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The Promotion of Environmental Management in the South Korean Health Sector—Case Study

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Abstract: Because of the comprehensiveness and urgency of environmental challenges, every stakeholder needs to be engaged in reducing environmental impacts. The healthcare sector has rarely been studied, despite its intense effects on the environment, particularly through generating various forms of hazardous waste and intensively consuming energy and water. Many healthcare facilities exist in South Korea, and every citizen frequently visits hospitals thanks to the convenient system. To reduce the environmental impacts of the healthcare sector, the South Korean government has implemented various policy measures aimed at promoting environmental management in that sector. This study evaluated the eco-efficiencies of 21 hospitals from 2012 to 2015 using data envelopment assessment (DEA), used the analytical hierarchy process (AHP) to analyze hospital staff members' answers to a questionnaire asking about the relative importance and performance of individual environmental management tasks, and also identified environmental management tasks that should be prioritized by building an importance-performance analysis (IPA) matrix using those questionnaire responses. This study found that eco-efficiencies have improved during the period, and that mandatory policy measures were more effective than voluntary agreements for improving eco-efficiency. This implies that rigorous reporting and monitoring should be implemented along with any voluntary agreement. In addition, this study found that the top priorities are "establishment of vision and strategy for environmental management" and "organization of task team for environmental management and task assignment". This shows the necessity of additional policy measures, such as training or consulting to promote the priorities. In addition to policy recommendations for diffusing environmental management in the South Korean healthcare sector, the methodological approach sheds light for researchers interested in environmental management in the healthcare sector because previous studies depended on qualitative approaches, particularly case studies.

Keywords: environmental management; eco-efficiency; healthcare sector; data envelopment assessment; importance-performance analysis

1. Introduction

The 2015 Decision of the Conference of Parties (COP) in Paris emphasizes the participation of non-Party stakeholders, including cities and other subnational authorities. In addition, the decision encourages Parties to cooperate closely with non-Party stakeholders in an effort to strengthen and expand mitigation actions [1]. The transnational actions of non-Party stakeholders become "the heart of the new climate regime" [2] because every sector's participation is paramount for coping with environmental problems and attaining sustainable development goals. However, environmental management (EM) has not been emphasized in social sectors such as public institutions, schools, and hospitals as much as in industrial sectors due to their relative contribution to environmental issues. The environmental footprint of the healthcare sector is closely related to the use of devices and chemicals to treat patients [3]. EM has not attracted the attention of hospital leadership because the principal goal of the healthcare sector is "achieving high value for patients . . . defined as the health outcomes achieved per dollar spent" [4]; EM needs to be promoted in this sector because its operation is close to the people and more likely to directly affect people's lives.

In South Korea, there were 89,919 healthcare facilities in 2016, including hospitals, clinics, dental hospitals and clinics, oriental medical hospitals and clinics, and drugstores [5]. Korean citizens visited hospitals or clinics an average of 20.28 times in 2017 [6]. Patients and staff are at hospitals 24 h a day. Hospitals consume a lot of energy, chemicals, heavy metals, and radioactive isotopes, and they also produce various forms of waste, including biomedical wastes that can spread infectious disease if not properly managed [3,7–10]. In the United States, healthcare facilities were the second highest energy consumer, after manufacturing facilities, on the basis of electricity use per square foot [11]. The healthcare sector accounted for 8% of total CO_2 emissions in the United States [12]. In Egypt, about 39% of the hospital waste studied was hazardous [13]. The treatment of more serious illnesses requires more resources and thus generates more waste. For example, a single dialysis session consumes 500 L of water and produces 2.5 kg of solid waste [10]. Recognizing the importance of EM in the healthcare sector, the United Kingdom regularly estimates and issues data on the carbon footprint of the healthcare sector; the GHG (Greenhouse Gas) emissions of that sector have decreased by 11% from 2007 to 2015. The British healthcare sector has a separate GHG reduction target, in line with the Climate Change Act of 2008: an 80% reduction by 2050 [14].

In South Korea, medical waste generation increased by about 15% per annum from 2006 to 2015. In 2016, health facilities generated 221,592.4 tons of medical waste. Almost all medical waste was incinerated [15]; the incineration cost for medical waste was about four to five times more expensive than that of municipal waste [16]. Therefore, EM needs to be diffused in South Korean hospitals. To promote EM in the healthcare sector, policy measures such as Voluntary Agreements (VAs), the Environmental Information Disclosure System (EIDS), the Greenhouse Gas and Energy Target Management System (GETMS), and the Emission Trading System (ETS) are practiced in South Korea. By the end of 2017, 41 hospitals participated in VAs for EM [17]. By the end of 2016, 21 hospitals and 57 public healthcare institutions participated in EIDS [18]. Although the South Korean government continuously tries to diffuse EM in the healthcare sector, the status of EM and the effectiveness of these measures in the healthcare field have rarely been studied in a comprehensive manner. Many studies have focused on a specific area of EM, for example, case studies of waste management in hospitals [8,9,13,19–21]. Few studies have used a quantitative approach to investigate the performance of EM in South Korean hospitals comprehensively.

This study aims to promote and enhance EM practices in hospitals by presenting policy recommendations based on a diagnosis of current EM practices with a focus on the eco-efficiency. This study evaluates changes in the eco-efficiency of the South Korean healthcare sector based on Data Envelopment Analysis (DEA). It uses data of 21 Korean hospitals from 2012 to 2015, including water and energy consumption, waste generation, hazardous chemical use, sales, and the number of patients at individual hospitals. In addition to diagnosing EM performance at these 21 hospitals, this study surveys 29 hospital staff members who were in charge of environmental management. This study uses the analytic hierarchy process (AHP) to evaluate the relative importance and performance of individual environmental management tasks based on the questionnaire answers. This study also conducts an importance-performance analysis (IPA) to evaluate the effectiveness of EM and to develop recommendations. First, previous studies regarding environmental management in the health care sector are reviewed in the Literature Review section. Next, the methodology used (including DEA, AHP, and IPA) and datasets are explained in the Methodology and Data section. The results and their implications are discussed in the Results and Discussion section. Finally, major findings and limitations of this study are presented in the Conclusions section.

2. Literature Review

Studies of EM in hospitals investigated the factors motivating EM in hospitals [22,23], the status of EM implementation, and the effects of policy measures such as the VAs and the ETS on EM in hospitals.

