A Systematic Literature Review on Home Health Care Management*

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Abstract. This work provides a systematic literature review based on an up-to-date assessment of the concepts, procedures and operational management in home health care (HHC). Worldwide, and especially in Portugal, there is a growing demand for HHC services, whether health or social, often supported by private or public institutions of social solidarity or health. The methodology was developed to, in the first phase, collect a set of potentially relevant articles, from which some journal papers with a high degree of citation were analyzed. The searched databases were Scopus and Web of Science. In a second phase, all identified documents were pre-processed with a bibliometric analysis between 2010 and 2021 to support the current state of HHC. The main contributions of this work are a summary update of the literature dealing with HHC routing and scheduling management, some discussions on current past and actual trends, and some future research directions.

Keywords: Bibliometric Analysis, Home Health Care, Scheduling, Routing

1 Introduction

HHC services are designed to deliver social, paramedical, or medical care to patients at their homes. The HHC services are a response that provides individualized and personalized care at home to individuals and families when, due to illness, disability, or other impediments, they cannot ensure, temporarily or permanently, their basic needs and/or the activities of daily life.

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Population aging has led to a significant increase in the demand for HHC services in recent years. Taking Portugal as an example, the 2021 Census of the National Statistics Institute reveals that the number of people over 65 has increased by 20.6% in the last ten years. In addition, forecasts suggest that the aging rate in Portugal will double in the coming years [14].

HHC services made it possible to reduce unnecessary hospitalization costs, in addition to valuing the family context and the improvement that comes from it [8]. On the other hand, it potentiated many additional organizational difficulties for institutions that practice home service. These difficulties are often seen as strategic, tactical, and operational planning. Within each of these plans, many issues raise questions that query many policies, norms, and standards.

The growing demand for this type of service and the difficulty in keeping up with the growth of the providing institutions led to a boom in research in industrial engineering, operational research (OR) and optimization. For example, Benzarti et al. [3] worked on the division of territory and the proper allocating of resources, meeting different criteria. These scientific problems are often characterized by: lack of certainty in the operational plan (travel time, changing patient requirements), a workforce diversity with a range of skills and limitations, patient preferences (visiting hours, gender, etc.), allocation of the care workers (compatibility), the routes (allocation and schedules) and the importance of service quality, which is one of the primary goals in this topic.

This work is more concerned with HHC routing and scheduling (operational level). This problem is characterized by the assignment of tasks in health institutions, the definition of visiting hours for a group of patients and the consideration of operational limitations when establishing the routes of care workers. In this context, some surveys appear in the literature related to the concepts above: for example, OR applications are in Sahin and Matta [34]. In other approaches, Marcon et al. [28], explain how multi-agent systems are used to support HHC planning, and more recently, Grieco et al. [22], analyze OR strategies and evaluate solution techniques used in HHC to deal with the various decision problems. Other reports highlight the scheduling and routing issues at HHC, with a comprehensive overview in this field [19].

The main objective of this paper is to carry out a systematic literature review and a bibliometric analysis, using tools, and identify the main requirements, constraints, objectives, and methods used for solving routing and scheduling problems in the HHC context. In this way, it will be possible to describe some of the main works in this area and to identify and structure the decision problems and their features in real life. Furthermore, a summary table will be provided highlighting some characteristics of the selected papers. Finally, the paper discussion is conducted to identify past, present, and future trends in the HHC topic. In particular, some future research directions will be given.

This paper is structured as follows: Section 2 identifies the research approach used in this work. The bibliometric analysis to extract some generic information from the selected papers is presented in Section 3. Section 4 contains a discussion of potential research directions, while Sect. 5 finishes the paper.

2 Methodology

This section outlines the steps involved in gathering and choosing papers for a bibliometric analysis on HHC between 2010 and 2021. First, a list of appropriate keywords was created and used to search the database: Home Health Care, Health care, Home care, Home Service, Scheduling, and Routing. Then, several "Keyword Combinations" are examined in two databases, commonly used in OR, the Scopus and Web Of Science (WoS). In order to avoid losing any important papers, the key terms are relatively broad. In terms of keywords combinations, it was considered the following:

- (Home Health Care AND Scheduling) OR
- (Home Health Care AND Routing) OR
- (Home care AND Scheduling AND Routing) OR
- (Home service AND Scheduling AND Routing) OR
- (Health care AND Routing AND Scheduling) OR

The preliminary search obtained a large number of publications in English for each database, which is why the first context limitation (operations research management, engineering, mathematics, computer science, and decision science) was implemented for the databases. The papers found were selected by reviewing the title, keywords, and abstract and allowed to distinguish some of their categories, namely in terms of their publication, if they are journal articles, conference proceedings, book chapters, or technical reports. It was specified that only journal publications would be used for this research. Additionally, it is crucial to note that certain documents with keywords outside the operational context of HHC were excluded, namely keywords that referred to "Wireless Sensor Networks", "Internet Of Things (IoT)", and "Energy", among other complementary ones.

