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A green supply chain taxonomy in healthcare: Critical factors for a proactive approach

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Abstract

Purpose: The aim of this study is to identify the critical factors of green supply chain (GSC) and to adapt these factors to the taxonomy of green practices in healthcare.

Design / methodology / approach: A qualitative multiple-case study approach was followed based on 60 interviews with nine French hospitals. An intra-case and a cross-case analysis was implemented.

Findings: The findings provide a taxonomy of healthcare GSC and show that regulation, cost reduction, top management commitment, employee training, information technology and measures of environmental performance are critical factors for GSC implementation. The study also underlines few emergent critical factors including the purchasing group, environmental champion, building construction, combining safety and green approaches.

Research limitations/implications: This study was conducted in France following a qualitative methodological approach. Future research can consider other national and cross-national investigations and other quantitative or mixed methods approaches.

Practical implications: The research provides managers and policy makers numerous invaluable suggestions for the implementation of GSC practices in healthcare facilities. To accelerate green supply chain implementation, managers can invest in the construction of new buildings, in information technology, and in the automation of flows.

Originality / value: To our knowledge, this is the first paper identifying the critical factors of GSC implementation in the healthcare sector. It is also the first attempt to provide a taxonomy of hospitals according to their green approaches (reactive, receptive, and proactive).

Keywords: green supply chain, hospital supply chain, healthcare, logistics, critical factors, taxonomy, multiple case study.

Paper Classification: Research paper

Introduction

Green supply chains (GSCs) have attracted increasing interest in recent years and with environmental pressures, organisations move from traditional supply chains to GSCs. A GSC is the integration of environmental considerations into supply chain management (Sarkis et al.

2011) involving waste reduction and greenhouse gas emissions, eco-design, green purchasing, ecological packaging and reverse logistics. Some researchers consider these practices to be a source of business-performance improvement and a competitive advantage for companies (Zhu and Sarkis, 2007; Sarkis et al., 2011; Agyabeng-Mensah, 2020).

Logistics & supply chain management research rarely explores the entire GSC by integrating product design, purchasing, production, storage, transport, and reverse logistics (Govindan et al., 2014). In the healthcare field, there has been primarily conceptual research such as the work from Ozkan and Akyurek (2016) which explored green practices from production to delivery to patients whilst most empirical studies focussed on waste management and green purchasing (Kaiser et al., 2001; Muduli and Barve, 2012; Malik et al., 2016). In addition, the majority of research papers on GSC are in the manufacturing context. Malik et al. (2016) have developed a tool to evaluate the environmental performance of healthcare suppliers and thus helping purchasers in the selection process of suppliers. Most studies examine the critical factors to implementing GSCs in relation to a specific sector (automotive, mining, textile, etc.) and they rarely examine the health sector despite the fact that healthcare facilities consume much energy and water and produce high quantities of household and infectious waste (Mukesh, 2001). The scarcity of studies on GSCs in the healthcare sector can be explained by several reasons. Firstly, it is difficult to access data because these are often linked to sensitive patient information. Another factor is the complexity of the healthcare supply chain including diverse groups, activities and actors (e.g. physicians, nurses, logistics and IT managers).We have chosen to study the hospital as a pivotal entity of the healthcare industry and also as a central point of consumption in the supply chain, thus generating a major environmental impact.

Previous GSC studies have attempted to identify and prioritise the critical factors towards the implementation of environmental approaches (Muduli et al., 2013; Govindan et al., 2014; Zhu et al., 2017) but without having a classification of organizations according to their green approaches (taxonomy) which could help to understand the differences in their environmental practices and the adapted critical factors of GSC implementation.

Taxonomy is a key framework in stimulating research and developing theories, especially in an emerging field such as the green supply chain of the healthcare sector (Paulraj et al., 2012; Harland et al., 2001). Unlike conceptual typologies based on theory, the taxonomic approach offers a classification derived from empirical studies and thus developing a better understanding of inter-organizational phenomena (Rich, 1992; Christopher et al, 2006).

Little research has used the taxonomic approach to study issues related to healthcare logistics and supply chain management. Rakovska and Stratieva (2018) have studied hospital supply chain practices and have identified three clusters of hospitals related to the extent of internal and external integration. However, this research does not offer a classification of environmental practices in the healthcare supply chain and the factors for its implementation. To fill the gap for GSC implementation in healthcare, we examine multiple cases in nine healthcare facilities in France. The study aims to identify GSC practices and the critical factors of their implementation in relation to a taxonomy of green approaches in hospitals. This is extremely important as the introduction of a GSC supports healthcare facilities to improve their business and public image, reduce their costs and enhance their competitive advantage (Malik, Abdallah and Hussain, 2016; Cousins et al., 2019). The taxonomy proposed provides insights on the factors to be mobilized by managers in order to develop and operate each GSC strategy.

The rest of the paper is organised as follows. Section 1 summarises the literature on the critical factors of GSC implementation and the hospital supply chain. Our methodological approach is detailed in Section 2. Section 3 presents the empirical results based on a cross-case analysis. Section 4 discusses these results before concluding with limitations and future research directions.

1. Literature review

1.1 Critical Factors of GSC implementation

GSC practices are increasingly considered by researchers and professionals as sources of business performance. Despite this positive vision of GSC, the implementation of environmental approaches remain limited in organizations. Therefore, we explore in this section the factors which encouraged the implementation of GSC by analysing research dealing with this issue published in leading journals of logistics and supply chain management.

Past studies have focused on the critical factors towards the implementation of GSC primarily in various industrial sectors. We will review the literature for these sectors to provide the basis for our empirical investigation in GSC implementation in healthcare.

Regulation

The existing literature has identified regulation and legislation as key factors in implementing GSC practices. Zhu and Sarkis (2007) define environmental regulations as coercive pressures

that support managers to implement GSCs and improve performance. In developed countries, the coercive pressures of laws and regulations have improved environmental awareness and led to environmental management practices. The Japanese government, for example, has adopted some of the strictest environmental laws in the world (Zhu et al., 2010). European countries impose strict environmental regulations and promote recycling (Zhu and Sarkis, 2007). The literature has nevertheless shown that the decision to implement an environmental regulatory policy is challenging for governments as it can slow economic growth. For example, in India, the fear of a drop in employment and economic growth due to environmental practices explains the low level of regulatory pressure (Muduli et al., 2013). The implementation of a GSC can also be based on certifications, such as ISO 14001 (environmental management system) or ISO 26000 which help companies to reduce their environmental impacts, improve image, and enhance their external relations and investment capacities (Mitra and Datta, 2014). Other studies have shown that government pressures can guarantee GSC performance, especially for companies adopting a proactive approach and integrating the legal framework (Walker et al., 2008).

