Pesquisa Operacional (2023) 43: e265411 p.1-28
doi: 10.1590/0101-7438.2023.043.00265411

Printed version ISSN 0101-7438 / Online version ISSN 1678-5142
www.scielo.br/pope
ARTICLES

RECOVERY OF A GREEN HOSPITAL SYSTEMS BASED ON ISO 14001: 2015 STANDARDS

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Received June 28, 2022 / Accepted February 20, 2023

ABSTRACT. This study targets six North Asia and African hospitals that provide clinical treatment, diagnostic, and consultation services. The study revealed a lack in the selected hospitals' infrastructure to support implementation successfully Environmental Management Systems (EMS). A factor analysis was performed based on five factors; EMS efficiency, the hospital's culture, support from top management, legislation, and time and budget controls. Out of 23 sub-factors tested, it has been found that 7 of them can control the differentiation of the factors. The results highlight human errors in chemical and medical materials that lead to environmental pollution. It was followed by a sub-factor that indicated that controls of hospital activities and correction of its performance depend on the feedback received from the environmental information system. The study's main conclusion is that recovering green hospital systems depends on successfully carrying out the ISO 14001: 2015 standard.

Keywords: environmental management system, green hospitals, ISO 14001: 2015 standards, continuous improvement, social responsibility, hazardous waste.

1 INTRODUCTION

An Environmental Management System (EMS) is an integrated development environment that can be achieved with the ISO 14001:2015 standard requirement. This seeks to take action beyond the existing environmental legislation and plan to continuously improve environmental activities to reduce the natural environment's adverse effects (Ociepa-Kubicka *et al.,* 2021). ISO 14001:2015 standard can support environmental protection and pollution prevention following

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economic-socio needs that match the EMS requirements (Tuna, 2022). Thus, it can support sustainable development through the completion of environmental protection procedures toward obtaining benefits economic, ecological, and social (Ferreira and Teixeira, 2010; Tudor *et al.,* 2005). So, most hospital environmental issues must be identified, such as waste management, reasons for air pollution, water and sewage disposal methods, soil contamination, reducing the effect of climate change, and efficient use of available resources (Saravanan *et al.,* 2021; Rajan *et al.,* 2019; Gavrilescu *et al.,* 2015).

In the context of healthcare organizations, most healthcare organizations use the EMS to improve their performance.

The EMS provides effective information systems that support regulatory requirements by offering annual performance reports, activity schedules, and *emergency* plans (Matthews *et al.,* 2004). The organizations obtain several advantages, e.g. minimizing the medical waste risks arising from their daily activities, reducing the annual budget for environmental protection, increasing the knowledge skill of the workforce, maintaining compliance with environmental regulations, and reducing legal responsibility and risks (Björnsdottir and Jensson, 2022; Christini *et al.,* 2004). In addition, most hospitals seek to provide medical services on time with reduced total costs for the health system by removing unnecessary activities of specialized care (Arnaudo, 2022). However, Sepetis and Kada (2009) study confirmed that most hospitals have suffered from the lack of an effective ecosystem, despite their commitment to applying environmental protection laws and standards (Sepetis, 2019). Furthermore, daily medical activities and processes (Mujan *et al.,* 2019; Watts *et al.,* 2019) aim to provide healthcare services and treat patients (Grol and Wensing, 2020), which leads to generating much waste in the environment (Nkechi *et al.,* 2013). It directly impacts the environment and negatively influences human health (Sepetis, ; Eckelman and Sherman, 2016). This includes a broad range of materials from used diagnostic samples, pharmaceuticals, needles, and syringes to soiled dressings, blood, body parts, chemicals, medical devices, patient organic waste, hazardous medical waste, and radioactive materials (Nkechi *et al*., 2013; Sepetis, 2019; Todd, 2009; Watts *et al.,* 2019).

Likewise, recent medical technological innovations may produce greenhouse gas emissions directly and indirectly while treating patients, increasing negative impacts on the natural environment (Valencia Urbano, 2021). Tsioumpri *et al.* (2020) study compared the procedures of sustainable development incorporated processes adopted by hospitals with different cultures and knowledge of EMS, a Swedish and a Greek hospital. The Swedish hospital has obtained ISO14001:2004 certification and its preparation for ISO14001:2015 certification. It has a hospital environmental plan incorporated into decision-making processes and budgets based on its annual environmental goals. In contrast, the Greek hospital was certified with ISO9001:2008 in 2015 for a number of activities. The findings argued how much difference in the application of EMS renewed.

EMS still needs to improve (Todd, 2009). Environmental issues can be identified according to the type of services provided to society. Regulations and environmental protection laws are also stated accordingly. So, a healthcare organization must develop strategies to avoid environmental

damage. Besides pollution control measures, it needs to re-engineer its medical products and processes of manufacturing. This must begin with inputs, processes, and outputs (Sroufe and Joseph, 2017).

So far, the social responsibility of the healthcare sector requires adopting an effective Environmental Hospital System (EHS) that contributes to environmental protection and also preserves the health of staff, individuals, and society. It often carries out these measures because of fear of sanctions and legal and social duties or to maintain its market share and reduce closer monitoring by environmental protection organizations (Sroufe and Joseph, 2017). Accordingly, it needs to conduct further research on the factors that can contribute to improving the hospitals' performance and the difficulties of applying EMS in healthcare organizations.

Therefore, this study focused on developing a strategy to recover green hospital systems by applying EMS based on ISO14001:2015. That contributes to optimizing their performance, reducing the medical waste resulting from their daily activities, and addressing the difficulties applied in the health sector.

2 LITERATURE REVIEWS

A conceptual theory of the recovery of green hospital systems based on applied ISO 14001: 2015 standards are developed here in three key parts. It begins with evaluating the effectiveness of hospitals' current EMS. Then it identifies the advantages of applying ISO 14001: 2015 standards in these hospitals. Finally, it classifies the types of healthcare waste and their disposal methods and identifies the obstacles to applying the hospital's environmental management system.

2.1 Environmental Management System

An Environmental Management System (EMS) arises because of human activities and their relationships with the physical environment and biological systems (Sepetis and Kada, 2009). It focuses on objective analysis that ensures and controls the continued development of technology without any change in the natural system (Eckelman and Sherman, 2016). Also, EMS is defined by the United Nations as developing environmental plans and policies that contribute to monitoring and assessing the environmental impacts produced by the industrial project. It includes all stages of production, from obtaining raw materials to the final product and the extent to which each stage impacts the environment. It also efficiently implements regulatory procedures, considering the costs and tax implications (WHO, 2017). Table 1 summarizes the history of the development of the EMS. The success of the implementation of the EMS contributes to achieving the environmental performance goals of any organization and promotes sustainable development, which includes (Rondinelli and Berry, 2000):

- The environmental objective is the environmental protection goal created by environmental policy, which the organization develops to verify its applicability and evaluation.