Thus, a total of 1400 papers were obtained, belonging to the vast majority of the Scopus database. After a brief analysis, it was possible to remove duplicate papers (180 papers) that would have been replicated. Therefore, 1220 papers were pre-processed for further bibliometric analysis.

The main objective of the analysis is to highlight documents through some faster filters, such as highly cited papers, open access, or the main references and trends, always focusing on HHC and addressing routing and scheduling problems. Studies such as the one by Cissé et al. [8] and Di Mascolo et al. [13] potentiated the creation of the scope of this work.

In this sense, an information extraction was performed based on a reduced selection of papers, considering the above-mentioned factors. Table 1 presents quantitative and qualitative outcomes of the selected journal papers reviewed related to HHC routing and scheduling. Some general features, such as the publication journal and the solving approach, are considered, whether a case study or more theoretical. Furthermore, the objective inherent to the work, namely in the minimization of "more classic" objectives (e.g., costs) or the presence of uncertainties, such as preferences, emergencies, time windows, among others, are presented.

Table 1. Overview of general characteristics of the analyzed publications.

Year	Reference	Publication Journal	Solving Approach	Problem		Objective	
				Case Study	Review	Min travel time/cost/ distance	Others
2011	[35]	JAOR	MILP - VNS	X		X	X
2012	[29]	EJOR	ALNS - CP	X		X	X
2012	[30]	EJOR	MILP – B&P	X		X	X
2013	[1]	ENDM	MILP – Matheuristic	X		X	X
2014	[6]	EJOR	CC	X		X	X
2014	[24]	ORHC	-	X		X	X
2014	[27]	HCMS	AVNS - MILP	X		X	
2015	[18]	J. Clean. Prod	2 st. Matheuristics	X		X	X
2015	[23]	Central EJOR	2 appr. MILP - CP	X		X	X
2015	[34]	IJLRA	-		X		
2016	[4]	EJOR	MILP – ALNS	X		X	X
2016	[31]	FSM	MILP – TS	X		X	X
2016	[36]	C&OR	MILP – 2 st. approach	X		X	X
2017	[5]	Omega	CC	X		X	X
2017	[8]	ORHC	-		X		
2017	[19]	C&OR	-		X		
2017	[28]	SMPT	Sim - MAS	X		X	X
2018	[9]	ORHC	MA	X		X	X
2018	[17]	JCP	MILP, (Meta-)Heuristics	X		X	
2018	[25]	C&IE	Metaheuristic	X		X	X
2019	[10]	SEC	MILP - MA - ACO	X		X	X
2019	[11]	SEC	MILP - trade off analysis	X		X	X
2019	[16]	NCA	Lagra. relax. - Heuristics	X		X	
2019	[20]	EJOR	MILP	X		X	X
2019	[21]	EJOR	Heuristic - LNS	X		X	
2019	[26]	C&OR	ANS	X		X	X
2020	[15]	ASC	MO, Fuzzy, Metaheuristics	X			X
2020	[32]	Omega	2-stage stochastic prog.			X	X
2021	[12]	FSMJ	Heurstic appr.	X		X	X
2021	[13]	C&IE	-		X		

Analyzing the publication year of the journal papers, especially in recent years, there is an increasing number of publications addressing HHC routing and scheduling. It is possible to verify that the journals with the most articles are those dealing with healthcare-related topics, operations research, manufacturing and production research, computer science, or mathematics. Some of the most common solving approaches are MILP - Mixed Integer Linear Programming, CP - Constraint Programming, CG - Column Generation, BP - Branch & Price, MAS - Multi-agent System, and MO - Multi-objective optimization, among others. Most publications suggest linear models and evaluate it using solvers like CPLEX, or using meta-heuristics such as the evolutionary algorithms, genetic algorithm, simulated annealing, among others (with resources from other types of software, e.g., MatLab). Other strategies, such as decomposition, multi-objective optimization, or hybrid methods, are increasingly being considered in recent works. Regarding the objective function used, the works were divided into two categories: the standard minimization of specific goals (time, costs, distance) and others (preferences, unexpected events, time windows, among others). For almost all the analyzed papers, the travel criteria were considered, since the problem in HHC was modelled as an extension of the VRP. Furthermore, many works also consider more than one objective (multi-criteria).