Competition and Customer pressure

Competition pressure is a factor encouraging organisations to take up new cooperation approaches that are positive for the environment (Pagell and Wu, 2009; Sarkis et al., 2011). Consequently, many companies integrated new environmental ideas in the design of products and in managerial practices. Companies also establish competitive intelligence to identify competitors' capacities and stimulate environmental innovation (Henriques and Sadorsky, 1999).

Customer pressure is another key factor for the implementation of GSC practices (Walker et al., 2008; Thun and Müller, 2010). These customers are, in turn, influenced by final consumers who are aware of environmental issues and who increasingly expect environmentally friendly products. Therefore, companies in a focal position must both apply an internal environmental strategy to maintain a positive image and involve other external partners (Subramanian and Abdulrahman, 2017). This overall strategy is necessary because the focal company may be perceived as responsible for the environmental impacts of all companies in its supply chain (Rao and Holt, 2005). Small companies are under particular pressure from their customers (Hall, 2001) too and are encouraged to meet the requirements of certain accreditations or environmental standards, such as ISO 14000. Researchers also encourage companies to support

their partners in establishing their GSCs because it has a shared positive impact on economic and environmental performance (Geng et al. 2017; Zhu et al. 2017).

Suppliers' engagement

GSC implementation can be based on suppliers' integration and this can provide important ideas towards the realisation of environmental projects (Hu et Hsu, 2010). Hence, a collaborative approach is important encouraging suppliers to help customers to understand the effects of environmental approaches (Lamming and Hampson, 1996). But some suppliers could also communicate and exchange little information on green practices with their customers and, as a result, it is complicated for companies to control and monitor suppliers' environmental practices (Rauer and Kaufmann, 2015). Inter-organisational trust and proactive environmental management play a key role in supplier engagement in the GSC practices (Hoejmose et al. 2012).

Cost reduction

Cost is a significant factor in GSC implementation (Zhu and Sarkis, 2007). In fact, due to strong competition and the scarcity of resources (Kalaitzi et al., 2019), initial investment costs of GSCs are perceived as being very high (Giunipero et al., 2012) causing short-term drops in economic performance (Zhu and Sarkis, 2007) and this decline is more pronounced for SMEs (Shibin et al., 2016). These costs are related to integrating new, clean technologies, setting up reverse logistics, and acquiring new competencies for managing GSC issues. Several studies have also shown that an investment in environmental approaches can reduce costs and constitute a competitive advantage for companies (Walker et al., 2008). For example, an eco-design or the use of renewable energy can bring down production costs. Increasingly, studies have attempted to reconcile the contradictions between environmental and economic approaches to supply chains (Zhu and Sarkis, 2007; Govindan et al., 2014) and Nurjanni et al. (2017) showed that organisations can reduce costs while minimising environmental pollution by optimising the closed-loop supply chain network design.

Top management commitment

Top management commitment is a major factor in GSC implementation (Ravi and Shankar 2005; Balon, 2016; Agarwal et al., 2018) and it is indispensable to adjusting processes and shifting internal culture towards an environmental strategy (Govindan et al. 2016). It also determines the overall impact of practices and environmental initiatives on supply chains (Olugu et al., 2011). Effective management commitment involves the activating of a leadership

model, communicating with employees and raising their awareness of the benefits of sustainable environmental approaches (Graves et al., 2013).

Employee training

Employees tend to have little knowledge of environmental practices, how to integrate them into supply chains, or the benefits for the organisation (Muduli et al., 2013; Govindan et al., 2014; Zhu and al., 2017). It is thus important to develop company expertise on GSCs by training employees. However, empirical studies have further shown that these training programs are limited, hindering the dissemination of environmental practices in organisations (Teixeira et al., 2016; Zhu et al., 2017). In addition, mobilising personnel is complex and requires adopting suitable training methods to improve staff skills and raise awareness of ecological and environmental principles (Handfield, 1997; Graves et al. 2013).

Technology and information systems

The role of technologies and information systems in supply chain integration has been widely emphasised (see Vachon and Klassen 2007) and when information systems have not been implemented, difficulties in integrating an environmental approach emerge (Ravi and Shankar, 2005; Govindan, 2014). These information systems are critical for communication and cooperation in the supply chain and, thus, the implementation of GSCs (Wang et al., 2008; Balon et al., 2016). Furthermore, novel technologies (e.g. big data, automated guided vehicles) play a critical role towards the improvement of the GSC and enhancing its environmental performance (Dubey et al., 2019; Benzidia et al., 2021).

Green performance measures

Very few companies possess adequate instruments for measuring their environmental performance (Handfield, 1997; Rauer and Kaufmann, 2015; Supeekit et al., 2015) and their absence perpetuates uncertainty about the actual benefits of a GSC and its implementation (Ravi and Shankar, 2005; Govindan, 2014; Rauer and Kaufmann, 2015). An environmental performance measurement system is required to justify the development of green purchasing, green products and reverse logistics (Handfield, 1997) which can be closely connected to the requirements of certain environmental standards such as ISO 14001 (Olugu et al., 2011). Performance measures can also justify the perceived or realised benefits of investing in green practices (Zutshi and Sohal, 2004).

1.2 The hospital supply chain and green approaches' taxonomy

Hospitals are undergoing profound organisational changes aimed at streamlining processes, optimising costs, and improving patient services. However, this is slowed by administrative inertia, lack of adequate competencies, and complex healthcare activities (Feibert and Jacobsen, 2019). The complexity of the hospital supply chain is related to a wide range of activities, a variety of physical processes and information flows, and multiple actors with sometimes contradictory objectives (De Vries and Huijsman 2011). The hospital supply chain integrates several flows with different characteristics (i.e. patient flows, pharmaceutical flows, laundry flows, catering flows, and waste flows) (see for example, Bourlakis et al., 2011). The management of these flows benefits from information systems and in particular from the emergence of advanced digital technologies such as Cloud Computing, Big Data Analytics, Artificial Intelligence (Beaulieu and Bentahar, 2021).

Patient flows are at the heart of hospitals' strategies and gradually integrated into a GSC approach to optimise, secure and improve the health chain. The crosscutting nature of logistics is crucial for coordinating healthcare actors and thus improving patient service quality.

The supply chain of pharmaceutical and other medical flows has a strategic role in hospitals because it is expensive and it requires setting up several innovative approaches related to purchasing, storage and traceability. For example, the implementation of RFID (radio frequency identification) improves the traceability of drugs. Unlike patient and pharmaceutical flows, laundry and catering flows are not at the heart of hospital work and hospital managers have opted to outsource the management of these flows.

