et al., 2016), in local government action plans (Herraz-Pascual et al., 2013), environmental risk assessment in deposits of red sludge (Wen et al., 2016), in capture and usage processes for CO_2 by carbonation cycles (Pan et al., 2016), in urban heating networks fed by large scale cogeneration plants (Ravina et al., 2017), etc. This is, however, not true in Health Care Organizations, even though they are the only type of organization that produces all categories of waste (Carnero, 2015). Hospitals are composed of several departments with contrasting purposes. They are complex systems due the appropriate use and operation of the buildings is a critical responsibility. Zimmer and McKinley (2008) list for example, hospital rooms with needs similar to residential buildings, laboratories preparing chemistries and operating or surgery rooms that need absolute cleaning needs. In this type of organization, the literature on environmental assessment systems built on mathematical models, and so objective and able to be judged openly, is almost non-existent, but worthy of note is Carnero (2015), which develops an environmental sustainability assessment system via a fuzzy analytical hierarchy process using the annual number of treatments undertaken to make objective comparisons between different organizations. Carnero (2018) constructs a model in the fuzzy environment of the Technique for Order Preference by Similarity to Ideal Situation (TOPSIS), to assess the environmental responsibility of a Health Care Organization. Nevertheless, these studies do not perform an environmental audit in the field of health care, as they do not include economic or legal criteria, which are included in the present research.

Life cycle assessment (LCA) and Life Cycle cost assessment (LCCA) are methodologies widely used in environmental management. In Geldermann et al. (1999), the environmental impact of kerosene burning during the flight of an aircraft is examined with a LCA. The ecological evaluation shows the substances which contribute to the potential environmental impacts caused by the kerosene burning. Brentrup et al. (2004) describe an LCA method to evaluate the environmental effects which are relevant to crop production. The study summarizes the environmental impacts into the following two indicators: human health and resource depletion and impacts on eco-systems. Song et al. (2013) evaluate the environmental impacts of municipal solid waste management using LCA method to know the relation between recycling rate and total environmental impact. Unger and Landis (2016) use LCA and LCCA to evaluate the environmental and economic impacts of medical device supply chains when varying levels of devices that are used in a hospital. In this context, Unger et al. (2016) suggest a sustainable health care checklist in order to evaluate the sustainability of medical devices and services using an environmental and economic life-cycle assessment.

There are also several methods in literature that are focused on the assessment of healthcare buildings. For instance, Wood et al. (2016) determine the most important aspects that could be affected during a hospital design process through the House of Quality tool for green design. Energy efficiency, indoor environmental quality, sustainability site planning and management, materials and resources, water efficiency and innovation are issues that are taken into consideration. Castro et al. (2017) propose a methodology based on a list of sustainability indicators which are considered in healthcare buildings. This study classifies the criteria in five categories: environmental, sociocultural and functional, economic, technical and site. Németh et.al, (2017) developed a quantitative aquatic environmental assessment method for the qualitative evaluation of surface and ground water bodies to provide an importance weighting among the environmental parameters evaluated.

Some researchers are considered around specific environmental issues. Xin (2015) only focus on gathering information about hazardous and non-hazardous medical waste generated by hospitals to develop a way for medical waste assessment in future researches. Data are classified according to their characteristics. Successful medical waste management is beneficial for risk reduction of hazardous waste (Noman et al., 2016). Other authors, (see Kern et al., 2013 and Zotesso et al., 2017), study different chemical processes for the treatment of hospital laundry wastewater to determine if the techniques are environmental friendly with a view to minimize the negative effects on the environment. In Ryan-Forgarty et al. (2016) a case study about energy and waste management in a healthcare organization is shown. The aim is to create a relation between both regulatory requirement and voluntary initiatives to get an environmental impact mitigation though an environmental education programme. Pinzone et al. (2016) study the improvement of sustainability in healthcare organizations that happens when the enhancement of human resources attitudes and behaviours towards the environment by means of green practices. In Blass et al., (2017) a system to measure environmental performance in health care organizations is proposed. Lack of strategic focus of performance indicators as well as difficulties for the improvement of environmental performance in hospitals are shown.

