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Home Health Care Operations Management: A review

Nada MOUNIB, Lina ABOUELJINANE and Maria LEBBAR
ROSDM Research Team, LMAID - Laboratory of Applied Mathematics and Business Intelligence, ENSMR, Rabat, Morocco
mounib.nada@gmail.com , aboueljinane@enim.ac.ma, lebbar@enim.ac.ma,

Fouad RIANE
Complex Systems and Interactions, Ecole Centrale Casablanca, Bouskoura Ville Verte, 27182, Casablanca, Morocco
fouad.riane@centrale-casablanca.ma

Abstract

Home Health Care (HHC) becomes a promising service among the health care services, due to the numerous benefits it offers such as increasing the 'stay at home' rate, freeing the hospitals from the cases where care could be provided at home, reducing health care costs and being aligned with the contemporary social needs. Nonetheless, the complexity factors involved in HHC services make the efficient management of such activity, from an operations management point of view, hard to obtain. In this paper, we propose a functional scheme of the service with a description of the HHC problem settings. We also detail the decisions at different planning levels that have an impact on HCC service performance. Finally, we give an overview of the different modeling and solving approaches that have been used in the literature to address the HCC service issues, and we end up with a discussion and future research directions.

Keywords
Home health care, Operations management, Healthcare management, Operations research.

1. Introduction

Home Health Care (HHC) is an alternative to conventional hospitalization in a health structure, which consists of delivering medical and paramedical care needed to a patient while the patient remains at home. The objective of HCC is to shorten hospital stays or even avoid them in order to reduce the congestion phenomenon in hospitals, while guaranteeing a good quality care service to patients (Benzarti et al. 2013). In recent years, the HHC service tends to become an important component of the health sector that has grown significantly, i.e. the employer firm revenue in the U.S. home health care service sector went from 43,233 (million US Dollars) in 2006 to 102,723 (million US dollars) in 2020 (https://www.statista.com/statistics/206518/us-home-health-care-service -employer-firm-revenue), in response to several factors such as demographic changes (aging of the population) increase in the percentage of the population with chronic diseases or physical or mental disabilities,the development of new technologies such as nanotechnology or telemedicine, but also to the continuous pressure from governments to control health expenditure. The COVID-19 pandemic further accentuated this demand when hospitals were faced with saturation of capacity to meet the demand for health services (Lin. et al. 2021). In addition to the increase in demand factor, the HCC service tends to be more popular due to many advantages it provides. Indeed, the care is more personalized with more attention, since the caregiver only has one patient at a time, while being surrounded by family which gives comfort, support and the peace of mind in most cases in addition to the patient-care worker relationship reinforcement (Cissé, et. al. 2017).

The increase in demand for the HHC service puts it under great pressure due to the various factors of uncertainty it has to face such as the frequency and location of patient demand, the type and duration of the care project per patient, the diversity, availability and location of stakeholders in the care project (doctors, nurses, social workers, transport providers, medical laboratories, equipment agencies, patients), the diversity of objectives (cost reduction, improvement of service quality, improvement of patient safety and comfort, balanced distribution of caregivers' workload, etc.), not to mention the context based factors related to the regulations, laws (Sahin and Matta, 2014).

Organizational management is further complicated by the fact that the staff are medically oriented even though the management of the service's operations would need Operations Research (OR) skilled people. As a result, most of the plannings that exist in real HHC organization are manual and suboptimal (Fikar and Hirsch 2016).

1.1 Home health care problems

In order to face these uncertainties while improving performance in terms of costs (purchase of materials and services, personnel, transport, storage of consumable material resources, etc.), quality of service (for the patient and caregivers), HCC managers have to make the best possible decisions at each level of planning. The problems to tackle vary from the strategic level based on a global demand estimation, where we could find capacity and resource dimensioning and design, strategic partnerships to make with different organizations, to the tactical level that encompasses districting problems, team size and composition decisions. To end up with the operational level that tackles the assignment and allocation problems, routing and scheduling of staff and the short term modifications to fix the last minute changes.