- Environmental policy is the organization's statement that describes its objectives and principles related to comprehensive environmental performance. It also includes the work structure and an organization's environmental responsibility.
- EMS is part of the overall management system. It includes organizational structure, planning activities, responsibilities, practices, procedures, and processes. Its review and protection of environmental regulations and laws, in addition to the resources related to environmental policy development, its application, and improvement.
- Measurement and evaluation, measuring methods, and monitoring are the main activities required for environmental performance assessment.
- The EMS needs to be reviewed periodically to determine how its implementation is consistent with the planned objectives.
- In order to improve environmental performance, the ISO 14001:2004 standard has been known as a renewed process to develop an environmental management system to improve overall environmental performance through an environmental policy.

The ISO 14001 standard defines a minimum set of requirements for environmental management that an organization must have effectively implemented to achieve registration. This can help companies focus on continually improving their environmental performance and control through their EMS. This EMS provides a structured framework to manage environmental risks and issues effectively and provides a process to initiate improvement. Shell's EMS is embedded in its broader health, safety, and environment management system (Crowe *et al.,* 2003). In the context of the healthcare sector, the new environmental policies adopted in each Health Care Unit voluntarily plan environmental managerial strategies. Hospitals gradually apply the tools of voluntary environmental management strategies, such as the international environmental management system ISO 14001 and the European system EMAS1 (Sepetis *et al.,* 2020; Sepetis and Kada, 2009).

2.2 Healthcare waste management

According to the World Health Organization (WHO) and the U.S. Environmental Protection Agency, around 10–25% of healthcare waste is classified as hazardous or special waste (Eleyan *et al.,* 2013). Even the percentage of these wastes appears to be lower than general waste. Nevertheless, it is a higher risk to human health and the environment because infectious and harmful material healthcare waste can influence human health. It contains carcinogenic, hemotoxic, pathological, chemical, and pharmaceutical waste. Other types have high heavy metal content, pressurized containers, and radioactive waste (Eleyan *et al.,* 2013). It has health risks that directly affect the lives of hospital staff and people who daily deal with health waste. Usually, this risk depends on healthcare waste management practices. For example, the risk level that affects the environment due to Portugal Hospitals' activities reported were 4.24 for the risk of healthcare

Table 1 – The history of the rise of the environmental management system.

Authors, Years	*Years*	*Developed by*	*A series of development in the EMS*
Lytle, 2007; Kroll, 2001	1962	Rachel Carson	He was the first to bring the world's attention to the environment after the publication of her book Silent Spring in 1962, based on the atomic explosions that caused massive damage to the environment in 1955
Handl, 2012	1968	UNGA	United Nations General Assembly had proposed a conference about the environmental issues
Barrow, 2006	1970	Increased pollution	Begin attention to EM issues due to the effect on the environment by the industries and increase human beings' activities
McAdam, 2017; Rhyner, 2017	1972	EC Stockholm, Sweden,	At the Environment Conference in Stockholm, Sweden determined the optimum utilization of the available material and social resources without harming the environment
Chu & Karr, 2017; Schuler et al., 2017	1987	Independent Commission on the Environment	It introduced the concept of sustainable development and defined the Organization's operating environment and its impact on the surrounding environment.
Çalış & Büyükakıncı, 2019; Heras-Saizarbitoria et al., 2018	1992	British Standards Organization	British Standards Organization (BS 7750) was derived from quality specification 5750
Wilson& Campbell, 2020	1994	International Standard Organization	the Environmental Management Specification was issued by International ISO
Delmas, 2002	Sept. 1996	International Standard Organization	ISO issued the first edition of the ISO 14000 Series, a set of guidelines for developing systems and practices in six environmental sectors.
Delmas, 2002	Sept. 1996	ISO: EMS series contains six sections	ISO 14001 and 14004 (EMS), ISO 14010 to 14012 (Environmental Auditing), ISO 14020 to 14025 (Environmental Labeling), ISO 14031 (Environmental Performance Evaluation), ISO 14040 to 14043 (Life Cycle Assessment), and ISO 14060 (Environmental Aspects in Product Standards).

Source: Table designed by the authors based on the previous studies.

staff, 4.08 for the waste workers, 3.29 for the patients, and 2.80 for the visitors (Ferreira and Teixeira, 2010).

The healthcare sector aims to provide high-quality health services first, without considering the type of energy used and its harmful environmental effects, as cited by *NHS England (2013*). It indicated that most hospitals are considered great energy users with unique requirements for facilities like heating, cooling, powering, and running medical equipment (WHO, 2017), mainly in operating theatres and treatment rooms. That has led to increased gas emissions. For example, the energy used for heating and power is responsible for 12% of all UK greenhouse gas emissions (DECC, 2011). So, the social responsibility of the health sector requires adopting measures

that contribute to reducing the impact of harmful emissions on the environment. Research maintains the quality of health service delivery to patients without increasing costs by adopting clean energy that it considers environmentally friendly, as Carbon Trust (2010) referred to. Therefore, hospitals need to adopt reduction strategies for harmful gas emissions. This strategy enables to balance between healthcare services (Morgenstern *et al.,* 2016). Based on the countries' social responsibility toward protecting the environment, the UNFCCC was issued in 1994 to reduce greenhouse gas emissions (Silva *et al.,* 2017).

Hospitals indicated the disposal of sewage in rivers and nonagricultural soils as a primary reason for the exposure to heavy fecal contamination. Consequently, it produces antibiotic-resistant bacteria in the community. Then, its influence proliferates in soil and surface waters, persists, and spreads in different environments (Novais *et al.,* 2005). For example, general waste gas produced due to health care daily activities has been estimated to be around 75–90% of the types of waste. The municipality and wastewater can dispose of this type of waste. It has been considered somewhat not dangerous and not requiring any suffering in handling and special treatment.

Sewage pollution results from poor disposal of patients' sewage waste containing enterococci (Eleyan *et al.,* 2013). Waste management hospitals must design a system for treating and disposing of healthcare waste, whether general or hazardous. This system reduces the impact of waste from environmental pollution and safety and ensures reliable healthcare for human health and the environment (Eleyan *et al.,* 2013; Sant'Anna *et al*., 2022).

An effective waste management system enables the sorting of medical waste according to the nature of the materials and the risks (Tsioumpri et al., 2020). This system contributes to reducing the impact of this waste from environmental pollution and safety. It also ensures reliable healthcare for both human health and the environment. Besides, sewage treatment processes could provide advantages like renewable energy production (Sant'Anna *et al.,* 2022). Nevertheless, it is demanding to control solid waste management in developing countries compared with industrialized counties for several reasons like the novelty of the medical technologies used, the difference in the location of health care, the size of the health services provided to patients, physical capabilities, resources, collection, transport, segregation, and storage (Harhay e*t al.,* 2009).