Lastly, waste flows include general waste related to food, cardboard, paper which is non-hazardous (75% to 90% of hospital waste) and medical waste from healthcare activities which is considered hazardous (e.g. waste such as sharps and discarded blood that may be infectious, chemical or radioactive). Effective waste logistics management requires the adaptation of managerial approaches to types of waste involved. Therefore, hospitals implement innovative approaches to bring down the cost of waste management while reducing its environmental impact including optical sensor-based sorting technology to optimise solid waste processing.

Unlike industrial supply chains, managers in the hospital supply chain have a lack of logistics expertise and competencies, and low levels of supply chain integration are evident too (Bourlakis et al., 2011; De Vries and Huijsman 2011) making difficult to integrate an environmental approach into this supply chain.

A taxonomy of three main GSC approaches have been classified in the literature (Handfield, 1997; Zhu and Sarkis, 2007; Walker et al., 2008) and can be transferable to the health sector. This classification includes the reactive approach, the receptive approach and the proactive approach:

- The reactive green approach involves respecting regulations and avoiding sanctions. It is mostly centred on "end-of-pipe" practices such as waste reduction (Handfield et al. 1997; Zhu and Sarkis, 2007; Walker et al., 2008);
- The receptive green approach is a voluntary endeavor which considers the added value of green practices integrated into the organisational strategy. However, this approach is still limited to supply chain practices (e.g. integrating environmental concerns in the strategic planning of the organization). (Handfield et al. 1999);
- Finally, the proactive green approach considers environmental practices to be a competitive advantage for an organisation. Green concerns are not only part of an organisation's strategy, they are also broken down operationally into various supply chain areas (e.g. purchasing, production, waste, reverse logistics) and supported through certification and commitment from all actors (Handfield, 1997; Walker et al. 2008). This approach involves, for example, adopting certification projects like the Eco-Management and Audit Scheme (EMAS) or ISO 14001 which integrates green requirements used as framework of an effective environmental management system (Curkovic et al., 2000).

This study examines the French hospital sector which has undergone a series of reforms in recent years such as rationalizing practices related to operational processes and strategic decisions. These emanate from various factors, such as demographic changes with population ageing, the shortage of nursing staff and the lack of control over hospital supply chain costs. In addition, faced with ecological concerns, health stakeholders are committed to strengthening their environmental practices in relation to energy consumption and waste production (Molga, 2011). This was driven by regulations including the Law of Energy Transition for Green Growth (2015) where the French government has pushed hospitals to commit to reducing greenhouse gases by 2% each year.

Despite numerous decisions and institutional procedures being adopted by public policy to reduce the environmental impact of French hospitals (Molga, 2011), the implementation of environmental practices in hospital supply chains remains limited. Few studies exploring GSCs in hospitals have focused mainly on waste management or green purchasing. Kaiser et al.

(2001) developed tools that can help hospital managers in purchasing eco-friendly products to reduce waste and decrease costs.

Overall, hospitals are major environmental polluters but, equally, their endeavours to implement environmental approaches remain restricted. It is vital to identify and understand the different areas of hospital GSCs, to develop a subsequent taxonomy and to identify the critical factors for this GSC implementation.

2. Research methodology

Research on GSCs in hospitals is only emerging. The nascent nature of this subject leads to complex connections and underlying meanings that require exploration. Thus, a case study is an appropriate strategy to explore and understand GSC areas in hospitals and factors of environmental initiatives. Indeed, Eisenhardt (1989), Yin (1994), and Ellram (1996) recommend using a qualitative case study to analyse complex phenomena that are embedded in their context and when it is difficult to control behavioural events. In addition, studying multiple cases makes it possible to replicate and improve the external validity of the study results (Voss et al., 2010).

Due to the idiosyncrasy of our study and its context, we have adopted an abductive scientific reasoning process (Figure 1) that relies on a logic of theory or theoretical concept development (Niiniluoto, 1999). This reasoning is based on the articulation of theoretical concepts and empirical examination in a balanced way (Ketokivi and Choi, 2014). Therefore, we did not anticipate the empirical results by the a priori formulation of propositions (Ketokivi and Choi, 2014). We therefore remained open to any unforeseen discoveries of our empirical research (Gammelgaard, 2017). The choice of this methodological approach has allowed us to confirm some critical factors of the implementation of a green policy in organizations that have been highlighted in the extant literature and have also allowed us to discover new emerging factors related to the context of hospitals. This abductive research process has also extended theory by suggesting a taxonomic approach.

Figure 1

We adopt a multiple case study approach based on 60 interviews with nine organisations which are hospitals from the private and public sector primarily because hospitals have a significant, negative impact on the environment (e.g. 3,111 hospitals in France) and multiple activities consuming energy and water and producing a high quantity of general waste and infectious medical waste.

We initially identified hospitals with different levels of GSC implementation which facilitated the comparison and generalisation of results. The hospitals were divided into three categories: reactive, receptive, and proactive hospitals related to GSC approaches.

Specific criteria were involved in establishing our sample, such as hospital size (no. of beds, no. of employees) and private or public status. We based our data collection and analysis on the qualitative methodology principles developed by Miles et al. (2014).

Data collection was mainly carried out through in-depth, qualitative interviews and the research team had the privilege to have access to key managers working in nine French organisations (Table 1). The study's interview protocol is inspired by the interview guides employed in research by Handfield et al. (1997) and Walker et al. (2008). It was enriched by the recent literature on factors of GSC implementation (Govindan et al. 2014; Zhu et al., 2017). The interview guide was pre-tested and adapted following interviews with nine healthcare experts. For example, the construction of a hospital was underlined as a critical factor in GSC implementation and a new question was integrated into our interview guide.

The interviews were carried out in person with 60 key informants (e.g. health experts, hospital directors, healthcare managers etc.). Health experts are not directly related to hospitals and their input shed light on hospitals' strategy and GSC practices in healthcare in France. The interviews lasted from one to two hours and we were able to question at least five key informants concerned with GSC in each hospital allowing us to obtain a holistic input of the phenomenon studied, with limited perception and interpretation bias (Table 1). The interviews tackled the following themes in relation to hospitals:

- GSC strategy
- GSC projects
- GSC areas,
- Green supply chain initiatives
- Critical factors of GSC implementation.

We applied the approach developed by Miles et al. (2014), which starts with an intra-case analysis to identify the results related to the study context. The next step is a cross-case analysis carried out to compare the results and identify patterns of factors in hospitals' GSCs.