Other techniques are applied to overall new constructions, existing buildings or overhauls and conversion of buildings with the common objective to control the use of their resources. Apart from this general objective, the aim of this article is to ensure that health care organizations obtain a certification in accordance with standard ISO 14001 or Regulation EMAS to get successful results in environmental audits. All of this being framed within a continuous improvement process.

Regulation (EC) 1221/2009 defines an environmental audit as a management tool comprising a systematic, documented, periodic and objective assessment of the behaviour of an organization, the management system and the procedures designed to protect the environment with the aim of facilitating operational control of the practices that can impact the environment, and assessing compliance with the environmental policy of the organization, and particularly of its environmental objectives and goals.

There exists a variety of environmental audits, depending on the objective sought, the staff who will carry it out and the environmental areas assessed. (Ximénez & Zulueta, 2001).

- The first classification reflects the body that commissions the audit:
    - Internal audit: commissioned by the organization itself and the auditing staff may or may not belong to the company audited.
    - External audit: commissioned by another organization (for example a certifying body) and always carried out by an independent company.

- The second classification depends on the stage of the Environmental Management System (EMS) audited:
    - Initial review audit: carried out at the initial stage of EMS introduction so as to know the state of the organization before the system is activated, paying special attention to applicable environmental standards.
    - Review audit: commissioned when the EMS is up and running, to check the continuous improvement process and assess the degree of compliance with the objectives and goals set out.
- The third classification depends on some specific environmental aspect to be addressed in order to establish new objectives and foals in the organization.

Environmental audits in Health Care Organizations are within the third classification. For this kind, standard ISO 14001 does not specify any particular question, but it does consider it a highly useful support tool for an organization that wishes to introduce an EMS.

The EMS of a health centre has the global objective of assessing the management with regard to protection of the environment and the handling of natural resources. On the other hand, there are other objectives such as assessment of treatment and disposal of waste produced by the hospital in carrying out its activities (Orozco, 2009). This system may be introduced in accordance with standard ISO 14001 or regulation (EC) 1221/2009 on the voluntary participation of organizations in the EC environmental management and auditing systems (EMAS). The EMAS regulation is more demanding than the standard ISO 14001, and those organizations that comply with it have an excellent environmental image (Bracke et al., 2008).

To introduce an EMS, it is necessary to define a series of environmental indicators which will serve to quantify the development over time of the environmental protection of an organization. (IHOBE S. A, 2000). In recent years, environmental indicators have become an essential part of environmental impact assessments. For this reason, its influence of environmental management and the development of policy at all levels of decision making (Niemejier & de Groot, 2008). These indicators are also useful for converting the data analysed by the decision group into valuable information, when developing management policy. (Peterson & Granados, 2002). The purpose of these indicators is to control the environmental response of an organization and the human activities which affect the efficiency of current policies. An indicator should also reflect changes over time, should be reliable and reproducible (Hammond et al., 1995).

The intention of this paper is to present an innovative and objective system able to provide an environmental assessment of a Health Care Organization. As the current trend is to obtain environmental and energy management system certificates in all kinds of companies (Mas-Alique et al., 2014), using this system would help any medical centre when requesting recognition in accordance with standard ISO 14001, or the regulation EMAS. To this end, a set of hierarchically organized environmental indicators is defined, with the aim of applying the multicriteria decision technique Analytic Hierarchy Process (AHP). Criteria used are characterized by the descriptors and it is not as subjective a model as if a traditional AHP were applied. Finally, the results obtained from applying the model in a Spanish public hospital are set out, to check the validity of the system.

The paper is organized as follows. Section 2 describes the foundation of the methodology used and the environmental indicators used in the assessment. Section 3 shows the results. Section 4 gives the conclusions. Section 5 contains the acknowledgements and section 6 the bibliography.

MATERIALS AND METHODS

Analytic Hierarchy Process

AHP is a technique which allows complex multicriteria decisions to be analysed and organized. According to Saaty (Saaty, 1980), AHP consists of dividing a problem and then joining the solutions to the sub-problems into a conclusion.