2.3 The Obstacles to the application of EMS

Hospital management faces many constraints that limit improving environmental performance due to the inability to implement the EMS effectively. Accordingly, administration time needs to identify these constraints to correct them. The most important of these constraints are as follows (Babiak and Trendafilova, 2011; Christine *et al.,* 2004):

- ***The absence of guidelines and standards*** *regulating ecological behavior means random disposal of environmental resources to the point of lack of responsibility, whether civilian or ethical.*

- ***The lack of rules and standards*** *that can use in an environmental audit of the organization leads to ecological behavior.*
- ***The lack of an effective EMS*** *is one of the challenges facing any organization. It contributes to the timely identification and resolution of environmental problems, contributing to ongoing environmental changes. Making the right environmental decision depends on the accuracy of the information available to the management of the organizations, which can save time, effort, and costs.*
- ***Lack of cultural and environmental knowledge*** *due to inaccurate information on environmental protection measures. Besides, environmental protection organizations do not publish advice and guidance for reducing the environmental pollution.*
- ***The lack of cooperation*** *between the industrial and service sectors and environmental protection organizations leads to the inability to address and reduce environmental problems.*
- ***Lack of role in environmental control:*** *the absence of monitoring leads to environmental damage from human activities and industrial waste. Accordingly, it must support environmental protection monitoring and prepare legal legislation on environmental protection.*

3 METHODOLOGY

3.1 Study Scope

This study identifies the majority of issues that are obstacles to applying EMS. These issues relate to administrative, financial, clinical, biomedical, and other aspects of six large hospitals in North Asia and Africa: a public hospital, a maternity hospital, a child hospital, a cardiac surgery hospital, a general surgery hospital, orthopaedics, and a traumatology hospital. Table 2 summarizes the medical services provided to patients by the selected hospitals. These hospitals were chosen because they provide various medical services to patients at a rate of 24 hours per day. They provide daily vital medical services that result in health waste that may affect the surrounding environment. The public hospital provided various medical services to more than 500,000 patients annually since its establishment in 1958. It includes two hospitals, one for general medical services and another specializing in maternity, providing daily healthcare services to 11645 patients. At the same time, the surgical hospital performed 2654 various surgeries per month. The maternity hospital contains 100 beds, including 27 incubators in the intensive care unit for newborns, 7 maternity surgery rooms, and 5 general surgical rooms. The cardiac surgery hospital performed approximately 339 surgical per month.

3.2 Methods

Data was collected by a survey designed based on the conceptual framework model of the hospital EMS.

Table 2 – Medical services provided to patients by selected hospitals.

H	Healthcare services/Month	Patients	H	Healthcare services/Month	Patients
Public hospital	Clinical consultations	9175	Cardiac surgery	Cardiac surgical process	339
	Emergency department	2035		Cardiac consultations	2147
	Outpatient clinic	435		Surgical consultations	1051
	Hemodialysis	3462		Children's consultations	1267
	Radiological tests	5,323		Cardiac catheterization	336
	Ultrasound tests,	627		ECG	1765
	Computerized Tomography	80		X-rays	1611
	MRI tests	516		Sonar	225
Maternity	Natural birth	334		Different diagnoses services	1461
	Surgical birth	298	Orthopaedic surgery	Clinical consultations	932
	Intensive care	300		Emergency department	377
	Resuscitation rooms for a new baby	180		Surgical operations	221
	Laboratory tests	1632		Intensive care	347
Child hospital	Clinical consultations	1213		physiotherapy clinic	197
	Emergency department	1931		ECG	345
	MRI	182		X-rays	2085
	Helical Press	145		Sonar	672
	Radiology Test	1535		MRI	378
	Sonar test	1061	General surgery	Various surgeries	2654
	ECG	14		Laboratory tests	4672

Source: Table designed by the authors based on the data collected.

In addition, it identifies the significant factors and sub-factors of a questionnaire to measure the obstacles to the application of the EMS in the selected hospitals (Shrestha, 2021). The survey supports the study hypotheses and conceptual framework of the EMS. It consisted of 23 questions that covered this study's factors and sub-factors based on the conceptual framework of the component matrix model. A quantitative analysis was performed to investigate this study's hypotheses. A Likert scale (strongly agree, agree, indifferent, disagree, and strongly disagree) allowed the staff to express how much they agree or disagree with specific issues related to hospital activities and obstacles experienced in applying the EMS. Based on this, the validity and reliability of the questionnaire were verified. Of 150 staff invited to participate in this survey, 107 responded to the survey, from hospital administrators, clinical department directors, doctors, and nurses, as shown in Figure 1. The rate of selected hospitals' participation in the questionnaire was as follows; 27% from public hospitals, 21% from maternity hospitals, 18% from child hospitals, 13% from cardiac surgery hospitals, 15% from general surgery hospitals, and 6% from orthopaedic traumatology hospitals, as shown in Figure 2. In the context of subjects-to-variables ratio terms, the sample size is considered acceptable to produce a reliable factor analytic solution (Suhr, 2006; Taherdoost *et al.,* 2022).

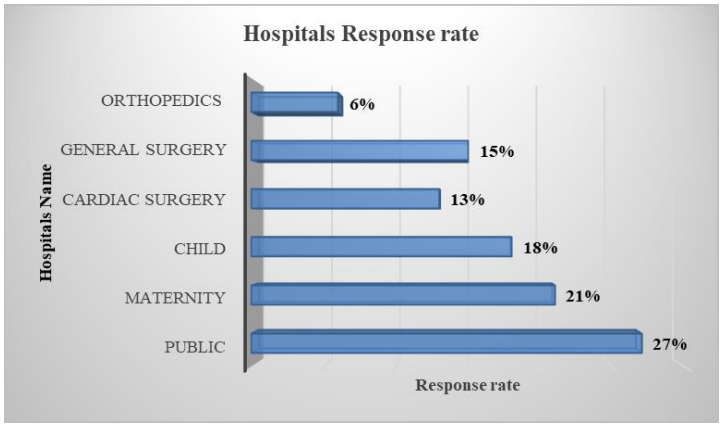

Figure 1 – Response rate for selected hospitals.

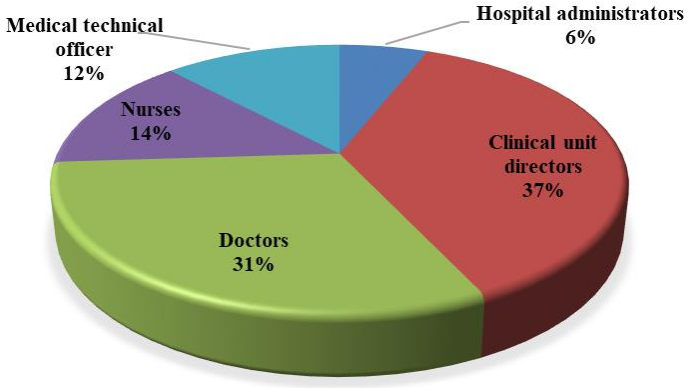

Figure 2 – Response rate for hospitals staff.

