chasm: a new health system for the 21st century (Institute of Medicine, 2001) had in the practitioner and research communities, exposing severe organizational problems in hospitals.

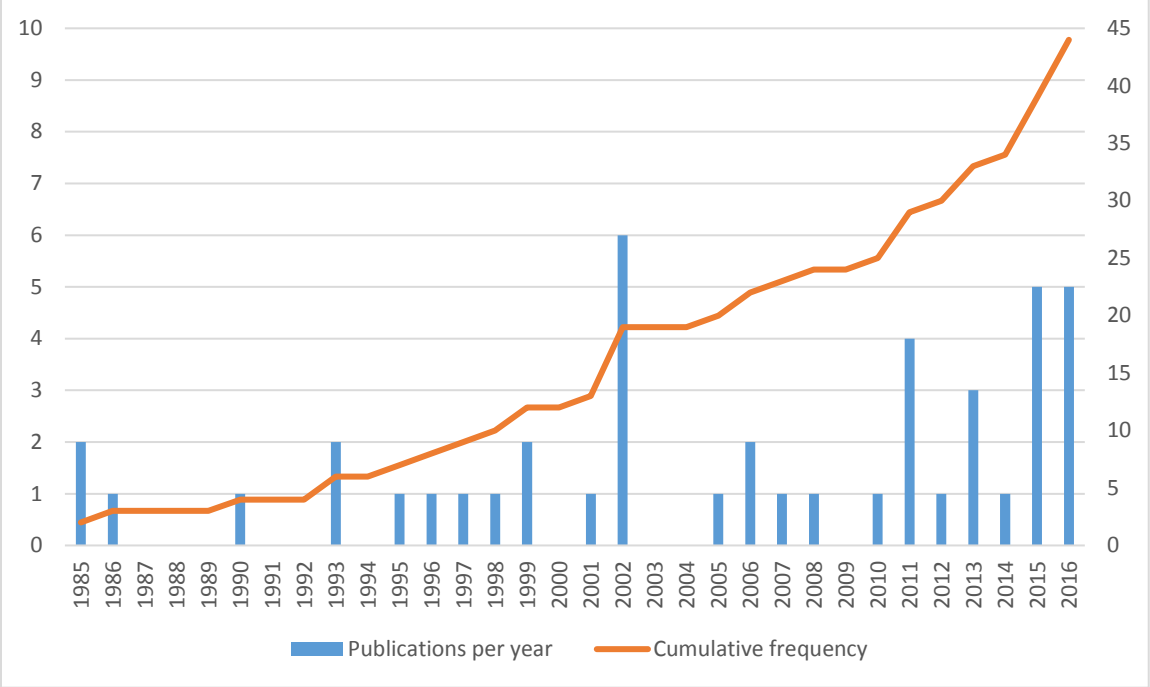

Figure 2. Cumulative frequency of publications focused in hospitals

It has been demonstrated through investigation that the publications of these reports had an impact on the literature and research in healthcare (Stelfox, 2006). According to Stelfox (2006), the period after the publications saw research addressing in a greater way topics related to organizational structure, patient safety and quality. The presence of these two publications in the beginning of the decade drew interest into the applying OM in hospitals, since OM is an area that is focused on designing, controlling and improving systems and operations to produce goods and services (Stevenson, 2011, p. 4). The information from the sample in our study supports this conclusion. However, it is important to note that, from the 44 articles in the sample, only one made a direct citation to these publications (McFadden, 2006).

Product Life Cycle or Knowledge Life Cycle is composed on four stages: introduction, growth, maturity and decline (Rink & Swan, 1979). For this research field, the introduction stage covers from 1985 to 2009 and the growth phase starts in the most recent years, starting from 2010. This is a sign of early development of this research area and of the initial adoption. However, to complement the characterization of the literature, RQ2 was addressed in the following subsection.