The application of AHP starts with the design of the decision structure hierarchy (Eskandari et al., 2016), produced by a decision maker or a decision group. This hierarchy comprises the objective of the problem to be analysed, the criteria and sub-criteria to be taken into account, and the alternatives considered in the decision. Then, an evaluation of the elements is performed, by pairwise comparisons of the criteria and sub-criteria, which may be qualitative or quantitative. To do this, it is necessary to make a value scale indicating how many times more relevant one element is than another with respect to a criterion or a property in which they are compared (Saaty, 2008). The scale used, established by Saaty (Triantaphyllou & Mann, 1995) is shown in Table 1. These pairwise comparisons make up, together, a pairwise comparison matrix.

Table 1 Fundamental scale of Saaty.

Importance	Definition
1	Equal importance.
3	Moderate importance.
5	Strong importance.
7	Very strong importance.
9	Extreme importance.
2, 4, 6, 8	Compromise values between those above.
Reciprocal	If activity i has one of the numbers assigned above zero in comparison with activity j, then j has the inverse value in comparison to i.
Rational	Ratios derived from the scale.

In general, the pairwise comparison matrices are like that shown in Eq. (1)

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

Matrix A has the following characteristics:

- It is a square matrix, size *nxn*, where *n* is the number of elements compared.
- Matrix *A* is reciprocal and positive.
- a_{ij} is the preference of the alternative in row *i* when compared with the alternative in column *j*.
- When $i=j$, the value of a_{ij} will be equal to 1, as the alternative is compared with itself.
- It can be verified that $a_{ij} \times a_{ji}=1$.

Once the pairwise comparison matrix is obtained, the priority of each element must be calculated. This establishes a ranking of alternatives, and the alternative with the highest value is chosen as the most satisfactory (Chowdhury & Roy, 2016).

AHP allows the level of consistency of the judgements given to be assessed, to guarantee the quality of the final decision (Buiza-Camacho et al., 2016). To calculate the consistency of the judgements given by the decision maker, Saaty proposes the Consistency Index (CI), defined as in Eq. (2):

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (2)$$

Where λ_{max} is the main value or maximum autovalue of matrix A and n is its order, such that $\lambda_{max} \geq n$. The CI depends on the order of the matrix, and so Saaty defines the Consistency Ratio (CR) as:

$$CR = \frac{CI}{RCI} \quad (3)$$

Where RCI is the mean random consistency index obtained by randomly simulating the judgements for reciprocal matrices of order n. The values of the RCI (Aguarón & Moreno-Jiménez, 2003) are calculated as shown in Table 2.

Table 2 Random Consistency Indices (RCI).

n	3	4	5	6	7	8	9	10	11	12	13
RCI	0.525	0.882	1.115	1.252	1.341	1.404	1.452	1.484	1.513	1.535	1.555

Consistency is considered acceptable when RC is less than 10%.

This technique is very widely applied due to its ease of use and its simplicity, and thus, AHP is better accepted by decision makers and used extensively in the literature. Among the most important applications are (Bhushan & Rai, 2004):

- Choice: selection of an alternative from a group of alternatives.
- Prioritization: determining the advantages of a set of alternatives.
- Resource assignment: searching for the best combination of alternatives subject to a series of restrictions.
- Market comparison: comparing processes or systems with other markets, with prior knowledge of the processes or systems.
- Quality control: guaranteeing consistent application.

Environmental indicators

In recent years, environmental indicators have become an essential part of environmental impact assessment (Luna-González & Rodríguez-Hurtado, 2012). For this reason, its influence on environmental management and the creation of policies at all levels of decision making has increased (Niemejier & de Groot, 2008). They have an important role in defining environmental policies, as they allow the evolution of the state of the environment, human influence, and the effectiveness of the measures taken to protect the environment, to be measured (van der Voet et al., 1999).

The Public Society for Environmental Management defines environmental indicators as an instrument that quantifies evolution over time of environmental protection in an organization, identifying trends and allowing immediate correction if necessary (IHOBE S.A, 2000). Among the features that environmental indicators should have are the following (Royuela, 2001):

- Relevance: at national level, although they may be used at regional or local levels.
- Pertinence: with respect to the goals of sustainable development and others.
- Clarity: comprehensible, simple and unambiguous.
- Viability: within the limits of the national statistical system and available at the lowest possible cost.
- Limitation: in number, but covered by an enrichment criterion.
- Representativeness: chosen by consent.