There are competitive drivers, regulatory drivers, and ethical drivers that motivate hospitals to participate in EM [22]. Hospitals introduce EM to reduce administrative costs, to improve competitiveness by differentiating themselves to the public using certificates earned through EM practices, and to attain accompanying benefits such as safety enhancement [24,25]. Hospitals also conduct EM due to external factors such as government regulations and increased pressure for social responsibility [26]. In addition to the external pressure regarding social responsibility, the willingness of top management is another ethical driver for EM. The influence of these drivers varies along with various characteristics of hospitals, such as their governance structure and ownership. For example, the greater importance of regulations at public hospitals is attributed to their governance structure [22]. In addition, size and location have been found to affect the influence of regulatory and competitive drivers on hospitals' EM adoption and practice: expenses are perceived as more important in small hospitals than in medium ones, and even more important in large hospitals [23].

Many studies have focused on waste management in hospitals, due to the unique profile of waste generated in hospitals [8,9,13,19–21,27,28]. Almost all case studies have pointed out issues related to the inappropriate segregation of waste generated in hospitals in developing countries and argued the necessity of training or educating hospital staffs [8,9,13]. One study argued for an integrated system to dispose of waste generated in hospitals, using composting, incineration, and recycling based on an LCA (Life Cycle Assessment) analysis of various waste disposal scenarios [27]. Recognizing the huge amount of waste generated from disposable materials used in hospitals, Campion et al. (2015) conducted a life-cycle assessment of the environmental impacts of the consumption of disposable packages, which consisted of "a set of sterile, disposable products prepackaged for a specific procedure," at 15 hospitals (12 in the United States, 2 in Thailand, and 1 in Global Links (an NGO (Non-Governmental Organization)). They then suggested an alternative green or environmentally preferred custom pack that could reduce the impact by 80% over the average disposable pack [29]. Some studies have been conducted on EM issues beyond waste management. For example, Saad (2003) focused on indoor pollutants, which can harm the health of hospital staffs and patients [30]. Carraro et al. (2016) conducted a comparative study that surveyed risks and legislation regarding hospital wastewater, finding that there are regulatory loopholes for some substances, including antibiotic residues, even in industrialized countries [20]. In addition to the waste or water, Chiarini, Opoku, and Vagnoni (2017) compared sustainable procurement practices at public hospitals in Italy and the United Kingdom by analyzing the responses to seven questions regarding sustainable procurement. They found that the Italian hospitals tended to focus on compliance with laws or regulations, while the British organizations tended to ask suppliers to improve their performance over time [31]. However, that study did not further investigate the factors that led to those differences.

Some studies have investigated or suggested a framework for EM in the healthcare sector [7,32] and have identified barriers to the spread of EM [33]. Blass et al. (2017) developed a framework that enables consistent and robust measurement and reporting of environmental performance in hospitals [7]. Rian-Fogarty et al. (2016) investigated the effectiveness and applicability of an existing EM program, the Green Campus Program, in a case study of a teaching hospital in Ireland, finding that it is a "systematic approach to environmental action and education" [32]. Seifert (2018) conducted 14 in-depth telephone interviews with people who were in charge of EM at German hospitals that participated in voluntary environmental management systems. Through this qualitative approach, they found major barriers to the system, such as the heavy initial documentation burden and lack of knowledge and awareness across the all of the stages, including 'before initial registration', 'implementation and maintenance', and 'revalidation' [33].

Several studies have assessed EM and investigated its potential in hospitals. Faezipour and Ferreira (2018) identified factors influencing the water sustainability of three hospitals in the United States, and they modeled the causal relationship between the factors, water footprints of the hospitals, the cost of services and resources, and patient wellbeing. Water saving or water reuse was found to reduce the water footprint and cost of services and resources, and also enhance the overall wellbeing of the population that is affected by external freshwater quality [34]. Romero and Carnero (2017) established a multi-criteria model for environmental assessment of the health care sector. Their model consists of three criteria, 12 first-level sub-criteria, 46 indicators, and five alternatives. The questionnaires related to these indicators, e.g., "a value between 0 and 0.45 kg/patient of potentially infectious waste is obtained and is not removed in compliance with regulations," could be assessed using the AHP method based on different weightings of criteria. The authors tested this model to assess the environmental management status of a Spanish hospital. With a score of 0.6286, they showed the hospital carried out its environmental management well. The hospital did particularly well on the criteria related to energy consumption, hazardous waste generation, and legal matters [35].

Similarly, environmental management in the South Korean healthcare sector has been qualitatively studied. Early studies, conducted before the introduction of various policy measures, focused on defining eco-friendly hospitals and recommending policy measures for EM in the health sector. These presented key attributes of eco-friendly hospitals based on cases in developed countries [36], provided recommendations to improve EM in hospitals based on surveys [37], and pointed out the necessity of additional policy measures to strengthen EM in hospitals in preparation for an emission trading scheme [37]. More recent studies have scrutinized a specific policy measure or assessed EM practices in hospitals using specific criteria. Kang (2013) investigated the EIDS as practiced and presented recommendations for that specific policy [38]. Kim and Kang (2014) analyzed the EM practices at 44 hospitals using green management evaluation criteria and presented recommendations for the health sector [39]. Few studies have quantitatively and comprehensively investigated the performance of EM in hospitals. Therefore, a methodology for assessing EM in the health care sector, quantitatively as well as qualitatively, needs to be established.

3. Policies and Instruments for Environmental Management in Healthcare Sector in South Korea

3.1. Brief Survey of Healthcare Sector in South Korea

The number of South Korean health facilities totaled 89,919 in 2016 (see Table 1). Most of these were clinics, dental hospitals and clinics, oriental medical hospitals and clinics, and drug stores. Hospitals are classified according to specific requirements articulated in the Medical Service Act (Act No. 8366). Whereas clinics provide medical services primarily to outpatients, hospitals should have more than 30 patient beds. General hospitals should be equipped with at least 100 patient beds. Superior general hospitals are hospitals for treating high-level diseases; they are designated by the Ministry of Health and Welfare from general hospitals that meet the special requirement of having more than 20 specialized departments. As of 2016, there were 43 superior general hospitals, 298 general hospitals, and 2942 hospitals.

Table 1. Summary statistics for the South Korean healthcare sector in 2016 [40].

Total	Superior General Hospital	General Hospital	Hospital	Medical Clinic	Dental Hospital and Clinic	Oriental Medical Hospital and Clinic	Health Center	Drugstore
89,919	43	298	2942	30,292	17,246	14,150	3505	21,443

As of 2016, 221,592.4 tons of medical waste were generated from health facilities, including general hospitals, hospitals, medical clinics, public medical clinics, animal hospitals, nursing facilities, research institutes, mortuaries and crematoria, and prisons. Almost all of this medical waste (204,752.7 tons) was incinerated; the rest was treated with sterilization shredding devices [15]. The incineration cost for medical waste was about 600–800 thousand KRW per ton (about 560 to 750 USD per ton), which was 4–5 times more expensive than the cost of incinerating municipal wastes [16].