3.2 Which are the formal and informal groups of authors working (researchers and practitioners) in operations management in hospitals? (RQ2)

The second stage of this research involves the analysis of the author dimensions in the literature available. This phase is aimed to identify the formal or informal groups of authors working in this area, and further detail the information obtained in the initial stage regarding publication characteristics. This section is divided into three levels: authors' name, authors' institution of affiliation, and authors' country of affiliations. First, a total of 101 authors contributed to the 44 publications found for this study. The number of new authors per year publishing on OM in hospitals has been increasing over the last years (see Figure 3), supporting the finding from RQ1: OM in hospitals have been increasing between practitioners and researchers. Most publications were the result of the contribution of two or three different authors and, in the great majority of the cases, they published only once.

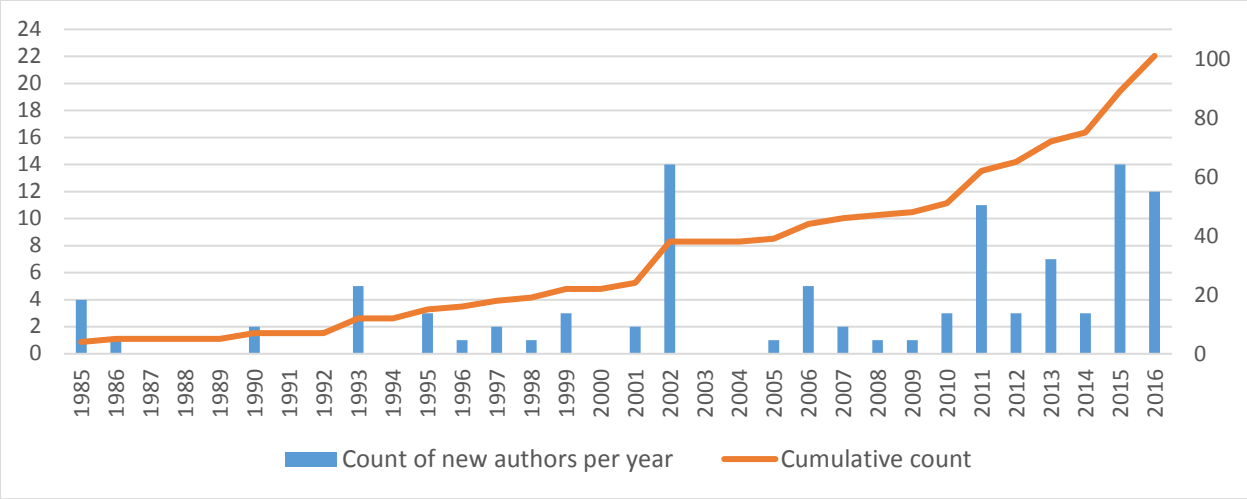

Figure 3. Count of new authors per year

There are 6 authors that made multiple publications in the area, their names presented in the following Table 1. These authors have published in the last 10-11 years, this information can suggest that there is an active group of authors that is becoming the reference group within this area and can guide the future research. This initial stage in the author communities and collaboration can be linked to the initial stage of growth identified in the publication characteristics. It is important to note the participations of Dirk Pieter van Donk, Justin Drupsteen, and Taco van der Vaart from the Netherlands, they published together in 2013 and 2016, becoming the only group to have multiple publications in the sample.

Table 1. Authors with multiple publications

Authors with multiple publications	No. of publications	Country of work
Dirk Pieter van Donk (2011, 2013, 2016)	3	Netherlands
Justin Drupsteen (2013, 2016)	2	Netherlands
Taco van der Vaart (2013, 2016)	2	Netherlands
Gregory N. Stock (2006, 2007)	2	USA
Kathleen L. McFadden (1996, 2006)	2	USA
Teresa S. Waring (2002, 2015)	2	UK

Another way to analyze contributions between authors is through the Social Network Analysis, which has been applied to this sample of publications through the software *Gephi* (version 0.9.1). The result is shown in Figure 4. It is important to note that the size of the nodes corresponds to the number of publications by that author, and the color refers to the number of collaborations with different authors in different papers. To form the graph, an algorithm of Force Atlas was used and different parameters were tried for the best layout to provide visual explanation. Four authors that published a single article and didn't have contributions are in the center (Al-Shammari, Buchanan, Pegels, and Ramanathan). In the case of McFadden (1996), since she published again later in collaboration with other authors (2006), is present in another part of the graph linked to them and is not seen as a single author.