Data analysis was carried out iteratively. To achieve triangulation and complementarity (Handfield and Melynk, 1998), the results were cross-referenced with other data sources (i.e., observations, reports, internal documents, and internal and external hospital communication). As part of a non-participating observation approach, two of the three researchers involved in the study visited nine hospitals. These visits improved our understanding of logistical flow management in the hospitals, waste management systems, and GSC initiatives. The collection of internal and external documents helped us to understand the green initiatives implemented, the level of their dissemination in the supply chain, and their contributions to the hospitals.

Table 1

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3. Results

3.1 Taxonomy of GSC approaches in hospitals

The hospitals studied have different GSC approaches (e.g. reactive, receptive or proactive) depending on strategy adopted and environmental practices implemented. This classification of hospitals helped to understand the critical factors involved in implementing GSCs.

3.1.1 Reactive approach (+)

A reactive approach is when an organisation can respond to the requirements of environmental regulations and, hence, hospitals act to reduce waste. Our study identified four hospitals (i.e. A-B-G-H) that have a reactive culture and clearly declared that GSC implementation is not part of their internal strategy but rather an approach to avoid risks related to infectious medical waste and statutory penalties. Their initiatives concern, for example, paper recycling (8), buying new eco-lamps consuming less energy and installing automatic lights (4), and improving inventory management to reduce packaging and waste (6), (see Table 2). Consequently, hospital personnel is not fully aware of environmental issues for this supply chain.

Managers expressed no desire to establish a green strategy and justified their attitude by the associated costs. In terms of governance, our study identified the lack of a service or a manager

devoted to green action and managers appointed employees with no direct competency in green practices and only ensured the correct implementation of guidelines.

"We have not evolved in this area even if we have already implemented various issues. The point where we have perhaps made the most progress is waste management because it integrates the environmental aspect which is highly regulated and the issue of cost reduction allowing us to optimize expenditure if we manage and sort out waste effectively" (Hospital Director, Hosp-B)

3.1.2 Receptive approach (++)

A receptive approach is a voluntary approach applied by hospitals to integrate environmental practices but it is followed in only few supply chain areas. Three hospitals following this approach started with environmental initiatives aiming to secure EMAS or ISO 14001 certification. They also established actions that respect the environment but that affect only part of the supply chain. The limitation of the use of materials for "single use practice" to reduce packaging (3) and the digitalisation of patient files leading to reduced paper waste in HospD are good examples (7). Other initiatives include purchasing certain local products in Hospitals D and C (2) and choosing suppliers close to hospitals fostering short supply and reducing CO_2 emissions related to transport (5). Lastly, HospF purchases baby bottles suitable for reverse logistics as used bottles can be recycled (2).

"We are not advanced, and this interview reminds us this. However, we have a program and a charter for respecting the environment dating six years with well-defined objectives (e.g. integrating environmental principles in the establishment's strategy, make an annual report on the progress of the environmental program and be in compliance with legislation). Overall, we are not yet good in implementing these objectives. (Hospital Director, Hosp-F)".

3.1.3 Proactive approach (+++)

A proactive green approach considers environmental practices as a source of value creation for the organisation and, therefore, organisations try to align green practices with operational processes. This proactive green approach has been followed by two hospitals (E and I) considered to be a source of economic performance. It is part of hospitals' strategy, replicated in various supply chain areas. Communication of environmental achievements is internally shared in the hospital and externally disseminated to stakeholders (1). Examples include HospI's external communication on the installation of an innovative automated system of infectious medical waste transformation and HospB's on the recycling initiative of tubes.

Hospitals' environmental actions are organised through EMAS or ISO 9001-14001 certifications. These hospitals also invest in projects for the environment. HospI was the first French hospital to install automated guided vehicles (AGVs) to optimise waste management. Equally, HospE was the first French hospital to install an innovative automated system to transform infectious medical waste into safely disposable waste combining economic and environmental performance. The project reached profitability after five years reducing waste by 80% (9). Both HospE and HospI foster an environmental culture at all levels (managers, employees etc.) including an environmental manager and an environmental champion to foster green supply chain practices.

"We have an environmental policy which is implemented in various health activities. It has the commitment of the whole establishment. We have an environmental committee and I am one of the driving forces behind our environmental approach which we started over 18 years ago. The first steps started with waste management and selective sorting of waste. Processes and indicators have been progressively improved. We were certified ISO 14001 in 2014 and we are still looking to integrate new environmental standards" (Top Manager, HospE).

Figure 2 summarises and defines the three suggested healthcare green supply chain taxonomy approaches that result from the empirical evidence.

Figure 2

Table 2

3.2 Factors for GSC implementation supporting hospital taxonomy

Building on the literature which analyses the generic factors of GSC implementation, this section will now discuss the key factors of this implementation in healthcare sector based on the empirical work; these factors are also linked to the hospital taxonomy (reactive, receptive, proactive).

Regulations

Regulation was frequently mentioned by informants who outlined that to succeed in GSC implementation, the application of environmental regulations should result from restrictive legislation rather than from voluntary solutions. An interviewee confirms this observation stipulating that when authorities reinforce controls and pressures, hospitals are encouraged to adopt environmental management. He explains that numerous establishments attempted to secure EMAS certification but stopped after three years because this standard is not coercive for hospitals. Only Hospitals E and I have a proactive GSC approach making green standards part of their strategic priorities by voluntarily adopting certifications (e.g. EMAS, ISO 14001).

Competition and customer pressure

Competition and customer pressure are not identified as factors of GSC implementation. Interviewees confirmed that there is no pressure emanating from both issues; for example, for customers, the main criterion is the quality of medical care. Hospital managers consider environmental issues to upgrade hospitals' image and state that the change in the mentality of younger customers implies that protecting the environment will be extended to all sectors in the future, including the hospital sector. Overall, this factor has no influence on the current implementation of GSC.

Supplier initiatives

Hospitals' suppliers do not act upon GSC implementation. Certain hospital managers have expressed an interest in supplier initiatives that integrate environmental policy in the manufacturing and commercialising of products and services. HospF was attracted by a range of biodegradable diapers offered by one of its suppliers and decided to adopt them. The management team considers that this type of purchase, although expensive, improves the image of the hospital and influences its activity.

Cost reduction

The cost of green practices is perceived to be high for all supply chain decisions (purchases of logistical and transport flows, storage and distribution etc.). The views of interviewees from Hospitals I, E and D differ slightly, as these hospitals have managed to combine economic and environmental objectives. For example, HospE installed the first innovative automated system in France, transforming infectious medical waste into general waste. HospI invested in a digital project to transform the heat from computer servers in a blockchain business firm to provide hospitals with hot water reducing both greenhouse gas emissions and energy consumption.