The work by Fikar and Hirsch [19] brings together much of the previous work regarding global citations, representative of an extensive review on the topic in question. The development of applications for scheduling and routing in HHC services remains extremely current, always looking for better optimization, the best approach with the best and fastest solutions [9,21], strengthening the growing need for the service and an increasingly common topic in the community.

3 Bibliometric Analysis

Bibliometric analysis is an emerging research area that is supported by a wide range of methods. Some of these methods are based on thematic analysis or network representation. In this sense, a brief bibliometric analysis was carried out, considering the 1220 documents from the databases between 2010 and 2021.

A new open source Python project based on a scientometric tool, named ScientoPy, was employed for this work [33]. This application allows to merge problems from Scopus and WoS sources, filter documents, remove duplicated records, extract and represent the h-index for the analysis topic, and pre-process graphical interfaces. Additionally, the application tool offers a variety of features to show indicators relative to authors, citations, organizations, wildcards, and trending subjects using many display options. This tool enables future bibliometric analysis in many emerging fields [33]. In addition, the Bibliometrix R-package was also used [2]. Regarding the dataset, it is possible to analyze the annual scientific production presented in Figure 1. The annual growth rate is the geometric progression ratio that provides a continuous rate over the period.

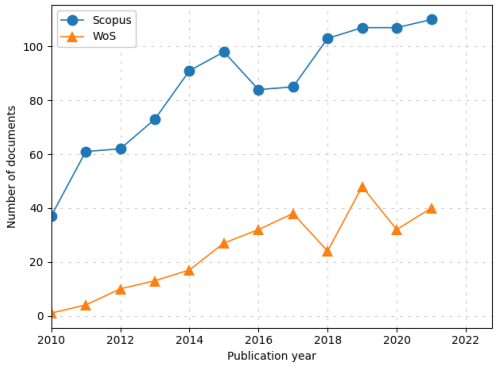

Fig. 1. Annual scientific production related to keywords.

As can be seen, more documents are connected to the Scopus database than the WoS. The historical evolution of the different keywords was analyzed, and Figure 2 shows each keywords cumulative number of occurrences per year. From Figure 2, it is possible to verify that keywords such as “Home Health Care” and

"Optimization" have a higher percentage of occurrence. Moreover, keywords such as "Vehicle Routing Problem", "Genetic Algorithm", "Linear Programming" and "MILP", have been experiencing sustained growth over the years, which supported the problem-solving approaches adopted by the researchers. In addition to its growth, especially in recent years, keywords like "Artificial Intelligence" (AI) have appeared in the latest research.

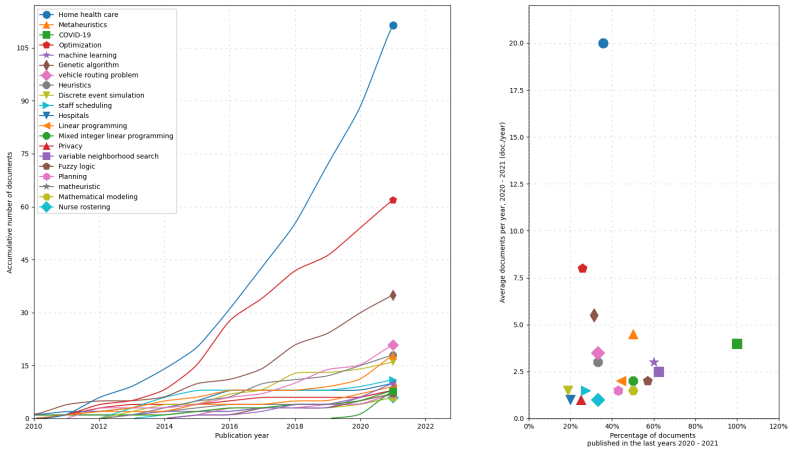

Fig. 2. Historical evolution of cumulative occurrences by keyword.

Using ScientoPy, it was possible to extract the top countries that produce more documents related to the keywords. Figure 3 shows the United States, China, and France are in the first three places, but for example, Portugal appears in position 11, which reveals the growth of publications in HHC management.

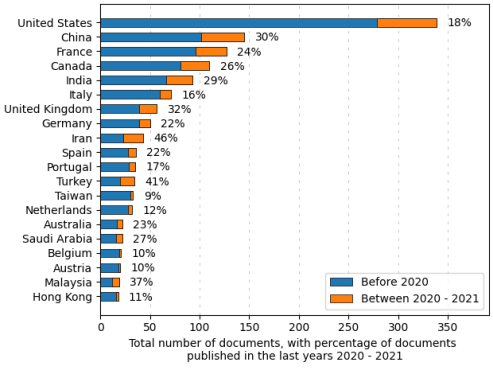

Fig. 3. Historical document publication by country.