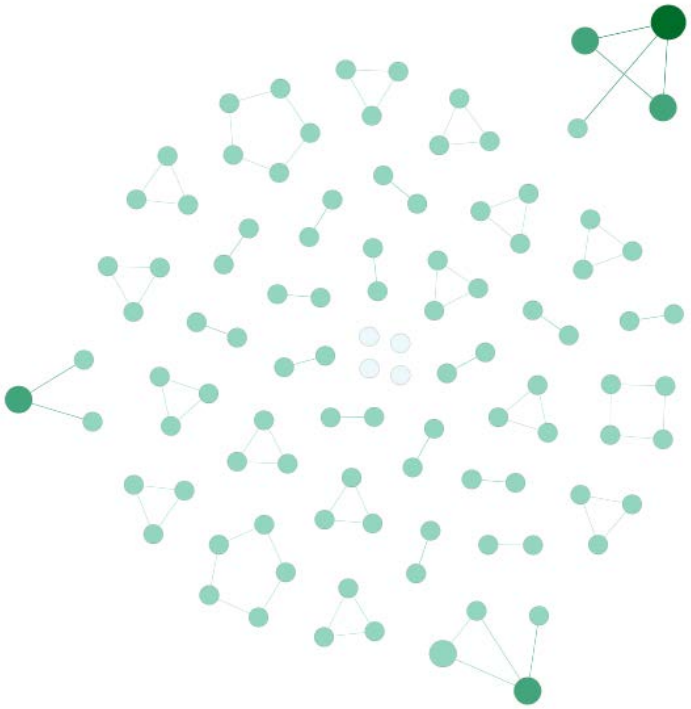

Figure 4. Social Network Analysis of author contributions

Second, 21 out of 44 papers were made through cooperation of different institutions (66.7% were made by representatives from different universities and 33.3% between universities and others institutions as hospitals). The dissemination of knowledge flows mainly from the academic area of business administration and operation management in universities to the hospitals and healthcare units. An interesting finding in this analysis, is the presence of an author from the Civil Engineering department. In a publication about patient satisfaction, managers' climate orientation and organizational climate, the team of authors studied a model for manager's orientation and its impact on the rest of the organization and in patient satisfaction. The paper features collaboration from two different areas of knowledge: Civil Engineering and Social, Political and Institutional science. The result is a study with a strong theoretical base in social and institutional studies, a research methodology proper for this area, and an equation model to test the results. This is an example of successful collaboration between different knowledge areas and applicability of external practices into hospital and healthcare research.

Third, to analyze the international aspect of this sample, authors were classified by their country of affiliation, resulting in 14 different countries of origin for the 101 authors included in the study. The country that groups the most authors is USA, and with the UK and the Netherlands they concentrate more than 65% of the total authors in these publications. Another aspect within international cooperation stands out is that, even if USA is clearly the biggest contributor in number of authors, there are only two authors that published more than one article, while authors from the Netherlands seem to have more cooperation and presence, as seen in Table 1. Also, out of the 44 articles, 6 featured international cooperation between the researchers and their institutions (see Table 2).

Table 2. International cooperation between authors and their institutions

Year	**Name of paper**	**Authors**	**Country of work**
1985	Discovering Local Logics in the Hospital World	P. S. Agrell J-C. Moisdon	Sweden France
1993	A Simulation Model for Scheduling in the Emergency Room	Masood A. Badri John Hollingsworth	UAE USA
2012		Vedran Capkun	France

	Service specialization and operational performance in hospitals	Martin Messner Clemens Rissbacher	France Austria
2006	Measuring the operational performance of intensive care units using the analytic hierarchy process approach	Prasanta Kumar Dey Seetharaman Hariharan Benjamin T. Clegg	UK Trinidad and Tobago UK
2016	Behavioural operations in healthcare: a knowledge sharing perspective	Matteo Mura Emanuele Lettieri Giovanni Radaelli Nicola Spiller	Italy Italy UK Italy
2002	Hybrid stockless: a case study	Hugo Rivard-Royer Sylvain Landry Martin Beaulieu	Canada Canada/France Canada

The small number of collaborations between authors from different institutions and between authors from different countries of affiliations is an evidence of the less mature research field (Keathley et al, 2016). Other relevant information in this research is to identify the main purpose of these papers, such as research and application of OM tools.

