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“TEN YEARS WORKING TOGETHER FOR A SUSTAINABLE FUTURE”

Hospital Environmental Performance Measurement: a bibliometric review of literature (1987-2017)

PASQUALINI BLASS, A. ^{a,c*}, GOUVEA DA COSTA, S. E. ^{a,b}, BORGES, L. A. ^c

a. Industrial and Systems Engineering - Pontifical Catholic University of Parana – PUCPR, Curitiba, PR, Brazil

b. Federal University of Technology – Parana, Curitiba, PR, Brazil

c. UNIDAVI, Rio do Sul, SC, Brazil

**Corresponding author, apasqualini@unidavi.edu.br*

Abstract

New environmental regulations and ongoing pressures on cutting costs and improving quality have forced hospitals to improve the performance of their operations, especially in developing countries. Healthcare deals with a significant amount of hazardous and non-hazardous materials and produce polluting outputs. Frameworks that directly address the measurement of environmental performance are regarded as paramount. The present study represents a bibliometric review of the literature on the topic 'hospital environmental performance measurement' during the period 1987-2017, i.e, since the publication of the Brundtland Report. A set of 10 papers was regarded as relevant to the study. A certain prevalence of studies placed in high-income countries was found, but a growing focus on the specific context of developing countries was also identified. The content analysis revealed that the proposal and testing of frameworks for the measurement of environmental performance in hospitals are still needed.

Keywords: Environmental performance. Measurement. Hospitals. Bibliometric review.

1. Introduction

The publication of the Brundtland Report in 1987 brought the topic 'sustainability' to the center stage as a core business (Mulder, 2017). Organizations in both industrialized and emergent countries have been urged to rationalize the way resources are used and impact the environment (Kleindorfer et al., 2005). The healthcare sector connects to the environment in two major ways. Environmental deterioration tends to generate health problems, which need treatment and, in consequence, healthcare services. Simultaneously, the waste generated by the sector, pollution and use of natural resources to provide these services should be minimized to achieve sustainability. As per Zimmer and McKinley (2008), hospitals in the United States produce approximately 6,700 tons of waste per day and healthcare waste is the fourth largest contributor of mercury to the environment. Expenditures may range between 259 and 401 million dollars per year in US hospitals (Unger and Landis, 2016).

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As the development of environmental awareness and regulations progressed, demands to cut costs related to public expenditure in healthcare have forced hospitals and other entities to improve their environmental performance (Karlsson and Öhman, 2005). The value represented by patients' health outcomes by currency unit invested has been connected to improvements in quality and performance (Porter, 2010). These improvements have led to the reduction of the waste of resources and an enhanced perception of medical care effectiveness and patient satisfaction (Maki et al., 2008).

In order to measure these improvements, performance indicators have been proposed by literature (Veleva et al., 2003; Townend and Cheeseman, 2005; Van der Geer et al., 2009; Yang et al., 2009). Nonetheless, most case studies reported in literature related to proposing environmental indicators are placed in high-income countries (McNatt et al., 2015; Amui et al., 2017; Braithwaite et al., 2017). In developing countries, healthcare operations involve high costs of provided services, limited productive resources and lack of public expenditure. New developments in conceptual and methodological frameworks are regarded as necessary to forge sustainability thinking (Duić et al., 2015).

Considering this context and the importance of environmental performance measurement in hospitals, especially in developing countries, the study aims to review the literature on the topic over the past 30 years. The period includes the year of publication of the Brundtland Report up until recently. Bibliometric methods are adopted to uncover publications, main authors and publication outlets, research centers/institutions and countries of origin of authors. In addition, a content analysis of the portfolio of papers seeks to identify proposed environmental measurement frameworks, especially those focused on developing countries and their context. The paper is divided in five main sections: Introduction, Theoretical Foundation, Bibliometric Review Design, Data Analysis and Final Considerations.

2. Theoretical Foundation

A significant number of frameworks have tried to overcome the complexity of performance measurement. Difficulties associated with the quantification of information and disregard for performance measurement systems already in place have been reported by literature. Metrics are vital elements to measure performance, since potential difficulties can be indicated by the gap metric-standard (Melynyk et al., 2004), especially regarding issues related to sustainability (Gunasekaran et al., 2001).