3.3 Study design

This study evaluates whether the current EMS adopted in the selected public hospitals efficiently reduces environmental pollution from daily medical activities. Its contribution towards improving the hospital's performance is based on its success in implementing ISO 14001:2015 standards. In this study, the application's most critical obstacles to EMS in selected hospitals were identified according to the research hypotheses and its questions as follows:

H1: Do hospitals have the infrastructure that contributes to the successful implementation of the EMS under ISO14001: 2015 standards?

H2: Does the hospital administration have sufficient knowledge about the application of the EMS under ISO 14001: 2015 standards?

H3: Did the current environmental management system contribute to reducing the environmental damage caused by the daily activities of hospitals?

A Factor analysis approach was adopted to prove the research hypothesis based on the component matrix that includes five basic factors: *Efficiency of the environmental information system in the selected hospitals, Supporting top management commitment to implement the requirements of the EMS, Healthcare organizations' culture and knowledge about EMS based on the ISO 14001: 2015 standards, Controls, legislation, laws, and oversight systems implemented to protect the environment, and Time and budget required to implement EMS.*

3.4 Factor Analysis

The factor analysis method can be applied to investigate any variety of component analyses, given a direct operational interpretation, with determined its exact stopping point. This technique is acceptable for analyzing a large data set when a component analysis is utilized as an alternative or an initial first-stage solution (Bandalos and Finney, 2018; Schubert *et al.,* 2001). Factor analysis is often applied to develop or test a theory. It is performed to explore the underlying structure of an instrument or data group. Accordingly, it is adopted to reduce the number of independent variables, especially when the main variables contain many sub-variables, which achieve multiple benefits when the relationship between them is high (Mertler *et al.,* 2021; Kline, 2014).

Factor analysis is defined by Taherdoost *et al.* (2022) as "a statistical method used to investigate the relationships between the observed variables that are located inside the same group, as measured by questions or elements" (Shrestha, 2021). In the present study, the factor analysis for the matrix components considers five key factors that have a direct effect on carrying out the EMS in selected hospitals, as shown in Figure 3. In each analysis, a range of choices and decisions contribute to improving the factor analysis's accuracy and enhancing the resulting solution's quality (Taherdoost et al., 2022). This study used the factor analysis method to determine the acceptable ratios to the main factor by analyzing the Component Matrix and Rotated Matrix. Then, it used the PLS-SEM to measure the reliability and validity of factors that affect the application of EMS at selected hospitals. This includes composite reliability to evaluate internal consistency, individual indicator reliability, Average Variance Extracted (AVE) to evaluate convergent validity, and, finally, finding discriminant validity to determine the relationships between the indicators and the latent EMS factors (Hair Jr. *et al.,* 2017).

The matrix components were:

First Factor: The efficiency of the environmental information system in the selected hospitals*. In monitoring performance, the hospital relies on the feedback provided by the environmental information system that achieves environmental goals and contributes to coordinating relations between organizations of environmental protection and the hospital. It includes five sub-factors related to evaluating the efficiency of applying the current EMS in the selected hospital and whether the information needed to make the right environmental decision is accurate and timely.*

Second Factor: Supporting top management commitment *to implement the requirements of the EMS at selected hospitals. It includes three sub-factors related to top management's knowl-*

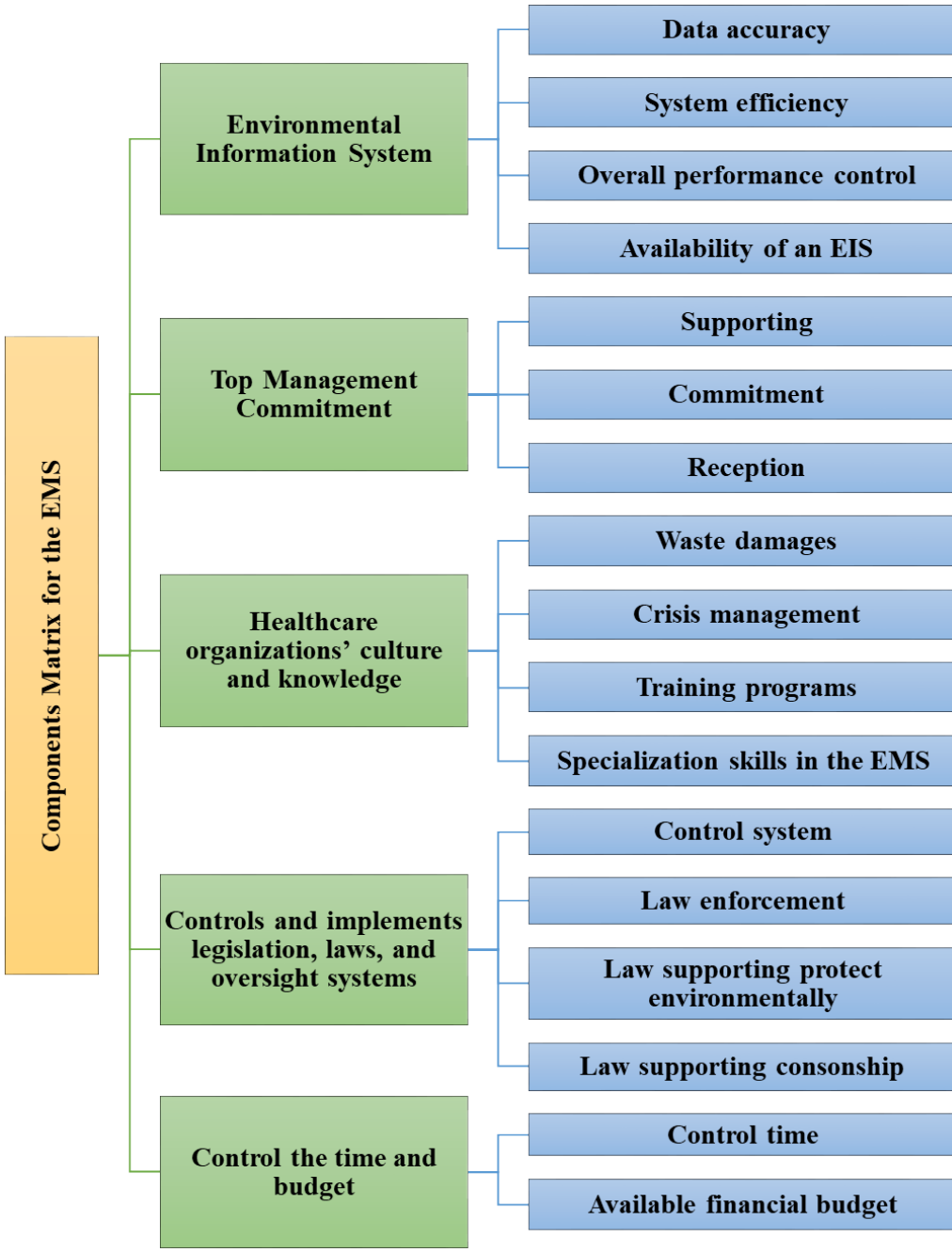

Figure 3 – Component matrix for the EMS.

edge and skills about the EMS. Also, top management must provide resources to support the implementation of the EMS.