Among the objectives of these environmental indicators is control of the environmental response of an organization and the human actions that affect the efficiency of current policy. Furthermore, an indicator should reflect changes in a time period after being introduced, and should be reliable and reproducible (Hammond et al., 1995).

Environmental criteria in health centres

Following the recommendations of the Commission of the European Communities for applying regulation (EC) nº 761/2001 (European Union, 2009), the criteria used in this paper are classified into three main groups: Criteria for environmental behaviour, Criteria for environmental management and Criteria for environmental condition. Each criterion includes a set of first level sub-criteria, which, in turn, contain second level sub-criteria. A series of indicators have been defined for the latter, with associated scale levels. For reasons of space, they are not all defined in this article, but they may be seen in full in the supporting file (Online Resource 1).

The criteria for environmental behaviour allow assessment and follow-up of the environmental impact of an organization. They focus on the planning of processes and the material means available, and on controlling their use. This group includes the following sub-criteria: Atmospheric emissions, Water, Energy consumption, Consumption of materials and Waste.

As an example, we now give the definition of the sub-criterion Waste, and one of its associated indicators. For the other criteria, sub-criteria and indicators used in the model, the same methodology and format has been used to describe them.

Waste: the quantity of waste generated in a big environmental problem Health Care Organizations. Thorough control of waste is necessary in order de manage it effectively. According to Law 83/1999, of the 3rd of June, which regulates activities related to the production and management of bio-sanitary and cytotoxic waste in the Comunidad de Madrid (Comunidad de Madrid , 1999), waste generated by health centres is classified as follows:

Class I: General waste.

Class II: Bio-sanitary waste treatable as urban waste.

Class III: Special bio-sanitary waste.

Class IV: Bodies and human remains.

Class V: Chemical waste.

Class VI: Cytotoxic waste.

Class VII: Radioactive waste.

Once the types of waste that can appear in a Health Care Organization are known, a choice is made of those that may cause most problems if not adequately controlled, and indicators are defined for them. Here is an example of an indicator:

Ratio of potentially infectious waste per patient: This indicator assesses the quantity of potentially infectious waste collected and eliminated in accordance with statute. The lower the value of this criterion, the better the sustainability of the centre. If disposed of directly, like waste treatable as urban waste, there is a risk to the staff of the clinic, to the wider community and to the environment. In the case of health centres, the maximum quantity of waste whose collection and disposal is subject to local laws to prevent infections, is 0.90 kg/patient (Carnero, 2014). The scale levels for this indicator are shown in Table 3.

Table 3 Scale levels for the indicator Ratio of potentially infectious waste per patient.

Levels	Definition
L1 (highest level)	A value of 0 kg/patient of potentially infectious waste is obtained, and is disposed of according to by-law.
L2	A value from (0, 0.45] kg/patient of potentially infectious waste is obtained, and is disposed of according to by-law.
L3	A value from (0.45, 0.90] kg/patient of potentially infectious waste is obtained, and is disposed of according to by-law.
L4	A value > 0.90 kg/patient of potentially infectious waste is obtained, and is not disposed of according to by-law.
L5 (lowest level)	Doesn't know/doesn't answer.

On the other hand, the criteria for environmental management are related to the need to control and assess the management of the processes and efficiency in achievement of a company or organization (Atehortúa, 2005). This group comprises the following sub-criteria: Legal matters, Staff/patient/environment sensitivity, Green purchasing and Waste management.

In this case, the example shows the definition of the sub-criterion Green purchasing, and one of its associated indicators.

Green purchasing: Health Care Organizations purchase many products every year. Among these purchases are computer equipment, cleaning products, furniture, electrical apparatus, paper, clinical materials, etc. All these things have an impact on the environment during sourcing, production, use and disposal; this may include emission of greenhouse gases, exhausting of natural resources and loss of biodiversity.

Green purchasing is a tool that centres may use voluntarily to contribute to the reduction in damaging effects on the environment. It consists of, when buying or contracting products and services, taking into account not only economic or technical aspects, but also their environmental impact over their life cycle; that is, considering the environmental behaviour of the supplier. This system offers benefits to the Health Care Organization, such as improving its image and leading to environmental progress. The indicator associated with this sub-criterion is defined here:

Environmental management of suppliers: This indicator is defined as, when contracting suppliers, demanding a series of special conditions so that the contract respects the environment as much as possible. The conditions are that the suppliers should remove, transport and dispose of or recycle the waste produced in accordance with the environmental management of the health centre. The health care centre informs the suppliers of its environmental policies and responsibilities. Suppliers should accept this commitment and keep to it. The levels defined for this indicator are shown in Table 4.