Per Coote (2002), the United Kingdom National Health Service (NHS) produces 600 thousand tons of clinical, pharmaceutical, infectious and domestic waste at a cost of 42 million pounds every year. Adair et al. (2003) reports that there is no consensus on the domains to be included in the measurement. Moreover, the authors found that it involves a complex set of tools and activities for the improvement of healthcare. Reviewing the frameworks developed in the US, Canada, Australia, United Kingdom and the one prescribed by the World Health Organization (International), only Australia (through the Australian Institute of Health and Welfare – AIHW) showed it to have sustainability as a framework domain. Purbey et al. (2007) indicate that performance measurement in hospitals is still an unresolved issue.

Metrics suggested by Zhu and Sarkis (2004) include reductions of air emissions and waste of water, increased investments in training and 'green' purchases, and reduced costs with waste treatment and energy consumption. Hardi and Pinter (1995) argue that indicators that aggregate heterogeneous dimensions are not readily available to be included in the decision-making process. Organizational decision processes guided by a reduced set of indicators may require substantial structural changes. For instance, despite the wide scope of indicators proposed in the Balanced Scorecard (Kaplan and Norton, 1992) applications in healthcare, environmental performance indicators are not usually

declared. When environmental measures are present, they tend to refer to existing regulations and/or sustainability programs (Veleva et al., 2003).

Despite the importance of the sustainability, especially in hospitals, environmental indicators tend to be found as isolated measures of performance initiatives. They refer to the minimization of the sector activities and ways to manage hospital waste and provided services (Woolridge et al., 2005; Li et al., 2008; Li et al., 2009). The present study aims to review the evolution of the research on the topic over the last 30 years. The planning and design of the bibliometric review are described next.

3. Bibliometric Review Design

Bibliometric methods are shown to be effective in representing a scientific roadmap on the study of a specific topic or area (Yataganbaba et al., 2017). Seeking to study the evolution of the research on 'hospital environmental performance measurement', most cited authors, main publication outlets, research centers/universities and countries of origin were observed. Moreover, a content analysis was used to uncover proposed frameworks for the measurement of environmental performance in hospitals. Tab. 1 presents the elements established as research protocol.

Tab. 1. Research protocol

Research terms	10 combination of terms
Reading	Title, Abstract, Introduction, Development, Results and Conclusion
Database	Web of Science™
Exclusion criteria	Studies related to hospital accreditation (not related to the environment); country and urban/city level environmental concerns; green infrastructure for healthcare facilities; internal environment/organizational climate; p4p studies (pay for performance); quality of care; rural level environmental concerns; strategies to improve performance in non-healthcare organizations.
Inclusion criteria	Studies related to environmental performance measurement in hospitals
Language	English
Types of publication	Journal and Conference Proceeding Papers
Period	1987-2017

Ten combinations of terms were used for data collection. The terms are regarded as keywords related to environmental performance measurement in hospitals: (1) Hospital + Environment; (2) Hospital + Environment* + Indicator; (3) Hospital + Performance; (4) Hospital + Sustain* + Environment + Framework; (5) Hospital + Indicator + Framework; (6) Indicators+ Environment + Sustain*; (7) Quality + Indicators + Health + Care; (8) Health + Care + Operations + Performance; (9) Health + Care + Performance + Indicators + Environment + Sustain*; (10) Health + Care + Performance. Fig. 1 describes the sequence of steps followed in the study.

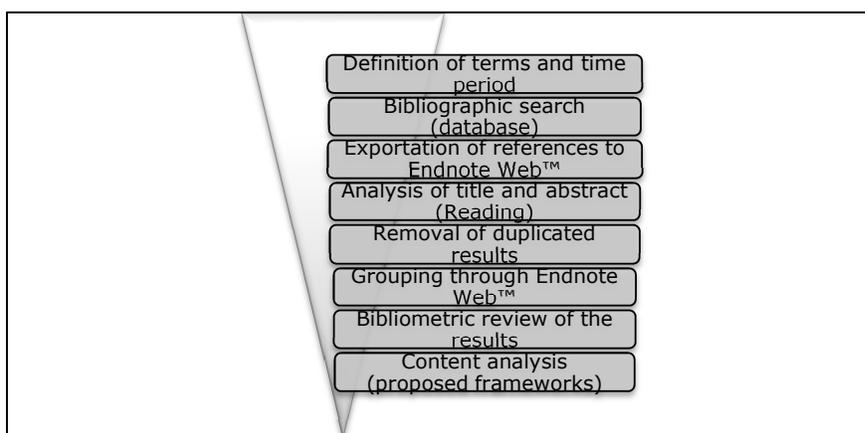


Fig. 1. Research procedures.