In Figure 3, the number of documents released in the last two years can still be verified, revealing a growing activity in the HHC area.

4 Discussion and Future Directions

Due to its contribution and significant impact on society, the HHC routing and scheduling problem has gained more attention recently. This challenge addresses different experiments involving HHC organizations at three important levels: strategic, tactical, and operational, as shown in Figure 4.

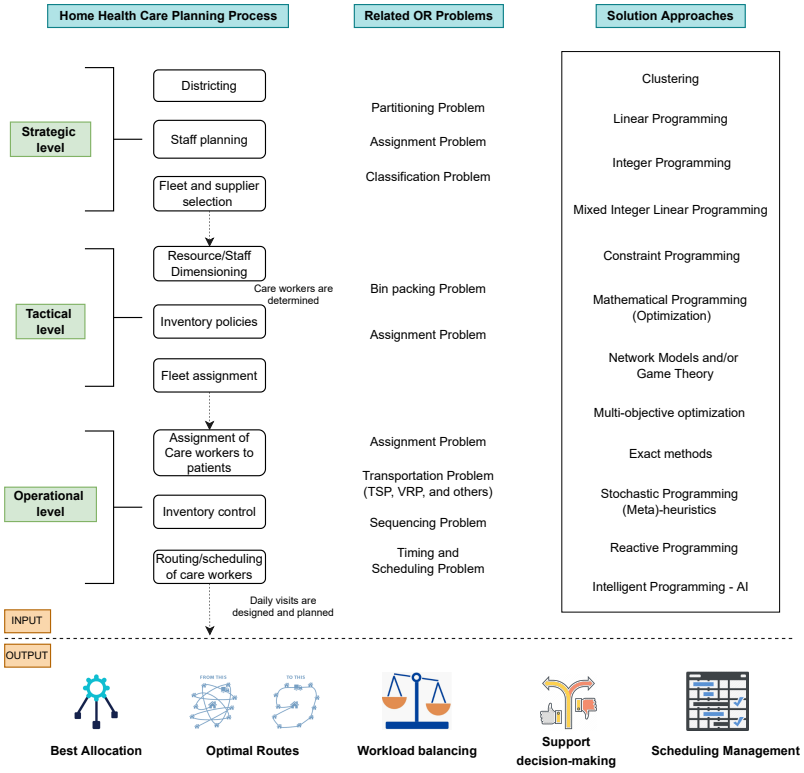

Fig. 4. A brief overview of the past, present, and future directions for HHC routing and scheduling.

Most authors validate their methods with real-world examples, which is expected to continue in the future, with more and more private or public HHC service institutions wanting to improve their processes. Most OR issues are variants of the VRP, with standard objectives (e.g., trip costs) or constraints (such as periodicity, time windows, legislative restrictions, skills, etc.). The latest re-

search recognizes that the approach to solving the HHC problem will meet increasingly specific procedures with distributed instances, uncertain constraints, and the possibility of unexpected events (real-time emergencies). In this sense, reactive programming, AI (such as multi-agent systems), and multi-objective methods can be the new focus in developing innovative applications and intelligent strategies to consider all stakeholders.

Furthermore, the remote monitoring of the health status by mobile health solutions can be considered as future direction [7].

5 Conclusion

This work presented a brief systematic literature review based on a bibliometric analysis concerning the management problem in the HHC context between 2010 and 2021.

Initially, some relevant keywords were defined, such as Home Health Care, Health care, Home care, Home service, Scheduling and Routing, and the search considered a set of 1220 articles from Scopus and WoS. A bibliometric analysis of the selected papers was then generated, describing current developments in HHC routing and scheduling.

The historical evolution of the keywords was analyzed, showing that "Home Care" and "Optimization" present a higher percentage of the occurrence. Furthermore, the increased use of the keywords "Vehicle Routing Problem", "Genetic Algorithm", "Linear Programming" and "MILP" over the years highlights the solving strategy adopted. The analysis also allowed to conclude that the United States, China, and France were the countries that produced the most documents related to the main keywords, with Portugal in 11th position. Moreover, a growing activity in the HHC area emerged, mainly regarding the number of documents published in the last two years. Finally, a brief overview of the past, present, and future directions for HHC routing and scheduling was presented.

Thus, this research highlights some areas for future studies that will help HHC organizations provide better and better services by addressing real-world issues, such as using mobile or web applications for management, monitoring, and decision-making in HHC. Combining AI with optimization techniques can ensure a productive workplace for healthcare workers while being sustainable.

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