Third Factor: Healthcare organizations' culture and knowledge about EMS are based on the ISO 14001: 2015 standards, w*hich are covered in nine sub-factors. It focuses on the hospital's plan to develop employees' knowledge about EMS through adopting ongoing training programs in the EMS that lead to an increase in their specialization qualifications in the EMS, whether the hospital management aims to carry out internal operations and activities more than solving environmental problems.*

Four Factor Controls and implements legislation, laws, and oversight systems *to protect the environment. It included four questions related to the extent to which the selected hospital administration's commitment to applying special legislation to protect the environment by using all efforts, legislations, legal, and primary provisions to support the oversight role towards environmental protection. All hospital activities are subject to regulatory controls to ensure they are not damaging the environment. Based on compulsory legislation and instructions available to protect the environment.*

The fifth factor is Control of the time and budget *required for applied EMS based on the ISO 14001: 2015 standards. It includes the availability of the financial budget and the time needed to implement the environmental management system in the selected hospitals.*

3.5 Validity and Reliability

Validation and Reliability procedures were performed to the quantitative research methods used in this study as demonstrated and justified as a significant way to prove that the study is conducted with conducted quality research. In order to ensure theoretical sophistication, an extensive review of the current literature was undertaken. Based on the factor analysis, a framework generated from this study was applied at the selected hospitals.

4 RESULTS AND DISCUSSION

Optimizing the hospital's performance is based on its success in implementing ISO 14001:2015 standards. Its efficiencies in disposal methods of health waste due to its daily activities reduce the impact of its damage on the surrounding environment, individuals, and society. For this reason, health organizations must understand the obstacles to applying environmental management systems in selected hospitals. So, in this study, a research hypothesis was validated using the factor analysis method to determine acceptable ratios to the main factors by analyzing the Component Matrix and Rotated Matrix. Then, it used the PLS-SEM to measure the reliability and validity of factors that affect the application of EMS at selected hospitals. This includes composite reliability to evaluate internal consistency, individual indicator reliability, average variance extracted to evaluate convergent validity, and finally, finding discriminant validity to determine the relationships between the indicators and the latent EMS factors (Hair Jr. *et al.,* 2017).

Component Matrix investigated five basic factors with its sub-factor that affect applied EMS in the selected hospitals.

Factors in the Component Matrix were coded as follows:

F1 = The efficiency of the environmental information system in the selected hospitals, which was covered by five sub-factors coded as ($F1_1$, $F1_2$, $F1_3$, $F1_4$, and $F1_5$).

F2= Supporting top management commitment to implement the requirements of the EMS, which was covered by three sub-factors coded as ($F2_1$, $F2_2$, and $F2_3$).

F3= Healthcare organizations' culture and knowledge about EMS based on the ISO 14001: 2015 standards, which was covered by nine sub-factors coded as ($F3_1$, $F4_2$, $F3_3$, $F3_4$, $F3_5$, $F3_6$, $F3_7$, $F3_8$, and $F3_9$).

F4= Controls, legislation, laws, and oversight systems that are implemented to protect the environment, which was covered by four sub-factors coded as ($F4_1$, $F4_2$, $F4_3$, and $F4_4$), and

F5= Time and budget required to implement EMS at selected hospitals, which was covered by two sub-factors coded as ($F5_1$ and $F5_2$).

4.1 Investigation of the effectiveness of the environmental information system factor

This section determines the obstacles to implementing EMS and finding the optimal solution that helps the hospital administration correct its performance. The factor analyses are based on the matrix components to evaluate the efficiency of applying the current EMS in selected hospitals. It includes five sub-factors coded as $F1_1$, $F1_2$, $F1_3$, $F1_4$, and $F1_5$, which are related to evaluating the efficiency of applying the current EMS in the selected hospital. If the information that needs to make the right environmental decision is accurate and available in time is demonstrated in Table 3.

The result in Table 3 indicated that the hospital performance monitoring relied on the feedback provided by the environmental information system that achieves environmental goals. In monitoring performance, if the hospital relies on the feedback provided by the environmental information system that achieves environmental goals, it contributes to coordinating relations between organizations, environmental protection, and the hospital. However, this system is still inefficient in applying the current EMS in the hospital. Therefore, it needs a long time to implement.

4.2 Investigation of the top management commitment

Based on a matrix of components, a quantitative analysis aims to examine whether the top management offered the support and commitment to implement the requirements of the EMS at selected hospitals. This test was performed by three sub-factors coded as $F2_1$, $F2_2$, and $F2_3$, related to the knowledge and skills of top management about the EMS.

The results of this study showed the top manager and the executive's knowledge and experience in the environmental management system. Also, top management must provide resources to sup-

Table 3 – Optimum solution according to the environmental information system factor.

Sub-Factors	*Measuring Sub-Factors for the Environmental Information System (EIS)*	*Saturation ratio*	*Optimal solution*
$F1_1$	Controls are based on feedback from the EIS.	0.856	Acceptable
$F1_2$	The hospitals face obstacles in implementing the EMS.	0.744	Acceptable
$F1_3$	It offers accurate information in the time that contributes to making the right environmental decision.	0.723	Acceptable
$F1_4$	It has effective coordination with environmental protection organizations.	0.574	Acceptable
F15	It offers information about environmental protection organizations.	0.757	Acceptable

Source: Table designed by the authors based on the results of quantitative analysis obtained by an SPSS program.

Table 4 – Optimum solution according to the top management commitment factor.

Sub-Factors	*Measuring sub-factors for supporting the top management's commitment to applying the EMS*	*Saturation ratio*	*Optimal solution*
F21	Knowledge and skill	0.814	Acceptable
F22	Support its application	0.724	Acceptable
F23	Provide resources	0.636	Acceptable

Source: Table designed by the authors based on the results of quantitative analysis obtained by an SPSS program.

port the implementation of the EMS. They seek to support its implementation in the selected hospital, as shown in Table 4.

4.3 Investigation of the health organization culture and knowledge

Environmental responsibility is one of the main activities scheduled within the strategies and culture of health organizations (Babiak and Trendafilova, 2011; Björnsdottir and Jensson, 2022). That follows the Environmental Protection Instruction Manual and discusses its problems (DECC, 2011). It aims to become environmentally friendly by reducing the company's environmental impact (Carlini *et al.,* 2019; DECC, 2011). This study focused on measuring the level of information and culture of managers and employees about the EMS in the selected hospital. This study focused on measuring the level of information and culture of managers and employees about the EMS based on the ISO 14001: 2015 standards in the selected hospital, including

nine sub-factors. It focuses on the hospital's plan to develop employees' knowledge about EMS through adopting ongoing training programs in the EMS that lead to an increase in their specialization qualifications in the EMS. It identifies if the hospital staff was exposed to health risks due to the hospital's activities and operations. Whether the hospital management aims to carry out internal operations and activities more than solving environmental problems or believes rivers and oceans are the best way to solve environmental pollution.