The period was defined according to the publication of the Brundtland Report (1987) up until the present (30 years). Web of Science™ (Thomson Reuters®) was selected as the main database for data collection. It is a reference database in several knowledge areas. It includes tools for citation and

reference analysis, which allow bibliometric reviews. The database encompasses approximately 12,000 journals. Five collections were reviewed: Science Citation Index Expanded (SCI-EXPANDED) – availability 1945-Present; Social Sciences Citation Index (SSCI) – availability 1956-Present; Arts & Humanities Citation Index (A&HCI) – availability 1975-Present; Conference Proceedings Citation Index - Science (CPCI-S) - availability 1991-Present; and Conference Proceedings Citation Index - Social Science & Humanities (CPCI-SSH) – availability 1991-Present. Endnote Web™ is made available by Thomson Reuters for the Web of Science Platform. It was used as a tool to group and analyze the bibliographic references.

After the exportation of references, duplicates were eliminated. After examining the titles by order of relevance, only 86 were regarded as related to the combination of at least two of the terms: 'environmental', 'performance', 'measurement' and 'hospitals'. The abstract, keywords, introduction, development, results and conclusion of these papers were read next. A total of 76 references were eliminated, since they fit the exclusion criteria and were not closely connected with the object of the study. Tab. 2 presents the topics related to these excluded references.

Tab. 2. Topics related to excluded references.

Topic of excluded papers	Number of papers
Hospital Accreditation (not related to the environment)	1
Country and urban/city level environmental concerns (including hospital waste)	14
Green infrastructure for healthcare facilities	2
Internal environment/organizational climate	3
Pay-for-Performance studies	3
Quality of care	45
Rural level environmental concerns	2
Strategies to improve performance in non-healthcare organizations	6
Total of results	76

Only 10 references were regarded as relevant to the study on 'environmental performance measurement in hospitals' and were included in the portfolio of papers. The data analysis is described next.

4. Data Analysis

4.1 The bibliometric review of the papers portfolio

The set of 10 remaining papers was examined in terms of year of publication, publication outlets, distribution of papers and authors per country of origin, affiliation and number of citations. Moreover, the content of the papers was evaluated in terms of the existence of proposed environmental performance frameworks for hospitals. Tab. 3 lists the authors and paper titles.

Tab. 3. Authors and titles of the papers portfolio.

Authors	Paper title
Berhanu, N. and Abrha, H. and Ejigu, Y. and Woldemichael, K. (2016)	Knowledge, experiences and training needs of health professionals about disaster preparedness and response in Southwest Ethiopia: a cross sectional study
Blass, A. P. and da Costa, S. E. G. and de Lima, E. P. and Borges, L. A* (2017)	Measuring environmental performance in hospitals: a practical approach
Kangasniemi, M. and Kallio, H. and Pietila, A. M. (2014)	Towards environmentally responsible nursing: a critical interpretive synthesis
Laing, D. and Kean, W. F. (2011)	The greening of healthcare: fabrics used in health care facilities
Machado, C. M. L. and Scavarda, A. and Zhao, F. and Kipper, L. M. (2015)	A Proposal of an Energy Saving Technology Framework for the Hospital
Pinzone, M. and Guerici, M. and Lettieri, E. and Redman, T. (2016)	Progressing in the change journey towards sustainability in healthcare: the role of 'Green' HRM
Ryan-Fogarty, Y. and O'Regan, B. and Moles, R. (2016)	Greening healthcare: systematic implementation of environmental programmes in a university teaching hospital
Sadatsafavi, H. and Walewski, J. and Taborn, M. (2015)	Patient experience with hospital care - comparison of a sample of green hospitals and non-green hospitals
Townend, B. (1996)	The implications of sustainable development and the zero option for health care waste

Yang, Y. and Zhang, S. J. and Xiao, Y. H. (2017) Optimal design of distributed energy resource systems based on two stage stochastic programming

Note: (*) 'Measuring environmental performance in hospitals: a practical approach' was written by the authors.