Overall, cost reduction is a critical factor in implementing GSC regardless of the taxonomy of hospital's approaches (Table 3).

"We need to set up good practices to make staff aware of the costs linked to waste, especially medical waste. We are accountable and need to manage costs to keep our hospital functioning well. We launched a training and awareness campaign on waste management." (Quality manager, HospA)

Top management commitment

Top management commitment to be a key factor in GSC implementation. Informants in hospitals with reactive and receptive approaches have indicated weak commitment to green practices among top management. Hospitals adopting the proactive approach had already benefited from top management commitment to create a green organisation culture. Hospitals in early stages of developing a GSC require top management commitment to elaborate a strategic plan, to finance environmental projects and disseminate green approaches.

Employee training

Interviewees mentioned the lack of knowledge related to green practices in activities of hospitals and stated that Directors, doctors, assistant nurses, midwives, nurses, and technical managers have no specific skills related to environment management and received minimum training for implementing green approaches. Thus, training is considered as a critical factor to facilitate the transition to environmental awareness in organisations and to guarantee the implementation of GSC practices. Only two hospitals have a clear training policy (HospD and HospE) and that only Hospital E (proactive approach) applies the requirements and recommendations of ISO 14001 certifications. This hospital hires external consultants to ensure effective green practices are implemented, respecting the environmental guidelines of the certification. HospI tends to follow normative recommendations less closely.

Likewise, most reactive hospitals (HospA, HospB, HospH) consider employee training as a critical factor to GSC implementation but they do not have a training policy and only run occasional training courses.

Information technology

Only interviewees from HospC, HospE and HospI perceive information technology as critical for the implementation of environmental approaches. HospC has implemented an intranet portal to manage information of all departments. To strengthen the digital strategy, HospC has implemented an Electronic Patient Record (EPR) system facilitating access to patient information, improving the exchange of information between health professionals. Through the use of EPR, HospC improved the quality of care while reducing the use of paper and its negative impact on the environment. HospE has implemented an Enterprise Resource Planning (ERP) to optimise pharmaceutical flow (purchasing, production, storage and transport) while reducing paper and waste. HospI has implemented an information system linked to AGVs to improve the management of logistics flows, including the flow of waste. This information system optimises AGVs' transportation and deliveries and helps to better manage hospital waste and reduce human errors in mixing general waste and infectious medical waste.

These results show that reactive hospitals and some receptive hospitals have limited awareness of the positive impact of information technology on the implementation of GSC whilst proactive hospitals are committed to digitizing the SC from an economic, security and environmental perspectives.

"One of the drivers of green approach and this is linked to the impetus of the former Director, was first his dematerialization policy through the intranet portal in 2008. In 2009, we implemented the electronic patient record which improves patient management, allows the computerized drug prescription and participates in the goal of "zero paper" (Medical information manager, HospC).

Green performance measures

Interviewees identified the establishment of a monitoring and evaluation system to measure the impact of environmental practices on supply chain performance. Our study shows a notable lack of an environmental performance measurement culture for all reactive hospitals, despite its value. The existing measurement tools provide insufficient information on the current state of environmental aspects for the receptive and proactive hospitals and the progress made in these hospitals focus on waste performance measures because of the important costs generated.

The results highlighted the advancement of HospE in developing green performance measures, investing in an automated system transforming infectious medical waste into general waste and reducing the annual volume of infectious medical waste by 80%. This encouraged HospE to invest in a new and more sophisticated automated system for waste transformation. HospE has

also introduced scoreboards for monitoring and measuring drug stocks to better manage their expiration dates and thus reduce waste.

Apart from these factors which are in agreement with the extant literature, our study identified a plethora of unexpected factors which are discussed below.

Combining safety and green approaches

Interviewees emphasised that patient safety can be conflicted with the application of environmental practices as most managers promote and ensure patient security to the detriment of approaches aiming to reduce the environmental impact. Pharmacists are often confronted with choices relating to medication and medical device where they factor in patient safety first. For example, we can consider the prevailing practice of employing single-use medical devices with the aim of reducing the risk of contaminating patients. This improves patient safety but generates a significant amount of waste. Thus, hospitals managers must find mechanisms to combine safety and green approaches constituting a critical factor in GSC implementation. Only HospF has initiated actions to reduce single use in the catering activity such as a return to a washing system at the catering level instead of buying disposable tableware.

Purchasing group

All hospitals in this study are members of a purchasing group. Purchasing groups are horizontal cooperation between hospitals with the main aim of reducing cost of purchases and making savings. Few key informants (especially pharmacists and Directors) stated that they are constrained in their purchasing decisions by the purchasing group which is prevalent in both private and public hospitals. The environmental criterion is not a priority in the choice of suppliers and products offered to hospitals as purchasing groups encourage large, low-cost suppliers and discourage local suppliers and short channels and, subsequently, carbon footprint for transporting products and goods increases. Only HospE (member of a purchasing group) has an environmental vision of purchasing incorporating environmental criteria when choosing suppliers.

"In France, green purchasing policy does not exist. There is only one purchasing group that created a green index and uses green suppliers. The others purchasing groups are listing goods and their only criterion of choice is price which is a mistake because what you have to consider is other hidden costs" (Health Expert, Hospital Purchasing Group Director).

Construction of a hospital building

Most hospital Directors argued that an old building discourages them from integrating environmental dimensions as they find themselves confronted with ageing buildings unsuitable for effective GSC management. HospD and HospH which, follow receptive and reactive approaches respectively, have constructed energy efficient buildings. Their investment has led to reduced energy consumption in hospitals by making the most of solar resources and to the installation of new insulation materials.

The construction of new buildings in proactive hospitals is not limited to the energy aspect as new buildings integrate a broader vision of GSC approaches. For example, HospI designed and built a new construction adapted for the automated management of logistical flows and energy consumption, optimising transportation, and effectively managing waste and reverse logistics.

"We are in a building not adapted to green. A green approach would require a huge investment. However, we have a new building under construction which will be in line with the green supply chain criteria focusing on biomass and solar energy. This is an eco-construction" (Hospital director, HospB).

Environmental manager and environmental champion

Our work highlighted the crucial role of the environmental manager in the implementation of green projects and practices and in the diffusion of green culture. This implementation of green practices cannot be effective without the enthusiastic support of an environmental champion. Indeed, our work underlines the importance of an environmental champion with a mission to support and defend green approaches within the hospital supply chain who often has a strategic position within the organisation giving this person the power to support projects and actions promoting environmental concerns. Many interviewees reported the need for an environmental champion within the hospital due to the complexity of the organisation and this need was primarily highlighted by interviewees from HospE and HospI as a critical factor in GSC implementation primarily because these hospitals follow a proactive approach.