Accordingly, the hospital should try to increase the knowledge and culture of hospital administration and workers about implementing the EMS and its future benefits for the individual, the community, and the environment, as shown in Table 5.

Table 5 – Optimum solution according to the knowledge and cultural factor.

Sub-Factors	***Measuring sub-factors for organization knowledge and culture about EMS***	***Saturation ratio***	***Optimal solution***
$F3_1$	More table Hospital staff has specialization qualifications in the EMS.	0.583	Acceptable
$F3_2$	There are ongoing training programs in the EMS.	0.585	Acceptable
$F3_3$	The hospital has the plan to develop employees' knowledge about EMS.	0.766	Acceptable
$F3_4$	The hospital is interested in carrying out internal operations and activities more than solving environmental problems.	0.697	Acceptable
$F3_5$	The hospital managers believe rivers and oceans are the best way to solve environmental pollution.	0.696	Acceptable
$F3_6$	Hospital waste leads to pollution and environmental damage	- 0.863	Unacceptable
$F3_7$	The local population is causing substantial environmental pollution	- 0.869	Unacceptable
$F3_8$	The hospital staff was exposed to health risks due to the hospital's activities and operations.	- 0.892	Unacceptable
$F3_9$	Human errors in the use of chemical and medical materials lead to environmental pollution	0.944	Acceptable

Source: Table designed by the authors based on the results of quantitative analysis obtained by an SPSS program.

In addition to the extent of their cooperation in implementing the EMS and helping to reduce environmental risks, the factor analysis of the EMS elements in the selected hospital proved that 3 factors out of 23 factors tested did not obtain the required saturation ratios. 13% of the factors

in this study matrix limit the application of EMS in the hospital. That includes measuring the hospital's knowledge and culture about EMS like F31, F32, and F33, as appeared in Table 5.

4.4 Investigation of the controls and legislation factor

Similarly, a matrix component examined whether the control methods and implementation of legislation, laws, and oversight systems protect the environment. It included four sub-factors related to the extent of the selected hospital administration's commitment to applying special legislation to protect the environment by using all efforts, legislations, and primary legal provisions to support the oversight role toward environmental protection. All hospital activities are subject to regulatory controls to ensure they are not damaging the environment, based on compulsory legislation and instructions available to protect the environment. Table 6 shows that all hospital activities are subject to regulatory monitoring to ensure they are not damaging to the environment. Also, the hospital administration uses all efforts, legislations, and primary legal provisions to support the oversight role toward environmental protection.

Table 6 – Optimum solution according to the controls and legislation factors.

Sub- Factors	***Measuring sub-factors for controls and legislation rules that support applying the EMS***	***Saturation ratio***	***Optimal solution***
$F4_1$	All hospital activities are operating to protect the environment.	0.808	Factor loading
$F4_2$	It is committed work to protect environmental legislation.	0.764	Factor loading
$F4_3$	Compulsory legislation & instructions are available to protect the environment.	0.608	Factor loading
$F4_4$	Its usage of legislation and legal support the oversight role towards environmental protection.	0.474	Unacceptable

Source: Table designed by the authors based on the results of quantitative analysis obtained by an SPSS program.

4.5 Investigation of the time and budget factor

The last component tested in this matrix was the budget and time required for applied EMS based on ISO 14001: 2015 standards. It included two sub-factors coded as $F5_1$ and $F5_2$. This includes the availability of the financial budget and the time needed to implement the EMS in the selected hospitals. The study results showed that implementing the EMS in the hospital needs a long time due to its requirement to offer an expensive budget, as shown in Table 7. So, hospitals must consider actual costs and profits by implementing environmental administrative policies. That includes a public environmental administrative policy cost for urban medical waste and dangerous medical waste, separation, packing, and disposal of waste, education, and means of staff protection, volunteer environmental managerial policies cost, costs of energy, supply, and recy-

cling administration of the hospital, cost of operational change according to the Environmental, and other potential environment costs (Rondinelli and Berry, 2000).

Table 7 – Optimum solution according to the time and budget factors.

Sub-Factors	**Measuring sub-factors for the time and budget factor**	*Saturation ratio*	*Optimal solution*
$F5_1$	Appling EMS needs a long time.	0.599	Acceptable
$F5_2$	Appling EMS has required an expensive budget.	0.768	Acceptable

Source: Table designed by the authors based on the results of quantitative analysis obtained by an SPSS program.

4.6 Factor analysis for the matrix components EMS

Factor analyses for the matrix components were used to test the study's basic factors based on its sub-factors and approve their hypotheses. The goal was to identify significant factors that limit the EMS application in the selected hospitals, as shown in Table 8.

Figure 4 illustrates the relationship between the basic factors and identifies the most influencing sub-factors in the application of the EMS in the selected hospitals. As appear from Table 8, out of the 23 factors tested, it was found that 7 factors can control the direction of the differentiation questionnaire based on the Component Matrix and Rotated Matrix. This significant percentage contributes to choosing the distinctive factors in examining the current EMS applied in the selected hospitals. Figure 4 displays the effect of the EMS.

Moreover, Table 9 summarizes the arrangement of the EMS matrix components according to the factors analysis.

The investigation found a significant correlation between the main factors. This can help hospitals adjust to the Factor Analysis Model results. The factors are described from large to lowest effect on EMS applied in the selected hospitals. This sequential numerical arrangement in Table 9 explains the importance of the factor to which it belongs. It indicated that all factors had achieved a sufficient saturation percentage, which exceeded 30%. However, these factors differ regarding the extent applicable to EMS in the selected hospital. The first factor was $F3_9$, "Human errors in the use of chemical and medical materials lead to environmental pollution", with a saturation rate of 0.944. While the twenty-third factor was $F3_{10}$, "Hospital staff exposed to health risks due to the hospital's activities and operations", with a saturation rate of -0.892.

The data collected were analyzed using the rotation matrix to investigate the possibility of obtaining higher saturation rates. The results of the variance analysis indicated that 82.99% of the total factors could control the principal factors. That has displayed accurate saturation ratios, as shown in Table 10. The analysis of the total variance of the roots of the component matrix of the research sample indicates a cumulative variance ratio with repeatability of 82.991%. That means approximately 83% of the sample components have a high overload rate. Therefore, the optimal solution has been found through many factors nominated by the rotation matrix without adopting

Table 8 – Matrix components for factors analysis of the environmental management system.