The distribution of publications during the studied period was analyzed next: 1996 (one paper), 2011 (one paper), 2014 (one paper), 2015 (two papers), 2016 (three papers) and 2017 (two papers). It is noticeable the absence of studies up until 1996 and the gap between 1996 and 2011. In 2014, it appears the subject was brought up again, which remains until 2017. Nonetheless, the reason behind the lack of studies within a 30-year period seems to be unclear.

The publication outlets related to the portfolio of papers were also analyzed. The 'Journal of Cleaner Production' is at the top of the list; it published three of the papers. In second place, the 'Journal of Green Building' published two papers. Other four journals published each one paper and the paper 'The implications of sustainable development and the zero option for health care waste' was published in the 7th Iswa International Congress Proceedings. The country of origin of the authors was also analyzed. Tab. 4 lists the authors per country of origin.

Tab. 4 Distribution of papers per country of origin.

Authors	1st	2nd	3rd	4th
Berhanu, N., Abrha, H., Ejigu, Y., Woldemichael, K.	Ethiopia	Ethiopia	Ethiopia	Ethiopia
Blass, A. P., da Costa, S. E. G., de Lima, E. P., Borges, L. A*	Brazil	Brazil	Brazil	Brazil
Kangasniemi, M., Kallio, H., Pietila, A. M.	Finland	Finland	Finland	
Laing, D., Kean, W. F.	Canada	Canada		
Machado, C. M. L., Scavarda, A., Zhao, F., Kipper, L. M.	Brazil	Brazil	Saudi Arabia	Brazil
Pinzone, M., Guerci, M., Lettieri, E., Redman, T.	Italy	UK	UK	
Ryan-Fogarty, Y., O'Regan, B., Moles, R.	Ireland	Ireland	Ireland	
Sadatsafavi, H., Walewski, J., Taborn, M.	US	US	US	
Townend, B.	UK			
Yang, Y., Zhang, S. J., Xiao, Y. H.	China	China	China	

In terms of individual papers, a certain prevalence amongst European countries is apparent, since four papers included Europe-based researchers. Two papers included researchers from North America whilst two had authors from South America. There are also researchers based in Africa, Asia and the Middle East. Considering the number of researchers per country of origin, recently there has been a certain predominance of researchers from Brazil and Africa. In addition, the institutions and/or research centers were listed. Tab. 5 presents the data.

Tab. 5. Affiliation of the authors.

Authors	1st	2nd	3rd	4th
Berhanu, N. and Abrha, H. and Ejigu, Y. and Woldemichael, K.	Jimma University			
Blass, A. P. and da Costa, S. E. G. and de Lima, E. P. and Borges, L. A*	Pontifical Catholic University of Parana	Pontifical Catholic University of Parana	Pontifical Catholic University of Parana	Unidavi
Kangasniemi, M. and Kallio, H. and Pietila, A. M.	University of Eastern Finland	University of Eastern Finland	University of Eastern Finland	
Laing, D. and Kean, W. F.	Practitioner	McMaster University		
Machado, C. M. L. and Scavarda, A. and Zhao, F. and Kipper, L. M.	Faculdade Dom Alberto	Federal University of the State of Rio de Janeiro	American University of Sharjah	Universidade de Santa Cruz do Sul
Pinzone, M. and Guerci, M. and Lettieri, E. and Redman, T.	Politecnico di Milano	Università Degli Studi di Milano	Politecnico di Milano	Durham Business School
Ryan-Fogarty, Y. and O'Regan, B. and Moles, R.	University of Limerick			
Sadatsafavi, H. and Walewski, J. and Taborn, M.	Cornell University	Texas A&M University	University of Michigan	
Townend, B.	Institutes of Wastes Management			
Yang, Y. and Zhang, S. J. and Xiao, Y. H.	Chinese Academy of Sciences	Chinese Academy of Sciences	University of Chinese Academy of Sciences	

The portfolio of papers was ordered per citation numbers. As this metric was not available from the Web of Science Platform®, Google Scholar® was used to assess these numbers. Only two papers were cited multiple times: 'Towards environmentally responsible nursing: a critical interpretive synthesis' was cited in nine other references and 'Greening healthcare: systematic implementation of environmental programmes in a university teaching hospital' was cited twice. The five following papers were cited once. Finally, three papers were not cited: 'The implications of sustainable development and the zero option for health care waste' (1996), 'Knowledge, experiences and training needs of health professionals about disaster preparedness and response in Southwest Ethiopia: a cross sectional study' (2016) and 'A Proposal of an Energy Saving Technology Framework for the Hospital' (2015). Tab. 6 presents these results.