3.2. Policies and Instruments for Environmental Management in the South Korean Healthcare Sector

Four policy measures are practiced in South Korea to promote EM in the healthcare sector: Voluntary Agreements (VAs), the Environmental Information Disclosure System (EIDS), the Greenhouse Gas and Energy Target Management System (GETMS) and the Emission Trading System (ETS).

Since 2011, the Ministry of the Environment (MOE) has taken several initiatives, including establishing guidelines for EM in the public and service sector, including the healthcare sector; holding seminars and workshops for building EM capacities; sharing best practices in the healthcare sector; supporting the establishment of domestic eco-friendly hospital networks; and organizing expert meetings [41].

The MOE has implemented VAs with large general hospitals, university hospitals, and superior general hospitals since 2013 to promote EM in the healthcare sector. Ten hospitals signed a memorandum of understanding (MOU) for a VA in 2013; this signing ceremony between the Minister of the MOE and the hospital CEOs drew much attention from the press and public. In 2014, 11 more hospitals signed a VA, followed by nine more in 2015, six more in 2016, and five more in 2017; by the end of 2017, 41 hospitals participated in a VA for EM [17]. The hospitals with a VA can use the title of "Green Hospital" in their publicity. The MOE provides them up to 10 million KRW (about 9300 USD) in financial support for EM consulting, the establishment of an eco-friendly hospital network at the domestic and global level, and sharing of best practices and solutions regarding EM.

In July 2015, the South Korean government announced that it aimed to reduce national greenhouse emissions (GHG) by 37% compared to business-as-usual (BAU) emissions by 2030 [42]. To achieve this emission reduction target, two primary policy measures are in place: the GETMS and the ETS. Companies or business sites with GHG emissions or energy consumption exceeding specific criteria (Companies with emissions exceeding 50,000 tCO_2eq/year or energy consumption exceeding 200 TJ/year, or business sites with emissions exceeding 15,000 tCO_2eq/year or energy consumption exceeding 80 TJ/year, shall participate in the GETMS.) are required to participate in these measures. Entities with more substantial emissions or energy consumption are controlled under the ETS; those with emissions or energy consumption smaller than the ETS criteria are controlled through the GETMS. South Korea began the ETS on 1 January 2015. Tradable permits are allocated to controlled entities under the ETS according to a grandfathering principle (The whole allowance is distributed for free to the controlled entities for Phase I, from 2015 to 2017. From 2018 to 2020, 3% of the allowances are distributed through auction for Phase II). The entities must surrender permits equivalent to their emissions at the end of the year. Two hospitals, Kangnam St. Mary's Hospital and Seoul National University Hospital, have been subject to the ETS since 2015 [43]. Four general hospitals, Yangsan Busan University Hospital, Gacheon University Gil Hospital, Jeonbuk University Hospital, and Chungnam University Hospital, are controlled under the GETMS [44]. These controlled entities must make efforts to reduce their emissions or energy consumption to meet their annual target, which is established through a bottom-up process: the individual target is determined in consultation with the MOE [45]. At the end of 2016, 346 companies and facilities were controlled under the GETMS [45].

In addition, the MOE has operated the Environmental Information Disclosure System (EIDS) to promote the implementation of VAs and communication with people, to strengthen monitoring of environmental impacts, and to increase investment in eco-friendly companies by financial institutions and investors on the basis of the environmental information submitted to the system [46,47]. MOE initiated the EIDS as a pilot project in 2010; the MOE provides participating companies with benefits such as training programs and consultations. After 2012, the EIDS was expanded to include central government agencies, local governments, universities, public corporations, and large general hospitals and companies that have significant environmental effects [47]. These entities are required to disclose environmental information such as their business overview; plan and activity for EM; resource savings and pollution reductions; and EM attainments (e.g., EM-related awards, EM systems, or the status of the EM division) by Article 16.8 and 16.9 of the "Environmental Technology and Environmental Industry Support Act." As of 2015, 1216 companies and organizations participated in the EIDS, including 78 hospitals and public healthcare institutions. Details on the items of environmental information to be disclosed by the healthcare sector are shown in Table A1.

Thanks to government policy measures, some achievements have been observed. The hospitals participating in VAs saved costs through reducing energy and water consumption (See Table 2). In addition to these quantitative achievements, a Green Hospital in Seoul introduced the idea of green service, which treats elderly volunteers who clean up the neighborhood for free and helps low-income elderly people using revenue collected from an annual bazaar held with environmental NGOs (interview on 11 June 2017).

Table 2. Total annual achievements by hospitals signing a voluntary agreement for environmental management in South Korea [41].

Year	Voluntary Agreement and Annual Achievements (Total Electricity or Water or Cost Savings and Total CO_2 Reductions)
2013 (1st)	• 10 MOUs (Memorandum of Understanding) • 2010 MWh of electricity saved, 155,910 tons of water saved, 5305 tons of CO_2 reduction; consequent cost savings: 1300 Million KRW (Korean Won)
2014 (2nd)	• 11 MOUs • 1516 MWh of electricity saved, 47,482 tons of water saved, 1277 tons of CO_2 reduction; consequent cost savings: 500 Million KRW
2015 (3rd)	• 9 MOUs • 6178 MWh of electricity saved, 3188 tons of CO_2 reduction; consequent cost savings: 900 Million KRW

Note: In the third year, information about water consumption was not collected because the VA (Voluntary Agreement) emphasized electricity and GHG (Greenhouse Gas) emissions reduction.

4. Methodology and Data

DEA measures relative efficiency by comparing the efficiencies of individual decision-making units (DMU) in targets such as governments, hospitals, companies, programs, and policy measures. It was developed by Charnes, Cooper, and Rhodes (1978) [48] to measure the concept of efficiency, as defined by Farrel in 1957. DEA finds the "efficient frontier," which is the efficiency of the best practices; measures the "distance" of efficiency values of other DMUs from the "efficient frontier"; and provides rankings of efficiencies of individual DMUs [48,49]. As a result, potential improvements are identified for inefficient DMUs. DEA has advantages in providing information on the reference set and potential improvements that should be set as an example for inefficient units to become more efficient. Therefore, it has been widely used not only as a measure of efficiency, but also as a tool for setting goals for analysis and improvement.

Among the variants of the DEA model, this study uses an input-oriented model that aims to improve efficiency by minimizing the inputs required to achieve the targeted output [50]. The input-oriented model is more appropriate to environmental management in hospitals because it pursues enhancements in eco-efficiency by reducing inputs/environmental burdens given the desired output rather than increasing output while maintaining inputs. This study uses the input-oriented Banker, Charnes, and Cooper (BCC) model (1984) [51], allowing variable returns to scale (VRS). VRS assumes the increased outputs may or may not be proportional to the increased inputs. This differs from constant returns to scale (CRS), which assumes that the increased outputs should be proportional to the increased inputs [50]. The BCC allows measurement of technical efficiency by separating the effects of scale [51]; this is more appropriate for measuring pure technical efficiency while taking into consideration the different sizes of hospitals.