1.2 Objectives

Despite the growing importance of HCC services, the number of studies on operations management in these services is still modest as compared to those developed in the hospital context. The aim of this paper is to review the existing literature on HCC service operations in terms of decisions tackled, performance indicators addressed and models developed up to 2022 and to identify interesting unexplored topics for future research. Accordingly, we arranged this paper as follows: We introduce a functional diagram of the HCC service, in Section 2 of the paper, to describe the different steps from the admission process to the discharge of the patient. Section 3 consists of a decisions' level classification to distinguish the different possible planning horizons to consider while treating a HHC service problem. In Section 4, we provide a scheme to describe the aspect of performance considered in the literature and their relation with the decision level considered. Then Section 5 tackles the different modeling methods existing in the literature and their solving approaches. Finally in Section 6, we provide a discussion and highlight future directions that could be considered in future research.

2. Service Organization's Diagram

The aim of the HHC service is to provide the appropriate care to improve a patient's condition following several steps. In this section, we propose a description of the HCC process from an organizational perspective according to the DMAIC approach. Indeed, the service strategy is first defined in accordance with the legislation of the area, the market needs, the business portfolio, the mission, vision and values of the organization. The performance of the service is then measured and analyzed based on diverse indicators tackling not only the medical areas but also the logistical perspective, i.e. the service level, the demand satisfaction, cost reduction, flexibility and agility rate in order to identify the shortcomings and the improvement opportunities while considering the quality standards and objectives. The management of the projects to lead is another step of the process, its input would be the admission policies and requests, the patient's condition, resources availability and the organization of the service. This data would allow the service to identify the admitted patients, the needed medical and logistical resources, the typology of the medical activity and the operations management to end up with discharging the client. Finally, to be competitive, the service needs to improve its performance. This is a crucial stage that allows the use of experience feedback in order to improve practices both on the medical and operational levels (Matta et al. 2014). The whole process is represented in Figure 1. The Figure shows that each step of the process has inputs that could be the outputs of other steps.

A typical HHC curative project can be described as follows: The hospital or a family doctor could prescribe the HHC for a patient based on a certain diagnosis. A report summarizing the patient's condition needs to be sent to the HHC providers in order to make a prior assessment which would allow them to either admit or decline the request. The decision of the admission is a result of analyzing the new project's requirements with the specifications of the service, e.g. an agency that proposes a short term intense care would not be able to provide a long term needed product.