3.3. Which are the main focus (research or applications) of the publications in operations management in hospitals? (RQ3)

Each paper was revised to define if the document's purpose was to present an investigation (the document presents a research question and hypotheses, through a theoretical approach) or an application (document that presents applied theory to solve a real problem through methodologies and tools of OM): 86.4% (38 out of 44 papers) were focused on investigation, 9.1% (four out of 44 papers) were focused on applications, and 4.5% (two out of 44 papers) included investigation and application. This information shows a greater presence of theoretical approach in the sample. The research seems to be focused on building up theory, in many occasions the articles study practices used in other industries or sectors and how can they be applied in the hospital and healthcare sector, staying within the theory. This can be linked to the development phase of the research area, because, as described before, it is currently in an early stage.

The 44 papers documented the utilization of 86 research methods, this indicate an average of 1.9 research methods per paper; a paper could use a single or multiple research methods (e.g. literature review and survey). The most frequently used research methods were literature review (45.5%), survey (29.6%), case study (27.3%), and primary data (27.3%). On the other hand, a paper could use also a single or multiple analysis tools. In the 44 papers were identified only 8 different analysis tools out of 26 identified by (Gonzalez Aleu and Van Aken, 2017): modeling (45.5%), descriptive statistics (18.2%), regression (13.6%), simulation (13.6%), process mapping (11.4%), correlation (4.5%), design of experiments (4.5%) and brainstorming (2.3%). The high concentration in the utilization of a small set of research methods and the small number of analysis tools used is a indicative of low maturity of the research field (OM in hospitals) (Keathley et al., 2016).

A word analysis is used to identify the main ideas discussed in the publications; the goal is to identify main concepts, keywords and ideas that are part of the academic discussion in this research area. A keyword analysis was used to address this analysis. A total of 34 out of 44 publications included keywords, producing a list of 164 keywords. The keywords were grouped by general concepts and stemmed words, and this generated a list of 68 unique terms. The top four keywords (healthcare, hospitals, performance, OM) represent 5.9% of the total unique keywords, but account for 37.2% of the 164 keywords collected. From these four terms, three are strictly related to the research subject (healthcare, hospitals, OM), so the frequency of the term performance suggests that it is one of the most important subjects in the current literature.

A co-keyword network is the visual representation of the keywords in a sample and their relationships with each other. Each keyword and their connections with the other keywords in the same publication are inputted into the data, so the final diagram shows every connection and their frequency. Figure 5 has been generated using Gephi version 0.9.1, using the layout algorithm of Force Atlas combined with additional criteria for layout enhancement. The size of the nodes represents the frequency of each term in the full keyword sample. Additionally, the thickness of the edges

represents the frequency that two different terms appear in the same publication. Finally, node color relates to the number of relationships that the term has in the sample.