Table 4 Scale levels for the indicator Environmental management of suppliers.

Levels	Definition
L1 (best level)	The Health Care Organization has a system of green purchasing whereby the suppliers are responsible for removing, transporting and disposing of or recycling the clinical waste produced, in accordance with the environmental management of the centre.
L2	The health centre does not have a system of green purchasing.
L3 (worst level)	Doesn't know/doesn't answer.

Finally, the criteria for environmental condition give information about the environmental situation in the area where the organization or company is located. They are made up of the following sub-criteria: Biodiversity, Noise pollution and Emergency situations.

RESULTS AND DISCUSSION

Hierarchy Model

Table 5 shows the elements that make up the hierarchy model used in the environmental assessment model described. The model obtained is complete, non-redundant and the criteria and sub-criteria are mutually independent. Also, the number of elements involved in the comparisons is no greater than nine, and so the Miller index is satisfied. The hierarchy consists of an objective, three criteria, twelve first level sub-criteria, eight second level sub-criteria, forty-six indicators and five alternatives. These last correspond to the levels of excellence of the environmental assessment system, and are:

- Alternative 1 (A1): EXCELLENT: All levels required are always satisfied, and so there is an optimal and correct environmental assessment system.
- Alternative 2 (A2): VERY GOOD: All levels required are nearly always satisfied, that is, most of the indicators reach optimal levels. The system is highly acceptable although the indicators with poorer outcomes should be improved.
- Alternative 3 (A3): GOOD: The level required are satisfied sporadically. The indicators achieve medium or low levels. The EAS is acceptable although there should be work done to improve it.
- Alternative 4 (A4): DEFICIENT: The levels required are not satisfied. The indicators achieve low or undesired levels. The EAS should be grossly changed.
- Alternative 5 (A5): VERY DEFICIENT: Reaches the worst levels present in the assessment system. Corrective management action should be carried out to improve it.

Two additional alternatives are also defined:

- MAXIMUM (M): This level is reached when expectations are more than met, and the level of the indicator is above the alternative Excellent.
- MINIMUM (m): This level is obtained when expectations are not reached and the level of the indicator is below the alternative Very Deficient.

Table 5 Hierarchy Structure

Objective	Criteria	First Level Sub-criteria	Second Level Sub-criteria	Indicator
Environmental assessment system	Environmental Performance	Atmospheric Emissions		Sulphur dioxide (SO_2)
				Nitrogen oxide (NO_x)
				Non-methane volatile organic compounds (NMVOC)
				Ammonia (NH_3)
				Suspended particles ($SP_{2.5}$)
				Methane (CH_4)
				Carbon footprint
		Water		Total water consumption
				Waste water discharges
				Recycling and reuse
		Energy consumption		Gasoil consumption
				Electricity consumption
				Diesel / Natural gas consumption
				Renewable sources consumption
		Materials consumption	Office supplier	
				Paper consumption
				Chemical materials
			Ink/batteries/toner consumption	
				Fluorescent tubes consumption
				Radiographs
		Waste		Ratio of potentially infectious waste per patient
				Ratio of cytotoxic waste per treatment
				Ratio of chemical products with hazardous substances
				Water waste with hazardous substances
	Environmental management	Legal aspects		ISO 14001
				EMAS
		Staff/Patients/Environment Sensitivity		Environmental training plan
				Awareness campaigns
				Meeting with professionals from management and improvement area
				Information of environmental progress
				Environmental costs
				Fulfillment environmental objectives
				Complains and suggestions
		Green purchasing		Environmental management of suppliers
		Waste management	Identification	
				Proper identification of waste
			Segregation	
				Proper segregation of waste
			Packaging	
				Type of packaging
				Colors
				Reuse
			Waste collection	
				Waste collection
				Medicines collection
			Transport	
				Internal transport of waste
			Disposal	
				Protection and risk prevention policies of staff
				Responsibilities
	Environmental Situation	Biodiversity		Take care of species included in the IUCN Red list
		Acoustic pollution		Noise inside the health center
				Noise outside the health center
		Emergency situations		Environmental accidents