Main factors	Sub-Factors	EISF1	MCF2	OKCEF3	CLF4	BTF5
EISF1	$F1_1$	0.856				
	$F1_2$	0.744				
	$F1_3$	0.723				
	$F1_4$	0.574				
	F15	0.757				
MCF2	F21		0.814			
	F22		0.724			
	F23		0.636			
OKCEF3	$F3_1$			0.583		
	$F3_2$			0.585		
	$F3_3$			0.766		
	$F3_4$			0.697		
	$F3_5$			0.696		
	$F3_6$			- 0.863		
	$F3_7$			- 0.869		
	$F3_8$			- 0.892		
	$F3_9$			0.944		
CLF4	$F4_1$				0.808	
	$F4_2$				0.764	
	$F4_3$				0.608	
	$F4_4$				0.474	
BTF5	$F5_1$					0.599
	$F5_2$					0.768

Where: EISF1 is coded for the environmental information system factor, MCF2 is coded for the management commitment factor, OKCEF3 is coded for the Organization's knowledge and culture about EMS, CLF4 is coded for the controls and legislation factor, BTF5 is coded for budget and time.
Source: Table designed by the authors based on the results of quantitative analysis obtained by an SPSS program.

the matrix of components. Additional results will be analyzed based on the matrix components and the influence of each factor identified in the hypotheses' conceptual model. The analysis includes an evaluation of the effectiveness of the current EMS applied in a selected hospital, the support and commitment of the hospital's senior management towards the successful implementation of EMS, health organization culture and knowledge about EMS, whether the hospital administration uses all efforts, legislations, legal and primary provisions to support the oversight role towards environmental protection, and actual budget and time that required to complete implementation of environmental administrative policies.

4.7 Evaluation of the reliability and validity of applying the EMS factors

The final stage of the investigation is to evaluate the reliability and validity of applying the EMS factors in the selected hospitals based on the Partial Least Squares Structural Equation Modeling (PLS-SEM). Figure 4 shows the factors analysis that affects applying the EMS in the selected

Table 9 – Arrangement of the EMS matrix components according to the factors analysis.

Sub-Factors	*Over loading*	*Level*	*Matrix components of the Current EMS*
$F3_9$	0.944	1	Human errors in the use of chemical and medical materials lead to environmental pollution
$F1_1$	0.856	2	Controls of hospital activities and correction of its performance depend on the feedback received from the EIS
$F2_1$	0814	3	The hospital's senior management has Knowledge and skill
$F4_1$	0.808	4	All hospital activities are operating to protect the environment.
$F5_2$	0.768	5	Appling EMS has required an expensive budget
$F3_3$	0.766	6	The hospital has the plan to develop employees' knowledge about EMS.
$F4_3$	0.764	7	Compulsory legislation & instructions are available to protect the environment.
$F1_5$	0.757	8	It offers information about environmental protection organizations.
$F1_2$	0.744	9	The hospitals face obstacles in implementing the EMS.
$F2_2$	0.724	10	The hospital's senior management supports the application of the EMS
$F1_3$	0.723	11	It offers accurate information in the time that contributes to making the right environmental decision.
$F3_4$	0.697	12	The hospital is interested in carrying out internal operations and activities more than solving environmental problems.
$F3_5$	0.696	13	The hospital managers believe rivers and oceans are the best way to solve environmental pollution.
$F2_3$	0.636	14	The hospital's senior management provides resources that required to apply for EMS
$F4_2$	0.608	15	It is committed to protecting environmental legislation.
$F5_1$	0.599	16	Appling EMS needs a long time.
$F3_2$	0.585	17	There are ongoing training programs in the EMS.
$F3_1$	0.583	18	More table Hospital staff has specialization qualifications in the EMS.
$F1_4$	0.574	19	It has effective coordination with environmental protection organizations.
$F4_4$	0.474	20	Its usage of legislation and legal support the oversight role towards environmental protection.
$F3_6$	-0.863	21	Hospital waste leads to pollution and environmental damage
$F3_7$	-0.869	22	The local population is causing substantial environmental pollution
$F3_8$	-0.892	23	The hospital staff was exposed to health risks due to the hospital's activities and operations.

Source: Table designed by the authors based on the results of quantitative analysis obtained by an SPSS program.

Table 10 – Analysis of the total variance of the matrix components (roots).

Saturation values for the set of squares			*Factor (roots)*
Cumulative contrast ratio	***Percentage of variance***	***Totally***	
16.044	16.044	3.690	1
29.237	13.199	3.035	2
42.382	13.145	3.023	3
55.030	12.648	2.909	4
66.518	11.488	2.642	5
75.233	8.715	2.004	6
82.991	7.758	1.784	7

Source: Table designed by the authors based on the results of quantitative analysis obtained by an SPSS program.

hospitals. Then, this study adopted the PLS-SEM to assess the standard model. This includes four criteria as follows (Hair Jr. *et al.*, 2017; Hair Jr. *et al.,* 2021; Kono and Sato, 2022):

1. Cronbach's alpha measured internal consistency reliability. This appears greater than or equal to 0.70, while the Composite Reliability was greater than or equal to 0.60.

2. Indicator Reliability refers to the Average Variance Extracted. It appears greater than or equal to 0.50.

3. Convergent validity measures the indicator reliability and average variance extracted. It can clarify the colinearity between indicators, their significance, and the relevance of outer weights (Hair Jr. et al., 2017).

4. As a result, the convergent validity in this study indicated that the average variance extracted was greater than or equal to 0.50. These are acceptable indicators, as all EMS factors are close to their structure scale.

5. Discriminant validity shows no correlation between the indicators and the constructs (measurement models) and between the constructs (structural model).