Likewise. while many interviewees in seven hospitals have underlined the importance of the role of the environmental manager in the implementation of the GSC, only three hospitals with receptive (HospD) and proactive (HospE and HospI) green approaches have effectively hired environmental managers.

The results demonstrate a clear relationship between the taxonomy of hospitals' green approaches (reactive, receptive and proactive) and the critical factors of GSC implementation. Specifically, a number of factors are generally perceived by hospital stakeholders as being

critical to the development of GSC whatever the taxonomy followed (reactive, receptive, proactive). These factors include, inter alia, regulation, cost reduction, top management commitment and employee training, green performance measures. However, these factors are mobilized to a limited extent in reactive and receptive hospitals, whereas they are more developed in hospitals with a proactive approach. Furthermore, our findings reveal emergent critical factors which are mainly related to hospitals with a proactive GSC approach. Indeed, these factors have been rarely identified in reactive and receptive hospitals including the renovation or construction of new buildings, information technology, the purchasing group, the environmental manager and environmental champion and the combination of safety and green approaches. Finally, competition and customer pressure, and supplier initiatives have not been identified as critical factors to GSC implementation.

Table 3

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4. Discussion and conclusion

The findings illustrate that GSCs in hospitals remain underdeveloped. Hospitals are either reactive in response to regulation and centred on waste reduction, or they are receptive and limited to a few environmental practices. Only two hospitals (HospI and HospE) are at an advanced stage with a proactive GSC strategy and practices. These two hospitals have a clear strategy for the GSC, committed management, and an environmental manager and champion ensuring the implementation of the strategy at operational level. In addition, these hospitals invest in innovative GSC projects: innovative automated systems transforming infectious medical waste, the construction of buildings around the flows, and the automation of the waste management by AGVs. The results of the research have improved significantly our understanding of the diverse green approaches in hospitals and facilitate further the identification of critical factors for GSC implementation. Thus, the critical factors identified in the two hospitals adopting the proactive green approach are transferable, with some adaptation, to hospitals willing to shift from the reactive or receptive approaches to proactive ones.

Our findings support previous research highlighting the importance of regulation, supplier initiatives, cost reduction, top management commitment, employee training, information technology and environmental performance measures as critical factors for GSC implementation (Agarwal et al., 2018; Benzidia et al., 2021). As in previous studies in the

literature (Zhu and Sarkis, 2007; Graves et al., 2013; Muduli et al., 2013; Zhu et al., 2017), cost reduction is always mentioned by interviewees as a factor for GSC implementation. The commitment of top management is also a major factor in the implementation of GSCs. In addition, training healthcare professionals and healthcare managers in environmental approaches is important to facilitate the dissemination of GSC practices (Handfield et al., 1997; Graves et al. 2013).

Regulations and quality standards through certification also appear to be critical factors for the implementation of the GSC at hospitals. The evolution of regulations with a coercive and incentive approach to the environment is considered by healthcare stakeholders to be a critical factor for hospitals to progress from traditional supply chains to GSCs. This finding consolidates those of Chen and Sheu (2009), who emphasise the role of a dynamic approach to standard regulation and financial incentives in the development of GSCs. The implementation of EMAS or 14001 certifications can give impetus to environmental approaches, but they are difficult to maintain over time without pressure from the customer or regulation. Overall, the results of the study support the extant literature which emphasizes that companies with a developed quality approach can better develop the capacities necessary for the adoption of a sustainable supply chain by building on existing tools, methods and practices (Curkovic *et al.* 2000; Olugu et al., 2011) and pave the way for further work for GSC implementation in the healthcare sector.

The influence of supplier initiatives on GSC implementation remains limited to a single case (HospC) as we observed a lack of suppliers' engagement with green practices in most cases analysed. This is of utmost importance as the commitment of suppliers and their collaboration with the company promotes the integration of environmental approaches and thus facilitates GSC implementation (Walker, 2008).

Unlike companies operating in other sectors, healthcare organisations do not consider competition and customer pressure to be critical factors for GSC implementation as patients are driven mainly by the quality of care whilst the environmental dimension is not yet perceived as a competitive advantage by hospitals. However, eco-care is starting to emerge in the healthcare sector and it is likely to become necessary for hospitals in the coming years.

The study also illustrated original and novel insights for GSC implementation in the healthcare sector by identifying new, emerging factors including the critical role of the environmental manager and the environmental champion in the implementation of GSCs. The environmental manager mobilises a technical and managerial environmental expertise for the dissemination of

green practices whilst the champion defends and supports them enthusiastically. With very few exceptions, studies in the field of logistics and supply chain management have ignored the importance of a skillful environmental champion in the implementation of green approaches (Handfield et al., 1997; Walker, 2008). Our study sheds further light on this and addresses a major gap in the literature by confirming the critical role of the environmental champion and emphasises the joint and complementary commitment of a skillful environmental manager and an environmental champion belonging in the top management team. The joint involvement of these two managers has been observed in hospitals with proactive green approaches. Indeed, the human factor plays an important role for greening the healthcare supply chain (Jabbour, De Sousa Jabbour, 2016).

Purchasing groups have been criticised by practitioners as inefficient regarding cooperation and cost reduction, as well as limiting the innovation capacity in supplier contracts and products offered to customers (Rego et al., 2014). This research highlights the negative impact of purchasing groups on green approaches to hospitals too restraining environmental initiatives and projects at the intersection of the customer–supplier relationship.

Research on GSC has generally shown a contradiction between economic and environmental views (Govindan et al., 2014; Zhu et al., 2017). This study highlights a new paradox not addressed in previous studies regarding patient safety and the environmental dimension. Indeed, hospitals prioritize the safety of the patient compared to environmental concerns. Thus, it is important to find new mechanisms that reconcile not only economic and environmental approaches but also safety. This is another key finding emanating from this work which should be considered carefully by researchers as we strongly recommend future research addressing this paradox.

It is also important to design and build energy-efficient buildings facilitating effective environmental management at all levels of the supply chain. Indeed, green building designs reduce energy and water consumption as well as greenhouse gas emissions (Camgoz-Akdag et al., 2016). Overall, this research has improved the understanding of critical factors of GSC implementation in hospitals by incorporating factors identified in past studies analysing other industrial sectors and by supplementing our knowledge with new factors emerging from this study within the healthcare sector. This research proposes for the first time a taxonomy of hospitals and critical factors according to green approaches (reactive, receptive, and proactive). The taxonomy offers novel and significant insights into ways of implementing green supply chain practices in hospitals and how to reach maturity via the implementation of critical factors.