Pairwise comparison matrices

To perform the environmental assessment according to the hierarchy model set out above, the pairwise comparison matrices are divided into two groups: the first corresponds to the pairwise comparison matrices between the criteria and sub-criteria; and the second, between the scale levels of the indicators. 17 matrices of the first type, and 46 of the second, were assessed. In both cases, assigning judgements is done by three decision centres made up of a health professional, an expert in environmental matters, and a specialist in multicriteria decision techniques. From these three judgements, a geometric mean was taken, to calculate the resulting aggregate judgement for each matrix.

Table 6 shows an example of the pairwise comparison matrix for the sub-criterion Waste. This matrix includes the local and global weighting, as well as the CR, indicating inconsistency present in the judgements of the experts. Next Table 7 shows the pairwise comparison matrix for the indicator Environmental management of suppliers.

Table 6 Pairwise comparison matrix for the sub-criterion Waste.

Index		A51	A52	A53	A54
Ratio of potentially infectious waste per patient	A51	1	0.320	4.000	5.000
Ratio of cytotoxic waste per treatment	A52	3.125	1	6.950	5.940
Ratio of chemical products containing hazardous substances	A53	0.250	0.144	1	0.320
Water-based waste containing hazardous substances	A54	0.200	0.168	3.125	1
	Local weighting	0.278	0.565	0.056	0.089
	Global weighting	0.024	0.056	0.006	0.010
				CR=	0.099

Table 7 Pairwise comparison matrix for the indicator Environmental management of suppliers.

Scale levels	L1	L2	L3
L1	1	3	5
L2	1/3	1	3
L3	1/5	1/3	1
		CR=	0.04

It can be seen that the matrices are consistent as they do not exceed the index established by Saaty. As with the definition of criteria, not all the matrices are included, for reasons of space.

Priority and synthesis

Having obtained the pairwise comparison matrices, the local and global priorities must be obtained for each of the matrices calculated at the previous stage. A ranking of alternatives is then established to determine which of them is best for solving the problem in question (Boj et al., 2009). Fig. 1 shows the weightings obtained.

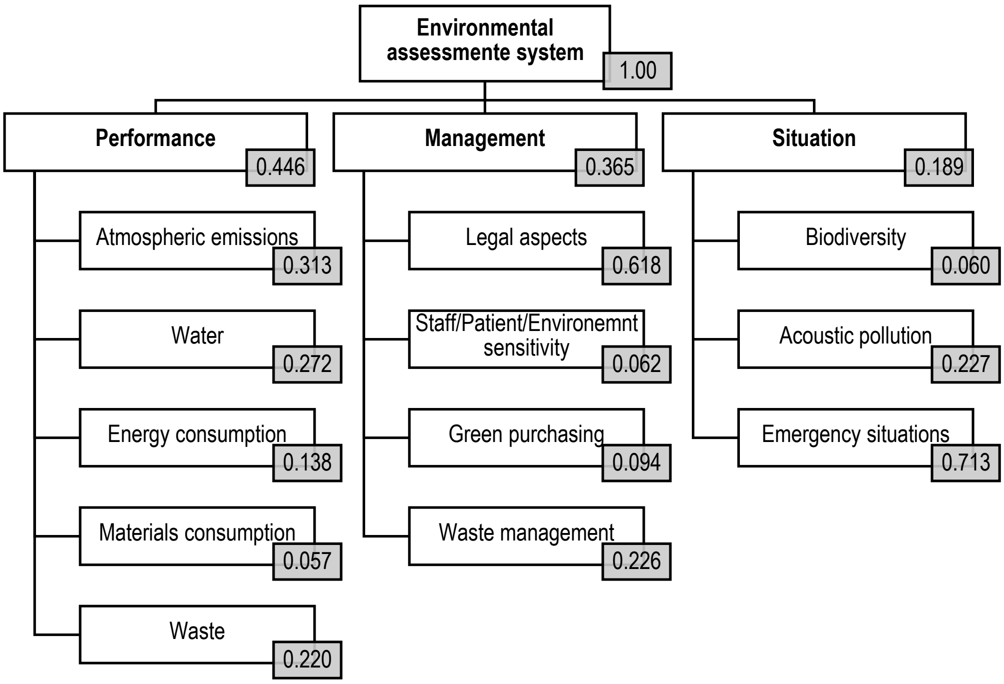

Fig. 1 Weightings obtained.