This study collected the data from all 21 hospitals that participated in the EIDS in South Korea over the period from 2012 to 2015 (see brief information on the 21 hospitals in Table 3) (The value of sales is adjusted to the 2012 value, after accounting for inflation.). First, this study analyzed four mandatory reporting items of the 20 reporting items that included quantitative information under the EIDS as input variables (see Table A1): annual water consumption (ton of water), annual energy consumption (TOE), annual waste generation (ton of waste), and annual hazardous chemical use in each hospital (kg of chemical). It used two other mandatory reporting times, the total annual sales (million Korean Won) and the number of patients (persons), as output variables. The variables can be seen in Table 4, and detailed values for each variable over the period can be found in Table A2. Only quantitative data that must be reported to the EIDS was used in order to obtain data from all of the EIDS-participating hospitals. Other qualitative information that is attainable from the EIDS was used for the additional IPA analysis.

Table 3. Brief summary of the hospital sample.

	Location (Provinces)	Public/Private	Number of Beds
H01	Gangwon	Public	15
H02	Gyeongsang	Public	884
H03	Gyeongsang	Public	616
H04	Gyeongsang	Public	887
H05	Gyeonggi (including Seoul)	Public	484
H06	Gyeongsang	Public	1227
H07	Gyeongsang	Public	30
H08	Gyeongsang	Public	100
H09	Gyeonggi (including Seoul)	Private	1101
H10	Gyeonggi (including Seoul)	Private	1989
H11	Gyeonggi (including Seoul)	Public	1786
H12	Gyeongsang	Public	950
H13	Jeolla	Public	962
H14	Jeolla	Public	1081
H15	Jeju	Public	643
H16	Gyeonggi (including Seoul)	Public	1029
H17	Chungcheong	Public	1268
H18	Chungcheong	Public	660
H19	Gyeongsang	Public	518
H20	Chungcheong	Public	414
H21	Gyeongsang	Public	562

Table 4. Variables for evaluating eco-efficiency in hospitals.

<table>
<tr><th colspan="2">Category</th><th>Unit</th><th>Details</th></tr>
<tr><td rowspan="4">Input variables (Environmental damage and resource consumption)</td><td>Water consumption</td><td>ton</td><td>The quantity of water used yearly</td></tr>
<tr><td>Energy consumption</td><td>TOE</td><td>Total energy consumption yearly, such as electricity, gasoline, etc.</td></tr>
<tr><td>Waste generation</td><td>ton</td><td>The total amount of waste generated yearly</td></tr>
<tr><td>Chemicals consumption</td><td>kg</td><td>The total amount of hazardous chemicals used yearly</td></tr>
<tr><td rowspan="2">Output variables (Economic value-added)</td><td>Sales</td><td>Million KRW</td><td>The total amount of sales yearly</td></tr>
<tr><td>Patients</td><td>Person</td><td>Total number of patients yearly</td></tr>
</table>

Eco-efficiency is defined "as being achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle, to a level at least in line with the Earth's estimated carrying capacity." Furthermore, "progress in eco-efficiency can be achieved by providing more value per unit of environmental influence or unit of resource consumed" [52]. Eco-efficiencies are calculated and evaluated using Frontier Analyst (version 4, Banxia Software Ltd, Kendal, Cumbria, United Kingdom), a DEA software application. For example, the absolute value of eco-efficiency of H01 is estimated (see the equation below). Among the estimated eco-efficiencies of the 21 hospitals, the benchmarked or highest value is identified, and its relative eco-efficiency is set as one. As of 2015, H01 is one of the most eco-efficient hospitals, along with eight others (See Table 5). Then, the eco-efficiency values of the other hospitals are compared to the benchmarked value to establish their eco-efficiency values relative to the highest eco-efficiency value. A smaller value means relatively lower eco-efficiency:

$$\text{Eco} - \text{Efficiency} = \frac{Economic\ value - added}{Environmental\ Damage}$$

In addition, this study surveyed 51 hospital staffs about EM (the 21 hospitals whose eco-efficiencies were assessed by DEA in this study and an additional 30 hospitals participating in the eco-friendly hospital network). The questionnaire used a symmetrical 5-point Likert scale to ask about the relative importance of individual reporting items of the EIDS as major management indicators with respect to EM diffusion in hospitals (see Table A3 for the detailed questionnaire). The reporting items are grouped into four categories: environmental management (or procurement) system establishment; resource/energy management and reduction activities; greenhouse gas emissions and environmental pollution management and reduction activities; and social/ethical responsibility compliance. There are specific items under each individual category (e.g., within the category of social/ethical responsibility compliance, there are three specific questions on the relative importance of domestic and international environmental regulation compliance vs. sustainability report publication, domestic and international environmental regulation compliance vs. responses to stakeholder requests for environmental information; and sustainability report publication vs. responses to stakeholder requests for environmental information). The questionnaire also asked about the performance of EM tasks for 13 items (Of 20 information disclosure items for the South Korean healthcare sector, items analysed in the DEA analysis were excluded when constructing the questionnaires.) that should be reported to the EIDS in individual hospitals. The questionnaire was emailed to the 51 hospital staffs on 8 May 2017; and 33 responses were received by 15 May 2017. These responses to the multi-criteria decisions were assessed using AHP to solve multi-criteria complex problems. The AHP allows the respondents, the staff responsible for environmental management in these hospitals, to evaluate the relative importance of items through pairwise comparison [53]. Among 33 responses, 29 responses with a consistency ratio smaller than 0.1 were analyzed. Saaty (1980) proposed a consistency index to evaluate the level of consistency of final decisions among respondents [54]. Generally, if the consistency index is less than 0.1, the consistency of the pairwise comparison matrix is considered to be good and reliable. The responses to the questionnaires were analyzed using the importance-performance analysis (IPA) matrix. This study draws this matrix using SPSS 18 (IBM, Armonk, NY, USA). The IPA is a technique for diagnosing the performance of services or products, comparing performance to their importance and suggesting insights into priorities [55]. Specifically, services or products located in quadrant 4 of the IPA matrix—the service or product is highly important, but performance is low—should receive more focus [56] (see Figure 1).

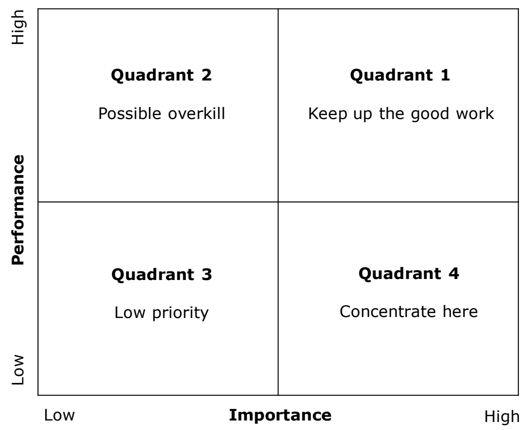

Figure 1. Importance-performance analysis matrix: modified from [56].