Tab. 6. Number of citations per paper.

Number of citations	Paper title	Authors
9	Towards environmentally responsible nursing: a critical interpretive synthesis	Kangasniemi, M. and Kallio, H. and Pietila, A. M.
2	Greening healthcare: systematic implementation of environmental programmes in a university teaching hospital	Ryan-Fogarty, Y. and O'Regan, B. and Moles, R.
1	The greening of healthcare: fabrics used in health care facilities	Laing, D. and Kean, W. F.
1	Measuring environmental performance in hospitals: a practical approach	Blass, A. P. and da Costa, S. E. G. and de Lima, E. P. and Borges, L. A*
1	Progressing in the change journey towards sustainability in healthcare: the role of 'Green' HRM	Pinzone, M. and Guerci, M. and Lettieri, E. and Redman, T.
1	Patient experience with hospital care - comparison of a sample of green hospitals and non-green hospitals	Sadatsafavi, H. and Walewski, J. and Taborn, M.
1	Optimal design of distributed energy resource systems based on two stage stochastic programming	Yang, Y. and Zhang, S. J. and Xiao, Y. H.
0	The implications of sustainable development and the zero option for health care waste	Townend, B.
0	Knowledge, experiences and training needs of health professionals about disaster preparedness and response in Southwest Ethiopia: a cross sectional study	Berhanu, N. and Abrha, H. and Ejigu, Y. and Woldemichael, K.
0	A Proposal of an Energy Saving Technology Framework for the Hospital	Machado, C. M. L. and Scavarda, A. and Zhao, F. and Kipper, L. M.

4.2 Content Analysis

The papers were analyzed using a two-fold approach. First, a summary of main objectives and outcomes was prepared, focusing on the review or proposal of frameworks for the environmental performance measurement in hospitals. Second, the abstracts of the papers were analyzed using WordCloud™. Per McNatt and Lam (2010), word cloud tools can be used to visualize text and supplement content analysis.

Berhanu et al. (2016) describes the results of a cross-sectional survey conducted with health professionals working at health offices, hospitals and health centers in nine districts in Ethiopia. The study sought to verify the readiness of these professionals while facing natural disasters. The authors concluded that although personnel present a comprehensive view of disaster impacts, intervention strategies need to be planned and considerable training is still required. The authors underline the importance of training and focus on the importance of indicators related to disaster warnings without proposing how to measure environmental performance in hospitals.

The paper by Blass et al. (2017), the same authors of the current paper, proposes a practical approach to measuring hospital environmental performance. A framework based on a literature review on existing approaches, field studies and current legislation is described and tested in six case studies in Brazil. The framework was associated with positive outcomes and meaningful indicators that measure and report environmental performance in hospitals.

"Towards environmentally responsible nursing: a critical interpretive synthesis" is a review paper by Kangasniemi et al. (2014). It is a study of peer-reviewed papers published between 2002-2012, seeking to investigate environmentally responsible practices performed by nurses. According to the

authors, the field of environmental management and related policies require scientific contributions to evidence-based practices. The study deals with theoretical frameworks, but does not directly address measurement.

Laing and Kean (2011) is a practitioner's paper. Both authors discuss the use of environmentally responsible fabrics in healthcare, which they designate as 'healthcare textiles'. Because of the chemicals used in the manufacturing process, fabrics used in hospitals can negatively affect the health of patients and healthcare workers. The authors recommend a third-party certification and highlight the existence of other issues associated with their use such as local sourcing, durability and standards of performance. Environmental concerns are raised without a more in-depth discussion on performance measures.