Managerial Implications

As a sector that generates a significant amount of waste and energy, hospitals are well placed to address managerial challenges of GSCs. This study can help managers to understand the critical factors on which they should focus to implement GSCs within hospitals. It also provides invaluable information on several activities in the hospital supply chain. Managers need to ensure the involvement of top management in the implementation of GSC practices, and facilitate training and the implementation of EMAS or ISO 14001 certifications. Managers need to maintain this effort over the long term establishing these green approaches among all employees and stakeholders of the hospital and, equally, being supported by the environmental manager and the environmental champion.

Hospital managers need to understand the GSC taxonomy they are in order to adapt environmental practices and implement the factors needed to move from one stage (taxonomy) to another. For example, a hospital that is classified in the "reactive GSC approaches" taxonomy needs to operate several critical factors to evolve towards the "proactive GSC approaches" taxonomy. These factors can include the implementation of traditional information technologies (ERP, RFID), innovative technologies (AGV, Big data analytics, Artificial intelligence), top management commitment, hiring a skillful environmental manager and environmental champion and finding organization strategies facilitating the combination of economic, environmental and safety dimensions.

Managers need to be aware of numerous challenges related to GSC implementation including the need to convince stakeholders to invest in the construction of new buildings (or renovations) as well as investing in information technology and in the automation of flows to better integrate green practices. Another managerial challenge will be to consider sourcing from local suppliers fostering a environmentally friendly approach and reconsider buying only from large supplier where the emphasis is on achieving low prices.

Overall, the paper has illustrated a plethora of key, critical factors (regulation, supplier initiatives, cost reduction, top management commitment, employee training, information technology and environmental performance measures) which need to be carefully considered by healthcare managers in their operational journey to implement GSC practices in hospitals. These factors will be extremely important to managers and practitioners notwithstanding that the paper will provide outstanding value to them too considering that the proposed taxonomy will be an excellent guide for developing appropriate operational strategies in relation to the three suggested healthcare green supply chain taxonomy approaches.

Limitations and future research directions

These results should be interpreted with caution, since they present certain limitations that could be tackled by additional research. We conducted our study in France and future research should include investigations from other national environments to ensure the generalisability of our findings and to reveal other national challenges and limitations.

Our interviews have focused on different categories of hospital employees related to GSC operations (Managers, Directors of hospitals, Pharmacists, etc.) and they have not included patients. This is related to the low interest and knowledge that patients have about environmental initiatives in hospital operations and SCM. Indeed, the main attention of patients is given to the quality of care. However, it would be interesting, in future research, especially in the context of the recent development of the culture of eco-care, to explore GSC issues with patients as they are a key stakeholder of hospitals.

Our study has focused on activities and operating functions of hospitals. Future studies may address other care activities such as medical treatment operations. The aim of the study would be to provide a thorough understanding of the initiatives taken by hospitals in managing waste of these specific activities and to attempt to generalize results throughout the hospital's supply chain.

This study is carried out in a French hospital organization and it cannot be generalized in other countries where the environmental issue does not have the same order of priority and it also depends on political support and institutional pressure. Future studies could be carried out in European countries to examine the possible generalization of our results.

This study is the first to provide the basis for a GSC research program in the healthcare sector and it will help to understand different approaches and areas of the GSC and the critical factors of its implementation. Further studies should concentrate on a single hospital flow in order to study closely its cycle of development and flows circulation throughout its supply chain and to evaluate its environmental performance. Finally, our study follows a qualitative approach. Future quantitative studies can be carried out to enrich our current findings including surveys with hospital supply chain actors where the issues posed in this work can be further tested and validated. Depending on data availability, further modelling work can also be undertaken in relation to the green, hospital supply chain-related flows aiming to showcase the areas and factors where dramatic improvements can materialise in relation to GSC implementation.

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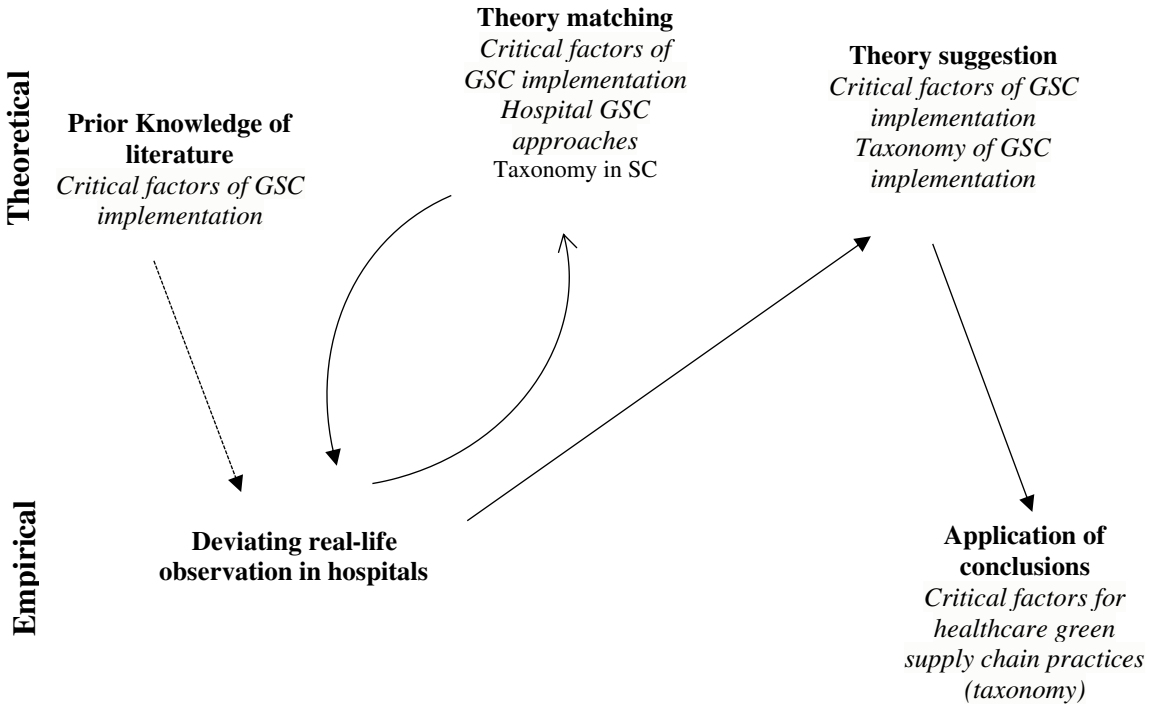
Figure 1: Abductive research process



Adapted from Kovács et al., (2005)