5. Results and Discussion

5.1. DEA Results

Table 5 presents the changes in eco-efficiency from 2012 to 2015. The variance in the average differences of the eco-efficiency scores was statistically significant at the 5% level, as seen in Table 6.

The average eco-efficiency of the 21 hospitals was 0.940 in 2015. The eco-efficiency of 12 hospitals was 1.0, which means that those hospitals were the most efficient. Among these hospitals, four hospitals participated in government regulation through the GETMS. The other nine hospitals were less eco-efficient than the 12 benchmarked hospitals. The average eco-efficiency score rose from 2012 (0.830) to 2014 (0.933) but then dropped slightly in 2015 (0.902). The gradual increase in average eco-efficiency from 2012 to 2014 shows improvements at the relatively less eco-efficient hospitals. In contrast, the slight decrease in 2015 implies regression by the less eco-efficient hospitals. H11, H12, H14, and H17 participated in government regulation through the GETMS; these hospitals showed gradual improvement in their eco-efficiency scores from 2012 to 2015. The scores at H11, H12, and H17 had been particularly lower in 2012. The notable improvement of their eco-efficiency, up to 1.0 in 2015, can be attributed to the implementation of the GETMS.

Table 5. Eco-efficiencies of 21 hospitals from 2012 to 2015.

Hospital	Year/Eco-Efficiency				Remarks
	2012	2013	2014	2015	
H01	1.000	1.000	1.000	1.000	-
H02	0.770	0.866	0.785	0.819	VA (2013)
H03	0.760	0.870	1.000	1.000	-
H04	0.715	0.722	0.797	0.761	-
H05	0.630	0.675	0.814	0.570	VA (2015)
H06	0.816	0.815	0.864	0.826	-
H07	0.830	1.000	0.982	0.771	-
H08	0.997	1.000	1.000	0.905	-
H09	0.905	0.829	0.897	1.000	-
H10	0.993	1.000	1.000	0.918	-
H11	0.592	0.824	1.000	1.000	GETMS
H12	0.663	0.927	0.961	1.000	GETMS
H13	1.000	0.757	0.842	0.867	-
H14	0.703	0.904	0.936	0.946	GETMS
H15	0.646	0.857	0.958	0.681	-
H16	1.000	1.000	1.000	1.000	-

Table 5. *Cont.*

Hospital	Year/Eco-Efficiency				Remarks
	2012	2013	2014	2015	
H17	0.643	0.657	0.881	1.000	VA (2014), GETMS
H18	1.000	0.932	1.000	1.000	-
H19	0.770	1.000	1.000	1.000	-
H20	1.000	1.000	0.879	0.898	-
H21	1.000	0.909	1.000	0.978	-
Average	0.830	0.883	0.933	0.902	-

Note: GETMS stands for Greenhouse Gas and Energy Target Management System.

Although H02 and H05 participated in VAs, their eco-efficiencies not only did not improve, but became even worse. This means that these two hospitals preserved the status quo or regressed regarding EM while other hospitals improved their eco-efficiencies. This result makes the effectiveness of VAs questionable, shows that VAs cannot guarantee that hospitals will execute activities or practices for EM, and implies that VAs have limitations in their current form and need corrective measures such as strict monitoring, reporting, and a feedback system.

Table 6. Statistics of variances of eco-efficiency scores.

Total Sum of Squares	Degrees of Freedom	Mean Square Error	*p*-Value
0.272	1.000	0.091	0.0001

The potential for improvement was evaluated for hospitals with lower eco-efficiency scores by comparing their actual production conditions and processes with hospitals that had the same production conditions and processes. Figure 2 shows the potential improvements that are achievable at nine inefficient hospitals. They could reduce water consumption by eight percentage points (ppt), energy consumption by 9 ppt, waste generation by 10 ppt, and hazardous chemical use by 24 ppt, to be in line with the most efficient hospitals. Notably, there is a significant room to reduce hazardous chemical use in less eco-efficient hospitals.

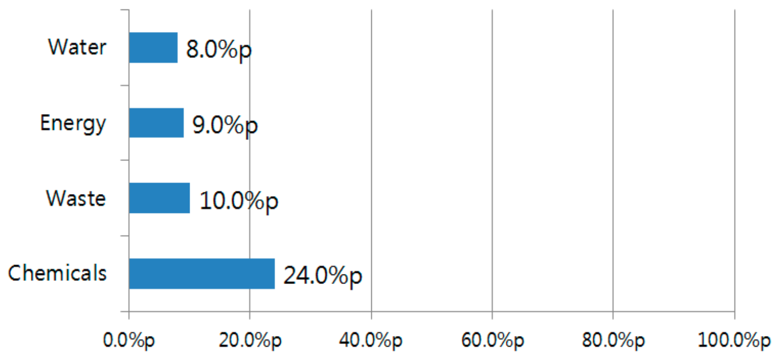

Figure 2. Potential improvements by variables in 2015.

By analyzing the potential improvements at hospitals with low eco-efficiency scores, each hospital could identify which input variables needed to be improved. In addition, more substantial alternatives need to be reviewed and adjusted to achieve an eco-efficiency score of 1.0.

5.2. IPA Results

Table 7 presents the results of a combined weighting analysis of the responses to the questionnaires that asked about the relative importance of the individual EIDS reporting items for EM in hospitals.

Of 33 collected responses, four responses with a consistency ratio larger than 0.1 were excluded [54]: thus, a total of 29 responses were analyzed. As a result of the combined weighting analysis, it was found that the hospital staffs recognized "management of energy use and reduction activity" as the most important EIDS reporting item for diffusing EM. In addition, the scores for "the establishment of a vision and strategy of EM", "organization of task team for EM and task assignment", "management of water use and reduction activity", and "management of GHG emissions and reduction activity" are greater than the average score of 0.077. This implies that these items are recognized as the highest priorities for promoting EM in the healthcare sector.

Table 7. Comprehensive results of the combined weighting analysis of relative importance of EIDS reporting items.