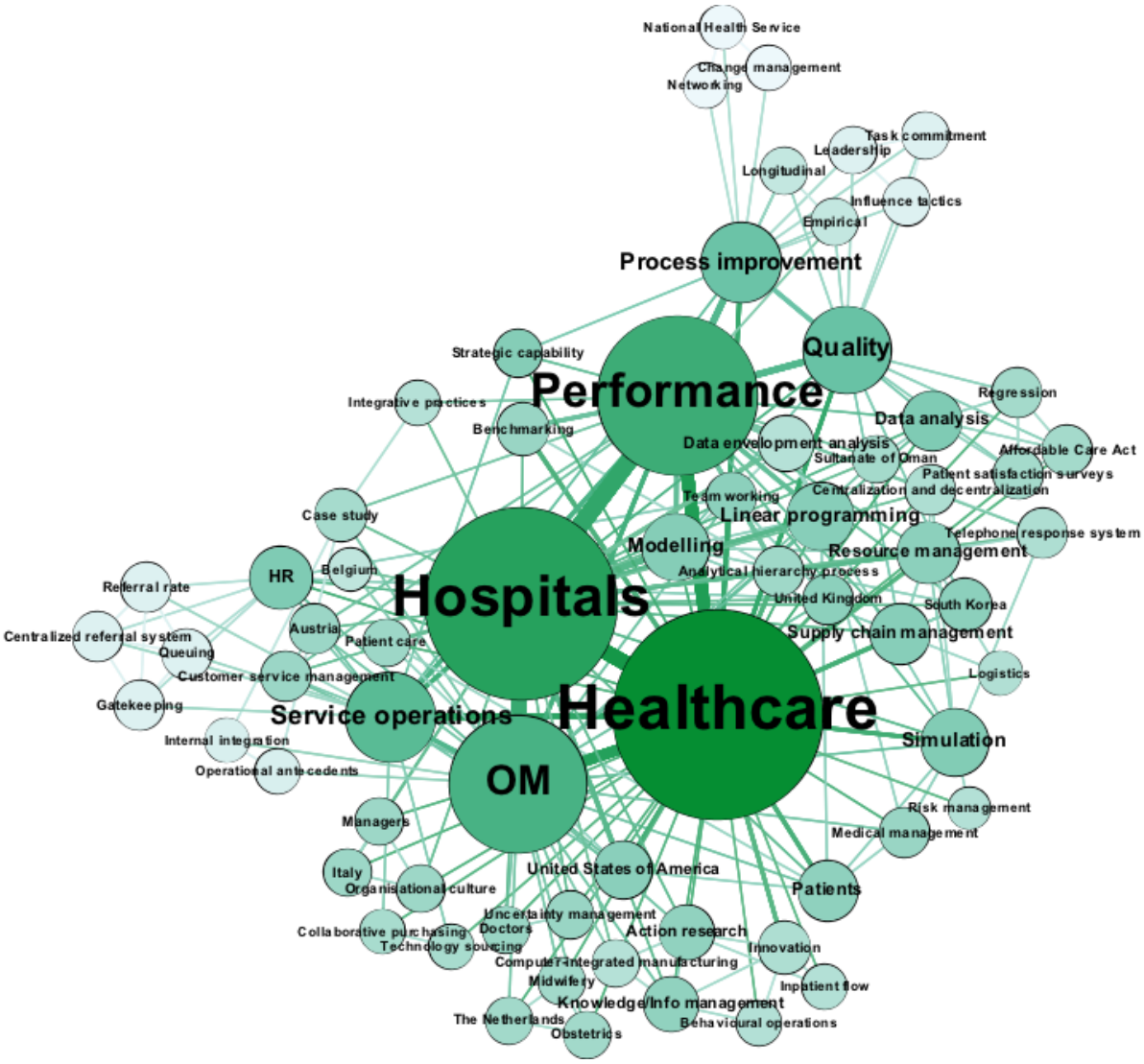

Figure 5. Co-keyword network (Gephi 0.9.1)

The most relevant keywords are evident since the previous analysis, where hospitals, OM, healthcare and performance have been mentioned. Additionally, in the keyword network, a relatively large group of terms was formed in the right-center area. Terms as modelling, linear programming, data analysis, resource management and simulation are highly linked and related with the most frequent keywords. This suggests that researchers are currently investigating a mathematical and more structured approach for problem-solving into this area.

3.4 Which are the main topics related to operations management addressed in the publications? (RQ4)

This classification corresponds to the subject of OM that the paper studies. A list of topics was retrieved from the International Journal of Operations and Production Management's online profile portal, which is presented by Emerald Group Publishing. The journal's profile lists most of the topics that it covers, accompanied by the quote "The scope

of the Journal covers all aspects of operations management: manufacturing and service, profit and non-for-profit, including, but not limited to, the topics listed below" (Emerald Publishing, 2017): capacity planning and control, e-business and operations, global operations management, human resource management in operations, information and knowledge management, lean/agile operations, logistics, order fulfilment and distribution, management of technology for operations, managing technological customization change, mass customization, material and inventory management, new product and service design/development, operation planning – scheduling - control, operations strategy, performance measurement and management, plan location-design-layout, project management in operations, quality management in operations, role of operations in sustainability, supplier/customer relationship management, and supply chain management. Each paper's content was analyzed to classify it by OM topic. Each publication could refer to one or more topics. As some subjects are similar, some definitions were detailed to provide structure and can be found in the Appendix section (see Annex 8.2).