Figure 2: Healthcare green supply chain taxonomy

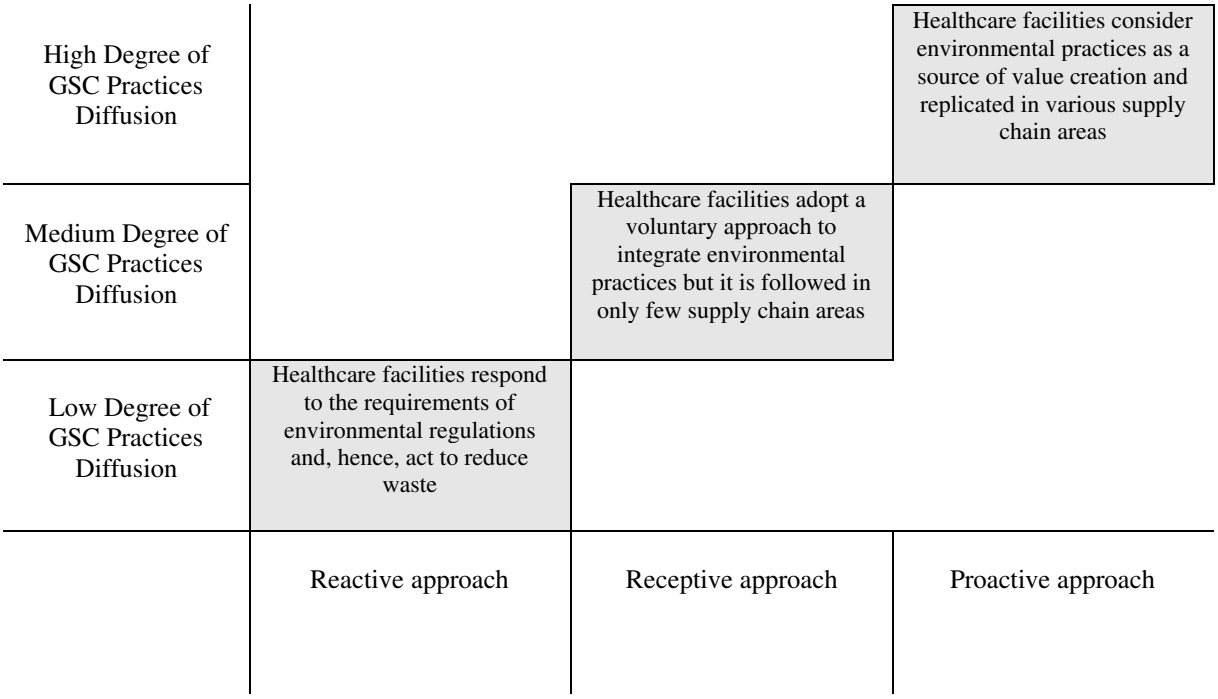


Table 1: Information on the healthcare facilities studied

Information on the healthcare facilities studied										
	HOSPA	**HOSPB**	**HOSPC**	**HOSPD**	**HOSPE**	**HOSPF**	**HOSPG**	**HOSPH**	**HOSPI**	**Health experts**
Status	Private, profit-making	Private, profit-making	Public	Private, profit-making	Private, non-profit-making	Private, profit-making	Private, non-profit-making	Private, non-profit-making	Public	
Specialty	Medicine Surgery Obstetrics (MSO)	MSO	Psychiatry	MSO	Cancer and research institute	MSO	Functional reeducation and adaptation	MSO	MSO	
No. of beds	70	259	349	218	419	146	70	1093	2033	
No. of employees	98	500	580	134	1,539	155	90	800	5000	
Age of building	1904	1968	1970	2016	1958	1994	2004	2013	2012	
No. of interviews	5	5	5	5	7	5	6	5	8	9
Categories of informants interviewed	Director Hygienist Pharmacist Quality manager Technical manager	Director Chief financial officer Pharmacist Quality manager Technical manager	Deputy director Health manager Pharmacist Medical information manager Environmental manager	Director Top manager 1 Top manager 2 Pharmacist Technical manager	Top manager Pharmacist Purchasing manager Logistics manager Technical manager Environmental manager Logistics agent	Director Hygienist Pharmacist Healthcare director Technical manager	Top manager Pharmacist IS manager Quality manager Technical manager Logistics manager	Top manager Pharmacist Purchasing Logistics manager Quality manager	Top manager Pharmacist Logistics manager Accommodation manager Purchasing manager Logistics agent Environmental manager Nurse	Director of research at a public hospital Hospital project Director Central purchasing Director of a hospital group Corporate responsibility manager for a hospital group Environment expert in the health sector Quality expert in the health sector Hospital quality manager Expert at the national health authority Regional health delegate

Table 2: Taxonomy of hospitals green approaches

GSC operations	**HospA**	**HospB**	**HospC**	**HospD**	**HospE**	**HospF**	**HospG**	**HospH**	**HospI**
GSC Approach	Reactive	Reactive	Receptive	Receptive	Proactive	Receptive	Reactive	Reactive	Proactive
Strategy (1)	+	+	++	++	+++	++	-	-	+++
Purchasing (2)	-	+	+	+	++	++	-	+	+
Packaging (3)	-	+	+	+	+	-	-	-	+
Energy (4)	+	-	+	++	++	+	++	++	+++
Transport (5)	-	-	+	+	++	-	-	-	+
Storage (6)	-	-	-	-	-	-	-	-	-
Waste (7)	+	+	++	++	+++	++	++	++	+++
Reverse logistics (recycling) (8)	+	+	+	+	+	+	-	-	+
Environmental projects (9)	-	+	+	++	+++	-	-	-	+++

Legend:
+++ Proactive GSC practices
++ Receptive GSC practices
+ Reactive GSC practices
- Lack of GSC practices

Table 3: Linking the critical factors of GSC implementation to hospital taxonomy

	Taxonomy of GSC approaches								
	Reactive GSC approaches				Receptive GSC approaches			Proactive GSC approaches	
Critical factors of GSC implementation	HOSPA	HOSPB	HOSPG	HOSPH	HOSPC	HOSPD	HOSPF	HOSPI	HOSPE
Regulation and norms	x	x	x	x	x	x	x	x	x
Market pressure									
Customer (patient) pressure									
Supplier initiatives							x		
Costs reduction	x	x	x	x	x	x	x	x	x
Top management commitment	x	x	x	x	x	x	x	x	x
Employee training	x	x		x		x		x	x
Information technology					x			x	x
Green performance measures		x			x	x	x	x	x
Environmental manager	x	x			x	x	x	x	x
Environmental champion								x	x
Purchasing group									x
Combining safety and green approaches	x	x	x	x	x	x	x	x	x
Hospital Building construction		x		x		x		x	x