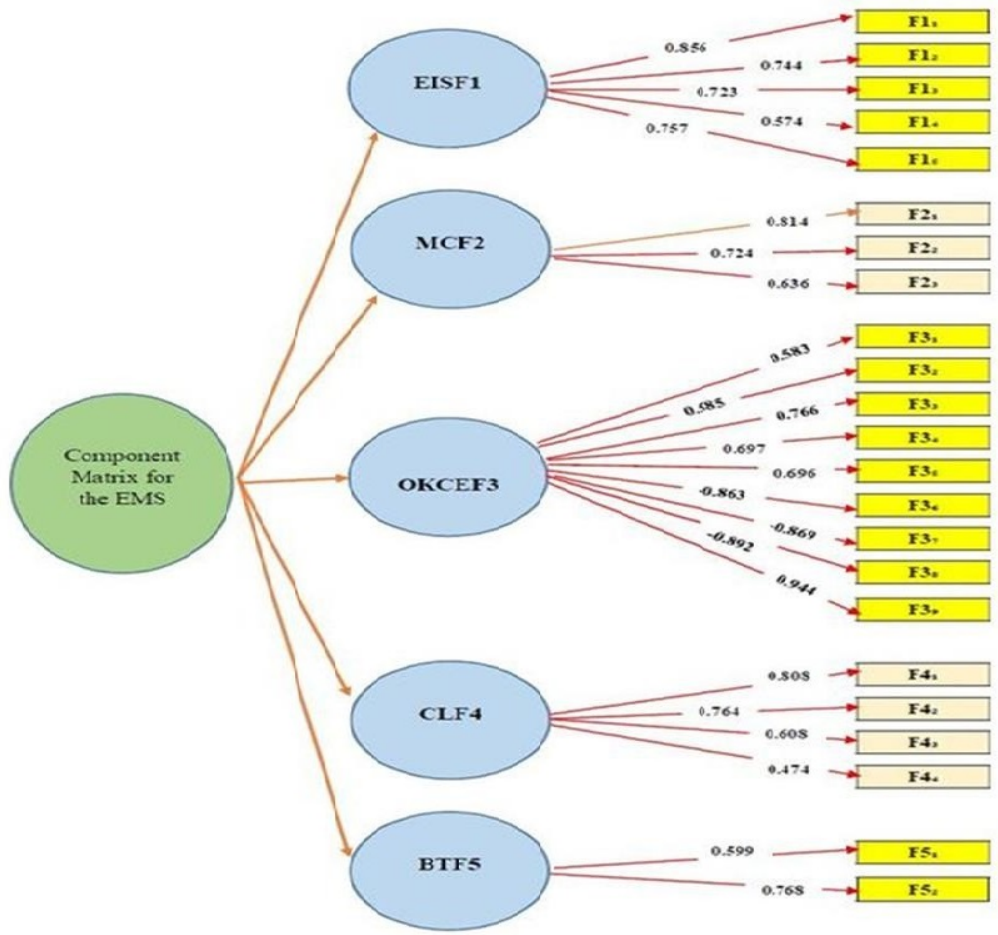

Figure 4 – Factor analysis effect of the environmental management system.

Table 11 shows the reliability and validity of applying the EMS factors in the selected hospitals. It indicated that:

1. The efficiency of the environmental information system; the results indicated that all its sub-factors had obtained standard saturations that exceeded the accepted value of 50.0. The value of the AVE exceeded 50.0, which is considered statistically acceptable. This indicates the convergent validity between all the sub-factors in this section. Therefore all factors are considered effective in applying the environmental management system in the selected hospitals. Similarly, to Support top management's commitment to applied EM, Time and budget must apply to EMS at the selected hospitals.

Table 11 – The reliability and validity of applying the EMS factors in the selected hospitals.

No.	Main Factors	Sub-Factors	Factor Loading	Cronbach's α	Composite Reliability	Average Variance Extracted
1	The efficiency of the environmental information system	$F1_1$	0.856	0.725	0.823	0.516
		$F1_2$	0.744			
		$F1_3$	0.723			
		$F1_4$	0.574			
		$F1_5$	0.757			
2	Supporting top management's commitment to applied EMS	$F2_1$	0.814	0.737	0.791	0.561
		$F2_2$	0.724			
		$F2_3$	0.636			
3	Hospital Culture and knowledge about EMS	$F3_1$	0.583	0.756	0.834	0.507
		$F3_2$	0.585			
		$F3_3$	0.766			
		$F3_4$	0.697			
		$F3_5$	0.696			
		$F3_6$	- 0.863			
		$F3_7$	- 0.869			
		$F3_8$	- 0.892			
		$F3_9$	0.944			
4	Controls, legislation, and laws used to apply EMS	$F4_1$	0.808	0.852	0.890	0.621
		$F4_2$	0.764			
		$F4_3$	0.608			
		$F4_4$	0.474			
5	Time and budget need to apply to EMS	$F5_1$	0.599	0.714	0.805	0.455
		$F5_2$	0.768			

2. Hospital Culture and knowledge about applying EMS; the results indicated that all its sub-factors had obtained standard saturations that exceed the accepted value of 50.0. Except for these sub-factors:

   - $F3_6$ =-0.863, *this factor investigated whether hospital waste leads to pollution and environmental damage,*
   - $F3_7$=-0.869, *this factor investigated whether the local population is causing substantial environmental pollution*, and
   - $F3_8$=-0.892, *this factor investigated whether the hospital staff was exposed to health risks due to the hospital's activities and operations*.

   For this reason, these sub-factors were ignored as they limited the application of EMS in the selected hospitals.

   The value of the AVE exceeded 50.0, which is considered statistically acceptable. This indicates the convergent validity between all the sub-factors in this section.

3. Controls, legislation, and laws used to apply EMS; the results indicated that all its sub-factors had obtained standard saturations that exceeded the accepted value of 50.0. Except for the sub-factor $F4_4$ =0.474. *This factor investigated whether the selected hospitals are using the legislation and legal support for the oversight role towards environmental protection.* For this reason, it was ignored as it limits the application of EMS in the selected hospitals. The value of the AVE exceeded 50.0, which is considered statistically acceptable. It indicates the convergent validity between all the sub-factors in this section.

5 CONCLUSION

This study selected six hospitals in North Asia and Africa that provide various clinical treatments, diagnostic, and consulted services such as heart surgery, paediatrics, childbirth, fracture surgery, and public health services. These hospitals seek to improve their current EMS but face many obstacles in their application. Factor analysis for the matrix components of the EMS indicated that several obstacles limit the application of the EMS in selected public hospitals. So, healthcare organizations must adopt new policies to protect the environment and reduce pollution due to daily hospital activities.

Accordingly, factor analysis for the matrix components of the EMS was used to test study hypotheses based on the conceptual framework model of the hospital EMS. Test performance included five critical factors directly affecting the current EMS used in the selected hospital. These were: *The efficiency of the environmental information system, the healthcare organization's culture and knowledge, Supporting top management commitment, Controls and legislation, and control of time and budget.*

In the context of the healthcare sector, this study suggested that recovering green hospital systems depends on their success in carrying out the ISO 14001: 2015 standards, which contributes to

improving its current EMS toward reducing the obstacles to its application at the hospital. These standards contribute to protecting the environment and reducing the risk of health pollution upon the staff health, patients, society, and the surrounding environment.

This study also emphasizes the necessity of using clean, environmentally friendly operations processes to reduce pollution rates resulting from hospital activities and treat health waste, educating workers in healthcare organizations and the general public about the importance of protecting the environment and how to reduce pollution rates by following the proper methods in treating health care waste. Where individuals contribute directly to environmental pollution and damage due to the lack of awareness and culture about environmental protection, legislation and regulations to protect the environment must be developed and published periodically for healthcare workers and the general public.

Furthermore, healthcare organizations must follow the right health methods to protect the hospital staff from the risks arising from the hospital's activities. This study demonstrated that hospital staff had been exposed to health risks due to hospital activities and operations, which need to be classified according to the level of risk.

This study is significant in the health sector and its effect on reducing environmental pollution from hospital activities. Also, it can be applied in the industrial sector in the future.

Acknowledgements

The authors acknowledge all the expert and executive managers, engineers, and staff who have supported this study by providing accrued information that assisted in achieving the objectives of this study.

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How to cite

MKALAF KA, ALSHAHEEN N, AL-HADEETHI RH & AL-BAZI A. 2023. Recovery of a Green Hospital Systems based on ISO 14001: 2015 standards. *Pesquisa Operacional*, **43**: e265411. doi: 10.1590/0101-7438.2023.043.00265411.