The results from the frequency information in Figure 6 indicates that, in the sample, research is focused on achieving an optimal level of operations in hospitals, managing the available resources as beds, doctors, equipment, nurses. Therefore, 5 main topics stand out: Operations planning, scheduling and control; Operations strategy; Performance measurement and management; and Capacity planning and control. This indicates that most of the problems and areas of opportunity are currently in those areas, which are closely related with each other.

Figure 6. Frequency of topics studied in the sample

It is also evident an interest in measuring and managing performance in hospitals, this could be related to the fact that they are service organizations and these aspects are underdeveloped in practice due to their complexity. This is a key aspect to optimize operations.

4. Conclusions

4.1Summary

As explained through the initial section, this study presents a characterization of the literature of OM in Hospitals through a sample of publications obtained from the IJOPM. The purpose is to analyze this sample and present a scoping study that is useful for an extended literary review with additional sources in the future. This document details the current state of this area of research.

This first stage of the research, about the dimension of publications, has demonstrated that the application of Operations Management in hospitals is in a phase of early growth and development, increasing in relevance during the last decade. A total of 44 publications on the subject have been found among the 2014 publications from the journal since its foundation in 1980. Through the analysis of the publication trends to answer RQ1, it was found that of the publications in the sample, 70.5 per cent have been made from 2002-2016, and 50 per cent of the total have been made in the last 10 years. This growth in relevance seems to have been strongly influenced by the publications of the Institute of Medicine in the beginning of the 2000s (2000, 2001). The data reflects that this development should continue in the following years and there are many areas of opportunity for development. The phase of this research area was defined by using the business approach of the product's lifecycle theory. The slow adoption in previous years followed by an accelerated increase in frequency started in recent years suggests a phase of early growth.

Later, the analysis for RQ2 showed that most of the publications have been made by groups of 2-to-3 authors that made a single publication. However, in recent years there has been a group of authors that is guiding the research: Dirk Pieter van Donk, Justin Drupsteen, and Taco van der Vaart from the Netherlands. They published together in 2013 and 2016, being the only group to have multiple publications in the sample. This also indicates a phase early development in the research area, and presents an opportunity for author collaboration and leadership, which can contribute to develop maturity (Keathley-Herring et al., 2016). Still in the author dimensions, the sample features representatives from 14 different countries, with 65% of the authors from USA, UK, and Netherlands in the respective order of representation. This concentration suggests that there is room for further international collaboration and development. There is also a high cooperation between authors from different institutions, with nearly 50 per cent of the articles featuring authors from different organizations. This is positive and can benefit the quality in future publications. An interesting example of collaboration between different knowledge areas was found between Civil Engineering and Social, Political and Institutional science. The result is a study with a strong theoretical base in social and institutional studies, a research methodology proper for this area, and an equation model to test the results. This is an example of successful collaboration between different knowledge areas and applicability of external practices into hospital and healthcare research. The area can benefit from more cases as this one in future research.

Through the analysis for RQ3 and RQ4, key information was found to understand the development in this area and the main topics present in the sample. The first finding in the content is that most of the papers (38 of 44) in the sample present exclusively an investigation research, while the presence of application is reduced. This finding can be linked to the early development stage identified in the sample. The content analysis provided the most frequent topics and concepts, which are related to performance, resource management, quality management and operation improvement. This provides the context of what is currently being investigated and the main areas of interest of OM in hospitals. As stated in the introduction section, hospitals are complex organizations with limited resources, and the research is focusing on these issues to reach an optimal level of operations. Also, the constant human interaction present in hospitals an area of interest for the application of OM in these organizations.

4.2 Discussion

This research provides a structured reference for researchers and practitioners to identify the state of research of OM in hospitals; it can be used to obtain information in the literature. In the case of practitioners, the study identifies what has been investigated already, the publications from previous applications are identified and can be followed for further development.

For researchers, it provides a similar advantage. Information in this study can be used as a scoping study and a starting point for an extensive literature review. Also, the main subjects of interest can be useful data for new authors to guide their research. The content analysis presents in a clear way the research lines that are being studied and which ones have opportunity for development. The different content characteristics are a clear image for this purpose.