It can be seen that the criterion with the greatest weighting, that is, the criterion of greatest importance, is Environmental behaviour. In second place is the criterion Environmental management, and in last place is Environmental condition. The result is considered solid because the sub-criteria covered by Environmental behaviour are very important in contributing to improving the environment.

On the other hand, one of the sub-criteria with the lowest values is Biodiversity. This result is reasonable because the intention of this sub-criterion is to conserve endangered species included in the International Union for Conservation of Nature (IUCN) in areas belonging to the health centre being assessed. As these centres are usually in urban areas, it is not common to find these species, and so the consequences are minimal.

PRACTICAL CASE: Assessment of a Spanish public hospital

A Spanish public hospital was assessed, to verify its environmental state, and so check that the system described here can be applied to any health centre. The health centre is located in the Autonomous Community of Andalucía and has nearly 1,000 beds. For reasons of confidentiality, no more information about the hospital is given.

The only requirement for using the method is to have the necessary data; in this case, the data can be found in the Sustainability Records for 2011. The questionnaire contains 46 questions. Each has a set of answers corresponding to the scale levels previously defined for each indicator. Depending on the answer chosen, the appropriate alternative is selected. Table 8 shows a section of the questionnaire. The complete questionnaire that was filled out in shown in Annex A.

Table 8 Section of questionnaire.

	Indicators	Scale levels	Alternatives				
			A1	A2	A3	A4	A5
Waste	Ratio of potentially infectious waste per patient	A value equal to 0 kg/patient of potentially infectious waste is obtained.					
		A value between (0, 0.45] kg/patient of potentially infectious waste is obtained and it is removed complying with regulations.		X			
		A value between (0.45, 0.90] kg/patient of potentially infectious waste is obtained and it is not removed complying with regulations.					
		A value higher than 0.90 kg/patient of potentially infectious waste is obtained and it is not removed complying with regulations.					
		Does not know/Does not answer					
	Ratio of cytotoxic waste per treatment	An equal value to 0 kg/treatment of cytotoxic waste is obtained					
		A value between (0, 0.35] kg/treatment of cytotoxic waste is obtained		X			
		A value between (0.35, 0.70] kg/treatment of cytotoxic waste is obtained					
		A value higher than 0.70 kg/treatment of cytotoxic waste is obtained					
		Does not know/Does not answer					
	Ratio of chemical products with hazardous substances	An equal value to 0 kg/analysis of chemical products is obtained					
		A value between (0, 0.05] kg/analysis of chemical products is obtained					
		A value between (0.05, 0.1] kg/analysis of chemical products is obtained			X		
		A value higher than 0.1 kg/analysis of chemical products is obtained					
		Does not know/Does not answer					
	Water waste with hazardous substances	An equal value to 0 kg/analysis of water waste with hazardous substances is obtained					
		A value between (0, 0.075] kg/ analysis of water waste with hazardous substances is obtained					
		A value between (0.075, 0.15] kg/ analysis of water waste with hazardous substances is obtained					
		A value higher than 0.15 kg/ analysis of water waste with hazardous substances is obtained					
		Does not know/Does not answer					X

Results

Fig. 2 shows the results of the questionnaire summarized as a pie chart. 36% of the questions, that is, of the indicators calculated, gave a value of EXCELLENT, 14% VERY GOOD, 7% GOOD, 7% DEFICIENT and 36% VERY DEFICIENT. This final result appears striking, but it is because the centre assessed did not have or did not know the information requested, and was penalized for it.

The alternatives MAXIMUM and MINIMUM are included in the alternatives EXCELLENT and VERY DEFICIENT respectively, since they have the same values. They are, therefore, not shown.