Category	EIDS Reporting Items	Score	Ranking
Environmental management (or procurement) system establishment	1. Establishment of a vision and strategy for environmental management	0.107	4
	2. Organization of task team for environmental management and task assignment	0.124	2
	3. Guideline and compliance with green purchasing	0.059	9
Resource/energy management and reduction activities	1. Management of water use and reduction activity	0.122	3
	2. Management of energy use and reduction activity	0.146	1
	3. Investment in new and renewable energy and the introduction of technology	0.048	11
GHG emissions and environmental pollution management and reduction activities	1. Management of GHG emissions and reduction activity	0.091	5
	2. Management of water pollutants and reduction activity	0.055	10
	3. Management of waste generation and reduction activity	0.066	7
	4. Management of hazardous chemical use and reduction activity	0.071	6
Social/ethical responsibility compliance	1. Compliance with domestic and international environmental laws and regulations	0.062	8
	2. Publication of environmental report and environmental information disclosure	0.030	12
	3. Response to stakeholder requests for environmental information	0.021	13
Average		0.077	-

Note: The EIDS stands for the Environmental Information Disclosure System.

The results of the relative performance of individual EIDS reporting items are shown in Table 8. It was found that "compliance with domestic and international environmental laws and regulations," "management of waste generation and reduction activity," "management of energy use and reduction activity," and "management of water use and reduction activity" scored the highest: 4.20, 4.10, 4.10, and 4.00, respectively. Scores were lower for "investment in new and renewable energy and introduction of technology," "publication of environmental report and disclosure," "organization of task team for EM and task assignment," "response to stakeholder requests for environmental information," and "guideline and compliance with green purchasing."

Table 8. Relative performance of EIDS reporting items.

EIDS Reporting Items	Score	Ranking
1. Establishment of a vision and strategy for environmental management	3.60	9
2. Organization of task team for environmental management and task assignment	3.50	11
3. Guideline and compliance with green purchasing	3.70	7
4. Management of water use and reduction activity	4.00	4
5. Management of energy use and reduction activity	4.10	2
6. Investment in new and renewable energy and the introduction of technology	3.30	12
7. Management of GHG emissions and reduction activity	3.70	7
8. Management of water pollutants and reduction activity	3.80	5
9. Management of waste generation and reduction activity	4.10	2
10. Management of hazardous chemical use and reduction activity	3.80	5
11. Compliance with domestic and international environmental laws and regulations	4.20	1
12. Publication of environmental report and environmental information disclosure	3.30	12
13. Response to stakeholder requests for environmental information	3.60	9
Average	3.75	-

Using the results for importance and performance, the IPA matrix was constructed (see Figure 3). "Management of water use and reduction activity" and "management of energy use and reduction activity" were in the first quadrant, which means that the current state needs to be maintained because both the importance and the performance of the task are high. Tasks located in the second quadrant should be priorities because the activity is important, but its performance is low. "Establishment of a vision and strategy for EM," "organization of task team for EM and task assignment," and "management of GHG emissions and reduction activity" fall in this area of "concentrate here." In contrast, "guideline and compliance with green purchasing," "investment in new and renewable energy and introduction of technology," "publication of environmental report and environmental information disclosure," and "response to stakeholder requests for environmental information" have low priorities, which means that both the performance and importance of tasks are low: these tasks are less emphasized. In the fourth quadrant ("possible overkill" area), tasks are relatively unimportant, but a great deal of effort is concentrated on them; unnecessary work should be discarded. "Management of emissions of water pollutants and reduction activity," "management of waste generation and reduction activity," "management of hazardous chemicals use and reduction activity," and "compliance with domestic and international environmental regulations" were included in this quadrant.

Comparison of the relative importance of environmental input variables for 2015 enables us to deepen the analysis of eco-efficiency. Water use (0.762) and energy consumption (0.754) are placed in the fourth quadrant because the eco-efficiencies of these two environmental input variables were higher than the average. On the other hand, the eco-efficiency scores of waste generation (0.532) and hazardous chemicals use (0.323) were lower than average, as were their importance levels. This result reveals the gap between actual performance (eco-efficiency measured by the individual environmental input variable) and the recognized performance (responses to the relative performance of corresponding activities). More specifically, hospital staff did not recognize the management of waste generation and hazardous chemical use as priorities; instead, they believed that their performance on those items was excellent because waste and hazardous chemical measures practiced in hospitals are straightforward and easy to mobilize staff for participation. In contrast, the actual eco-efficiency or performance of these items is lower, due to the large gap with the superior performance of hospitals regarding management of waste and hazardous chemical use. This result implies that it is necessary to adjust or raise the level of hospitals' reduction targets so they can be more eco-efficient.

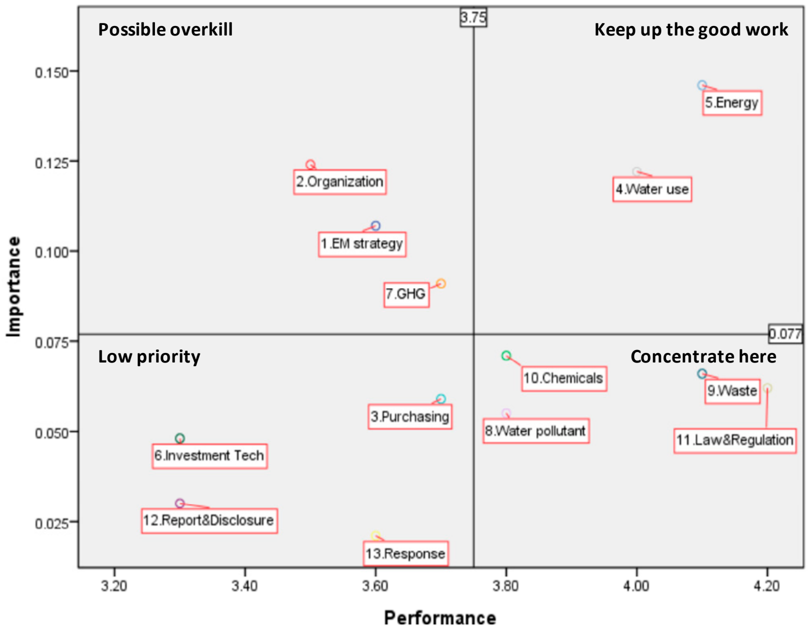

Figure 3. Result of importance-performance matrix. Note: Each number refers to: ① Establishment of a vision and strategy for environmental management; ② Organization of task team for environmental management and task assignment; ③ Guideline and compliance with green purchasing; ④ Management of water use and reduction activity; ⑤ Management of energy use and reduction activity; ⑥ Investment in new and renewable energy and introduction of technology; ⑦ Management of GHG (Greenhouse Gas) emissions and reduction activity; ⑧ Management of emissions of water pollutants and reduction activity; ⑨ Management of waste generation and reduction activity; ⑩ Management of hazardous chemical use and reduction activity; ⑪ Compliance with domestic and international environmental regulations; ⑫ Publication of environmental report and environmental information disclosure; and ⑬ Response to stakeholders requests for environmental information.