4.3 Limitations

This investigation is limited to a single journal, the IJOPM. This condition skews the results and they could vary against information from other journals or databases. However, this paper intends to present a scoping study. The selection of the journal was determined due to its academic relevance to the research in Operations Management (Scimago, 2017). It is also an academic journal that has a general approach to OM, which is useful to appreciate the role of OM in hospitals as part of the research area overall. Lastly, the journal was also accessible for the researcher and matched the study's requirements. The journal still provided a varied sample that featured different topics of OM and research tools, this enabled a complete analysis and proper conclusions that can be complemented with future

studies. This had a limited impact in the research results, the study still provided a detailed analysis of the three dimensions (publications, author, content) and the outcome is relevant for the research area.

4.4 Future research

As stated previously, this investigation should be used as a scoping study and reference point to perform an extensive systematic literature review. It can be extended with additional journals and databases to provide a general understanding. Additional journals focused on OM in hospitals should be considered for this purpose.

The future research should consider the current stage of this area, accounting the stage of development and the areas of opportunities mentioned in this document. The research area can benefit for further personal and international collaboration between authors. The higher number of researchers from USA, UK and the Netherlands can partner with authors from other countries for a transfer of knowledge and helping in the development of the area in different nations. Also, authors working full-time in hospitals or healthcare organizations should be part of the future collaborations. In the aspect of content, the future research should address more applications of OM in hospitals, rather than investigation-only publications. The area can benefit of more documentation of the outcomes of OM frameworks and tools. It is also of high relevance, according to the results, that a clear performance measurement and management framework is established and adopted in the area. This can only be achieved by defining the framework first, and then several case studies should be performed in different hospitals or clinics to document the outcomes of its use.

Also, there is opportunity for further employment of OM tools, as lean management, total quality frameworks, Heijunka, Kanban, Poka Yoke, Value Stream Mapping, among others. The sample lacked these subjects, probably due to the approach towards investigation and theoretical research. Operations Management applied in hospital has been proved effective for performance improvement in hospitals and problem solving. The current literature should be further applied and considered for development.

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6. Biography

Riccardo Maccaferri is a graduate student from a Bachelor degree in Industrial and Systems Engineering in the University of Monterrey, Mexico and current student of the Master in Management program in the École supérieure des sciences commerciales d'Angers, France. This academic program involved a double-degree through an agreement between both universities. His interests in operations management led to the work with Fernando Gonzalez Aleu to investigate this field with a focus in hospital and healthcare units.

Fernando Gonzalez Aleu is an Associate Professor at the Universidad de Monterrey (UDEM) in Mexico. He received a BS in Mechanical and Management Engineering at UDEM, a MS at ITESM in 1999, and both an MS and PhD in Industrial and Systems Engineering from Virginia Tech in 2015 and 2016, respectively. His research focuses on the applications of continuous improvement projects. Prior industry experience includes 15 years implementing quality systems, environmental systems, and management systems. He is member of the Institute of Industrial and Systems Engineers, the American Society for Engineering Management, and the American Society for Quality.

Luz María Valdez de la Rosa is currently a Director of Engineering Management Bachelor Academic Program in the University of Monterrey, in the state of Nuevo Leon, Mexico. She earned B.S. in Industrial Engineering and Systems and Masters in Quality Management at University of Monterrey, Mexico, and she is currently studying the Ph. D. in Administration Sciences from the Autonomous University of the State of Nuevo Leon, Mexico. She has 18 years of experience in the Quality field and 11 years as a higher education teacher. She has participated as consultant for the manufacturing and services in the quality field, and participated as ASQ and IISE member.

Jenny Díaz-Ramírez is professor at the University of Monterrey. She has worked previously as a professor at Tecnologico de Monterrey, Mexico and Pontificia Universidad Javeriana Cali, Colombia. She got a MSc in operations research from Georgia Tech and the PhD in Industrial Engineering from Tecnologico de Monterrey, Campus Toluca in 2007. Her research topics are applied optimization and statistics in topics such as health systems, air quality and logistics.