It can be said, then, that the health centre assessed obtains, in general, very good results in the environmental criteria that it manages. These criteria are related to energy consumption, the production of hazardous waste, legal matters, environmental sensitivity of staff, patients and others, and the environmental management of suppliers. On the other hand, issues to be borne in mind to continue contributing to the environment are, for example: the control of atmospheric emissions, the increase in consumption of renewable energy, and the logistics of the waste produced.

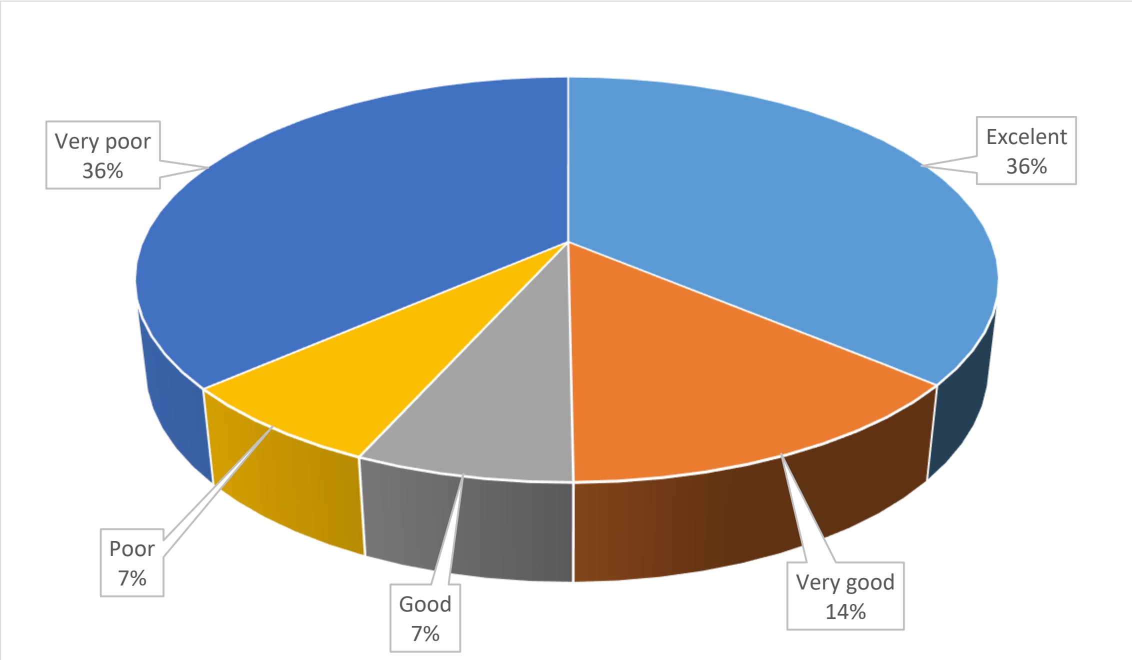

Fig. 2 Results of the sustainability assessment in a Spanish hospital.

In the final assessment, a score of 0.6286 out of 1 was obtained. Therefore, the centre assessed is well on the way to improving its overall environmental management. As a suggestion, it is proposed that they focus on those criteria with the weakest scores, in order to assess them and take action to improve the results. Once these actions have been taken, there should be an improvement in the sustainability assessment of the hospital when applying our methodology again.

CONCLUSIONS

This paper describes a method for carrying out environmental assessments in Health Care Organizations. With the support of this tool, any hospital that wishes to introduce an EMS according to standard ISO 14001, or to join the EMAS, can check the environmental state it is in, and which areas should be improved to obtain certification without difficulty.

Furthermore, the model is a novel means of contributing to improvements in sustainability in health centres. Unlike traditional audits, the use of multicriteria decision techniques including a hierarchy structure for the problem, helps the decision makers to organize the problem easily and define the desired objective explicitly. The method as a whole is able to measure criteria both qualitatively and quantitatively through a common scale. Finally, it is shown that the model can be used to assess different hospitals; the only requirement is to have access to the information in their sustainability reports.

As future work, the intention is to assess other hospitals to compare the results obtained and thus establish an improved hierarchy, eliminating the criteria that it is not in fact necessary to assess, if there were any, and redefining those that need it, adding new criteria as appropriate.

Acknowledgement

This research was supported by the Junta de Comunidades de Castilla-La Mancha and the European Regional Development Fund under Grant number PPII-2014-013-P.

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