The paper by Machado et al. (2015) focuses on reducing energy consumption in hospitals. The authors propose a three-fold approach based on (a) improvement plans and assessment management; (b) training and user awareness; and (c) energy diagnosis. It requires a consistent engagement of employees. This seems to be the main component to be gathered and provided by the approach. Recommendations are made in terms of guidelines. The need to track performance is emphasized, but no framework of indicators is proposed.

The study by Pinzone et al. (2016) reports the results of a survey on the impact of the 'Green' Human Resource Management (GHRM) policies within NHS Trusts. The research showed that building competences and involvement practices have a positive influence at organizational level, improving the collective performance. The authors focused on Green HRM and did go as far as to identify or propose performance measurement frameworks.

Ryan-Fogarty et al. (2016) describe the experience of the adoption of the 'Global Green and Healthy Hospitals Agenda' framework. The model was created by the coalition 'Salud Sin Daño' (Health Care Without Harm), an international network of healthcare systems, hospitals, communities, unions and environmental organizations. The framework includes 10 main objectives related to leadership, chemicals, waste, energy, water, transportation, food, pharmaceuticals, buildings and purchasing (GGHHA, 2015). It encompasses a comprehensive list of objectives and actions that can be implemented for environmental performance improvements, but does not present guidelines on how to develop specific indicators. The experience proved to be successful per the authors, generating learning and positive results through a systematic approach to environmental management and evaluation.

The paper by Townend (1996) addresses healthcare waste and its impact on the environment. The author highlights the importance to approach the issue, considering sustainability concerns. Nonetheless, performance measurement frameworks are not directly cited or studied.

The study by Sadatsafavi et al. (2015) focused on the comparison of patient satisfaction between 'green' hospitals (green facilities) and traditional hospitals. Data showed that patients' satisfaction achieved high levels when referring to green facilities. However, as stated by the authors, the impact of specific features on the experience of patients could not be verified.

Yan et al. (2017) developed a two-stage stochastic programming to evaluate the effect of uncertainties in load demands, energy prices and renewable energy intensity on a system's economy and optimal design. The system chosen for testing the model was a hospital in Lianyungang, China. The outcomes of the study showed that the economy is overestimated if the system is designed without considering uncertainties. Other dimensions were not directly dealt with in the model.

As per the analysis of the papers pertaining to the portfolio, it is possible to observe that frameworks are proposed and/or reviewed in four of the references: Blass et al. (2017), Machado et al. (2015), Ryan-Fogarty et al. (2016) and Yan et al. (2017). The additional papers approach different aspects of environmental concerns associated with hospitals related to resources (material and human) and patient satisfaction in 'green' facilities.

In the papers that propose performance measurement frameworks, only in Blass et al. (2017), there is

a systematic
determining
linked to

approach to
indicators



organizational goals to report the environmental performance status to stakeholders. Furthermore, only two of the papers placed their proposals and tested frameworks in the context of developing countries: Machado et al. (2015) and Blass et al. (2017). In order to supplement this analysis, the WordCloud™ tool was used.

The words 'environmental'/'environment' (41), 'healthcare/health' (34), 'green' (22), 'hospitals' (20), 'energy' (16), 'performance' (13), 'framework' (13) and 'approach' (11) stood out, emphasizing the concerns on the environmental performance in hospitals. Fig. 2 presents the word cloud produced by analyzing the abstracts of the papers in the portfolio.

Fig. 2. Word cloud of the abstracts.

The discussion on frameworks/approaches that address these issues was also present. Growing concerns on how health professionals deal and respond to the demands on mitigating the impact of hospital operations and improving practice and design were also found to be relevant.

5. Final Considerations

The bibliometric review on 'hospital environmental performance measurement' revealed the scarcity of studies over the last 30 years, since the publication of the Brundtland Report. A portfolio of only 10 papers were regarded as relevant to the topic. Most studies are still placed in high-income countries, but three of the papers showed that the concerns on the subject have gained space in developing countries. Nonetheless, the content analysis on the papers indicated that there is a gap in knowledge related to frameworks that directly deal with the performance measurement in hospitals. Considering the importance of the topic and impact of hospital operations on the environment, this is regarded as a paramount research opportunity. Only with the proposal and testing of meaningful frameworks, it will

be possible to achieve a sustainable present and future for hospitals, especially in developing countries.

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