6. Conclusions

Through the analysis of changes in the eco-efficiency of 21 hospitals from 2012 to 2015, this study investigated the status and effectiveness of environmental management in the South Korean healthcare sector. It is found that eco-efficiencies improved during the four years that were studied, and that the best 12 hospitals were equally eco-efficient in 2015. Obligatory policy measures, such as GETMS, were found to be more effective for improving the eco-efficiency of hospitals, while it was found that the effectiveness of voluntary agreements was not guaranteed. Therefore, rigorous reporting and monitoring should accompany VAs. It is worth noting that the United Kingdom regularly estimates and issues reports on the carbon footprint of the healthcare sector, which achieved an 11% GHG emission reduction from 2007 to 2015 [14]. Although the average value of eco-efficiency improved from 0.830 in 2012 to 0.902 in 2015, a significant potential for more improvement of eco-efficiency exists by reducing hazardous chemical use. The existing approach to hazardous chemical use in healthcare sector is somewhat reactive, focusing on how to effectively separate and safely dispose of hazardous wastes. This room for improvement implies the necessity of proactive approaches such as the introduction of innovative technologies or the development of alternatives.

Based on the IPA results, priorities for EM in the healthcare sector were identified, areas in which performance is low even though the tasks are essential. Interestingly, "establishment of a vision and strategy for environmental management" and "organization of task team for environmental management and task assignment" are included in these priorities. As García et al. (2015) argued, changes in management bring challenges such as time and cost [10], which are likely to slow down the spread of EM in the healthcare sector. Therefore, know-how and best practices need to be shared to enable followers to get past the challenges more smoothly. The government needs to support building a network or platform for sharing knowledge among hospitals. In addition, the government should focus on training and improving awareness of these priorities.

Based on quantitative analysis of reported data and qualitative analysis using responses to questionnaires, this study assessed EM in South Korean hospitals and provides implications for improving policy measures to diffuse EM in South Korean hospitals. The methodological approach sheds light for researchers interested in EM in the healthcare sector because previous studies depended more on qualitative approaches, particularly case studies. However, the number of analyzed hospitals is too small to represent all the hospitals in South Korea due to the limited availability of the data. Furthermore, because this study surveyed staffs at the 21 hospitals that participated in the EIDS program, the hospitals that did not participate in the EIDS were not represented. Additional analysis to investigate the status and performance of EM at those hospitals needs to be conducted shortly.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Environmental information disclosure items for the healthcare sector in South Korea.

Category	Item	Classification
1. Current status	1. Annual sales	Mandatory
	2. The total annual number of patients	Mandatory
	3. Environmental award-winning and agreement	Voluntary
2. Green management system	4. Environmental management visions, strategies, measures, and goals	Voluntary
	5. Dedicated organization, educational training, and internal evaluation	Mandatory
	6. Green purchasing guidelines and practices status	Voluntary
3. Resource/energy	7. Investments in raw material/water/energy saving and introduction of relevant technology	Voluntary
	8. Annual water consumption	Mandatory
	9. Annual energy consumption	Mandatory
	10. Investment in new renewable energy and introduction of relevant technologies	Voluntary
4. GHG/environmental pollution	11. Investment in GHG (Greenhouse gas) mitigation and introduction of relevant technology	Voluntary
	12. GHG management levels and emission intensities	Voluntary
	13. Investments in environmental pollution reduction and introduction of relevant technology	Voluntary
	14. Environmental pollution management facility and monitoring system	Voluntary
	15. Annual emissions of water pollutants	Voluntary
	16. Annual waste generation	Mandatory
	17. Annual harmful chemical usage	Mandatory
5. Social/ethical responsibility	18. Violation of domestic or international environmental laws and regulations	Mandatory
	19. Publication of environmental (sustainability) report	Voluntary
	20. Response to stakeholder requests for environmental information	Voluntary

Source: retrieved from the EIDS web page [18].

Table A2. Values of six variables at 21 hospitals from 2012 to 2015. Unit of measurement: Water (ton]; Energy (TOE]; Chemicals (kg]; Sales (million KRW]; Patients: (persons).

	Items	H01	H02	H03	H04	H05	H06	H07	H08	H09	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H20	H21
2012	Water	8760	340,094	119,187	270,052	154,797	349,163	26,504	12,997	420,332	1,017,140	396,076	220,151	326,081	304,885	145,980	322,702	423,675	181,413	83,175	78,721	148,921
	Energy	281	7143	4499	4983	3340	6535	658	780	10,242	21,846	11,835	6779	6158	8399	3677	6586	6524	3898	1807	1500	2742
	Waste	61	1974	609	957	696	901	89	51	2992	6185	3007	920	1169	1349	644	650	1569	1049	541	128	295
	Chemicals	36	8528	907	23,587	846	31,859	1724	1724	9253	51,480	58,978	21,137	6368	5443	2722	1983	3629	61	2341	2177	4264
	Sales	7659	268,547	97,813	171,176	71,331	265,330	16,098	4765	387,638	759,350	325,512	201,714	453,302	248,521	93,470	292,394	247,608	128,355	87,246	62,426	121,929
	Patients	62,830	1,194,736	357,181	848,648	506,523	1,148,492	125,606	64,847	1,471,829	2,751,238	46,962	820,959	1,922,494	1,260,091	608,935	1,408,000	350,499	716,954	162,155	120,803	644,430
2013	Water	8029	308,208	119,869	286,663	146,384	333,727	30,862	13,149	525,360	997,369	395,131	220,885	323,433	300,874	153,996	311,964	430,890	192,370	72,912	75,806	146,973
	Energy	273	7250	4987	4909	3378	6401	688	805	13,373	22,310	12,163	7059	6329	9320	3917	6408	7883	3964	1739	1560	2701
	Waste	62	2771	898	1008	670	1169	72	50	3443	5148	3182	910	1207	1387	750	752	1687	1122	529	138	385
	Chemicals	27	8074	556	20,865	674	27,460	1860	1860	11,267	46,896	44,727	25,401	6477	5443	2722	2226	4082	118	2049	2177	3692
	Sales	8683	276,297	108,845	182,002	75,778	267,049	16,172	5321	426,231	782,290	383,815	217,058	247,336	280,628	100,551	315,569	270,024	138,928	92,900	66,082	125,433
	Patients	66,193	1,194,812	426,648	824,518	505,132	1,164,848	131,367	68,409	1,575,750	2,800,784	46,752	868,767	327,031	1,228,678	655,066	1,416,201	379,202	689,821	163,834	120,109	174,727
2014	Water	8865	314,269	119,670	280,568	144,130	321,966	31,241	14,800	473,913	925,459	970,612	230,041	341,502	301,688	157,508	325,301	411,273	182,783	73,016	73,851	140,808
	Energy	287	6746	5110	4711	3164	6138	659	744	13,817	31,918	21,671	6983	5736	9897	3914	6630	8142	3834	1597	1418	2513
	Waste	66	2322	895	1061	481	1104	79	51	4133	8054	4703	957	1291	1513	809	980	1504	1161	542	339	372
	Chemicals	27.22	8119.31	438.17	21,772.44	428.19	33,565.85	1900.55	1900.55	13,426.34	38,773.09	47,840.40	25,310.46	7180.37	7801.79	2449.40	1784.43	816.47	92.53	2054.99	2775.99	3628.74
	Sales	9575	265,055	136,144	195,480	74,180	275,984	18,293	5357	493,645	1,061,225	827,961	246,168	256,585	297,485	113,150	337,573	289,853	140,850	93,202	66,849	132,751
	Patients	113,715	254,838	162,470	888,156	464,678	351,206	138,801	66,701	390,274	672,163	621,635	325,447	327,822	1,236,407	737,146	1,489,223	402,680	786,747	167,199	113,766	176,063
2015	Water	8811	291,220	139,360	267,343	132,853	320,840	28,980	15,000	461,282	1,000,039	1,025,677	250,218	342,879	306,575	158,641	366,833	407,997	202,507	76,776	76,123	139,035
	Energy	283	6586	5451	5359	3174	6751	680	701	14,476	30,494	23,541	7601	5766	9916	4064	6560	8480	4146	1603	1469	2382
	Waste	68	2192	984	1215	467	1114	103	59	3857	7833	4247	1103	1326	1539	838	1324	1531	1180	534	380	2043
	Chemicals	27	8118	460	24,494	367	25,739	1814	2087	15,876	34,564	51,280	29,574	6182	8269	2359	1939	181	47	2007	2830	3629
	Sales	10,450	264,535	152,380	211,768	64,398	284,263	18,496	4969	557,574	934,905	867,141	284,333	268,380	311,468	121,991	348,334	301,256	156,609	94,239	72,886	131,806
	Patients	124,107	246,241	166,512	913,765	92,805	351,207	136,429	61,328	418,911	562,725	621,138	353,571	326,590	1,214,742	449,007	1,520,590	405,040	777,613	165,225	127,252	165,615

Table A3. Questionnaire of survey for importance-performance analysis.

(Importance survey) Please indicate the degree of importance of each item as a key management indicator for spreading environmental management of hospitals.										
<Categories>										
Category	**More Importance Than**				**Equal**	**Less Importance Than**				**Category**
Environmental management (or procurement) system establishment	5	4	3	2	1	2	3	4	5	Resource/energy management and reduction activities
Environmental management (or procurement) system establishment	5	4	3	2	1	2	3	4	5	GHG emissions and environmental pollution management and reduction activities
Environmental management (or procurement) system establishment	5	4	3	2	1	2	3	4	5	Social/ethical responsibility compliance
Resource/energy management and reduction activities	5	4	3	2	1	2	3	4	5	GHG emissions and environmental pollution management and reduction activities
Resource/energy management and reduction activities	5	4	3	2	1	2	3	4	5	Social/ethical responsibility compliance
GHG emissions and environmental pollution management and reduction activities	5	4	3	2	1	2	3	4	5	Social/ethical responsibility compliance
<Items in the environmental management (or procurement) system establishment category>										
Item	**More Importance Than**				**Equal**	**Less Importance Than**				**Item**
Establishment of a vision and strategy for environmental management	5	4	3	2	1	2	3	4	5	Organization of task team for environmental management and task assignment
Establishment of a vision and strategy for environmental management	5	4	3	2	1	2	3	4	5	Guideline and compliance with green purchasing
Organization of task team for environmental management and task assignment	5	4	3	2	1	2	3	4	5	Guideline and compliance with green purchasing
<Items in the resource/energy management and reduction activities category>										
Item	**More Importance Than**				**Equal**	**Less Importance Than**				**Item**
Management of water use management and reduction activity	5	4	3	2	1	2	3	4	5	Management of energy use and reduction activity
Management of water use management and reduction activity	5	4	3	2	1	2	3	4	5	Investment in new and renewable energy and the introduction of technology
Management of energy use and reduction activity	5	4	3	2	1	2	3	4	5	Investment in new and renewable energy and the introduction of technology
<Items in the GHG emissions and environmental pollution management and reduction activities category>										
Item	**More Importance Than**				**Equal**	**Less Importance Than**				**Item**
Management of GHG emissions and reduction activity	5	4	3	2	1	2	3	4	5	Management of water pollutants and reduction activity
Management of GHG emissions and reduction activity	5	4	3	2	1	2	3	4	5	Management of waste generation and reduction activity
Management of GHG emissions and reduction activity	5	4	3	2	1	2	3	4	5	Management of hazardous chemical use and reduction activity
Management of water pollutants and reduction activity	5	4	3	2	1	2	3	4	5	Management of waste generation and reduction activity
Management of water pollutants and reduction activity	5	4	3	2	1	2	3	4	5	Management of hazardous chemical use and reduction activity

Table A3. *Cont.*

Management of waste generation and reduction activity	5	4	3	2	1	2	3	4	5	Management of hazardous chemical use and reduction activity
<Items in the social/ethical responsibility compliance category>										
Item	**More Importance Than**				**Equal**	**Less Importance Than**				**Item**
Compliance with domestic and international environmental laws and regulations	5	4	3	2	1	2	3	4	5	Publication of environmental report and environmental information disclosure
Compliance with domestic and international environmental laws and regulations	5	4	3	2	1	2	3	4	5	Response to stakeholder requests for environmental information
Publication of environmental report and environmental information disclosure	5	4	3	2	1	2	3	4	5	Response to stakeholder requests for environmental information

(Performance survey) Please indicate the extent to which your hospital has achieved the following environmental management activities.

Items	**Do You Think That We Are Promoting Environmental Management Activities Well?**				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
1. Establishment of a vision and strategy for environmental management	1	2	3	4	5
2. Organization of task team for environmental management and task assignment	1	2	3	4	5
3. Guideline and compliance with green purchasing	1	2	3	4	5
4. Management of water use and reduction activity	1	2	3	4	5
5. Management of energy use and reduction activity	1	2	3	4	5
6. Investment in new and renewable energy and the introduction of technology	1	2	3	4	5
7. Management of GHG emissions and reduction activity	1	2	3	4	5
8. Management of water pollutants and reduction activity	1	2	3	4	5
9. Management of waste generation and reduction activity	1	2	3	4	5
10. Management of hazardous chemical use and reduction activity	1	2	3	4	5
11. Compliance with domestic and international environmental laws and regulations	1	2	3	4	5
12. Publication of environmental report and environmental information disclosure	1	2	3	4	5
13. Response to stakeholder requests for environmental information	1	2	3	4	5

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