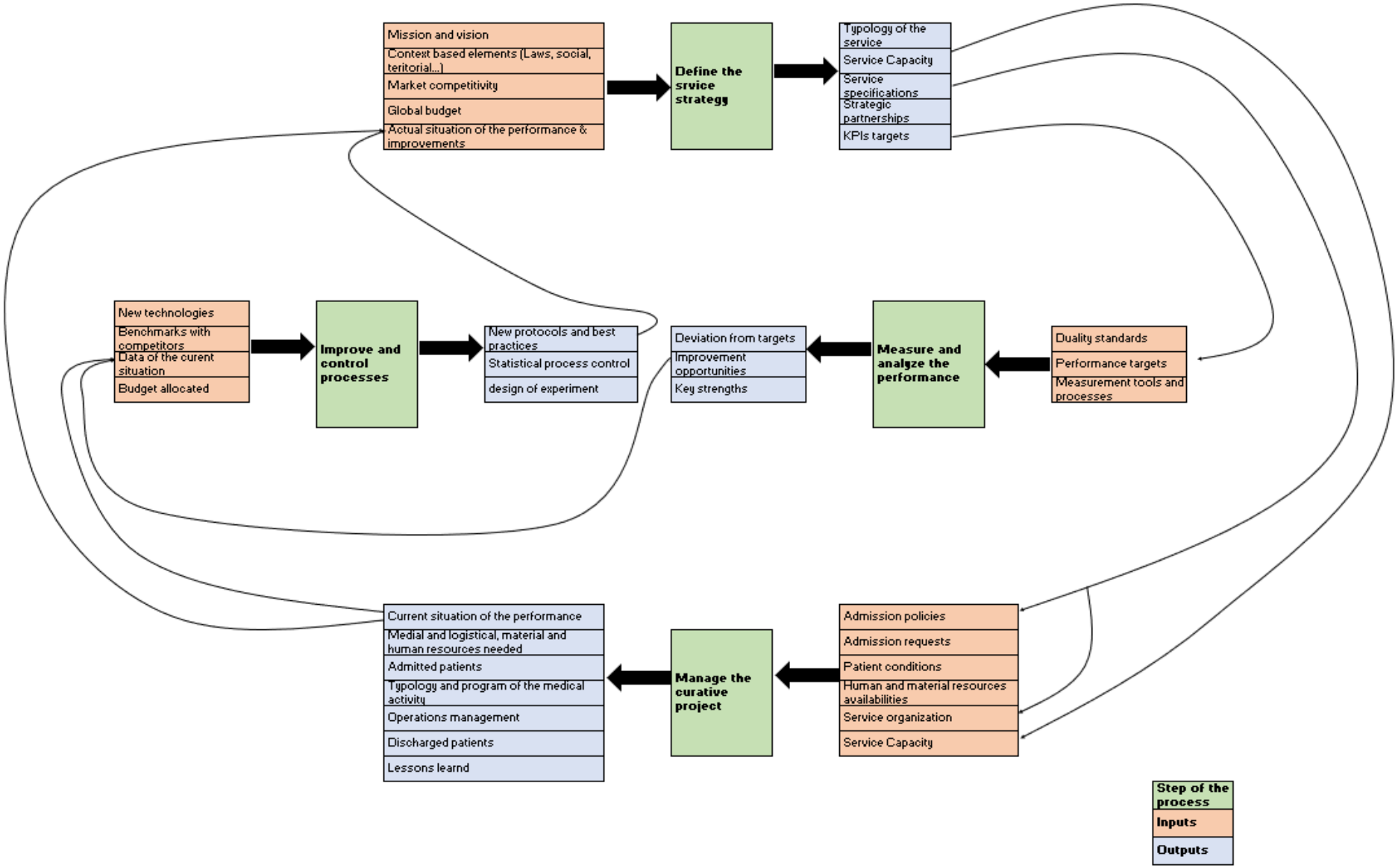

Figure 1. A proposed Functional diagram for HHC

The accepted patients are then invited to make the registration process which consists of a detailed assessment of the patient by using for example blood or radiology tests, local doctor consultation, historical medical reports.

This further evaluation enables the agency to pre-define the needed treatment, typology of the service, the required medical skills, the frequency of visits, the needed human and material resources.

A prior visit is usually planned, by the admin team, to the house of the patient in order to have visibility about the location, the neighborhood, and to visualize the delivery scenarios, e.g. where to put the equipment. Finally, an exchange with the patient would be beneficial to define the preferences of the patient e.g. in terms of availability and schedules, the nurse's preferences, the psychological needs etc.

All of the data gathered until this step will enable the service to define, more accurately, the allocation of the new patient to a district and a team matching with the skills requirements, the planning of the visits, the frequency and duration of visits, and the typology of the services to provide.

The next step would be to deliver the product according to the predefined planning, bearing in mind the importance of a continuous monitoring of the patient's condition enabling the redefinition of service's plan when necessary (Sahin, and Matta 2014).

Once the duration of the product's delivery is over, the agency discharges the patient, while managing the administration related topics in addition to the necessity of a reverse logistic plan in order to recover all the non consumable products such as medical equipment.

3. Service Decisions' Levels

From an operations management point of view, the problems to be treated address decisions at diverse levels, i.e. strategic (long term), tactical (mid-term) and operational level which includes short and very short term decisions (Sahin and Matta 2014).

The strategic level includes the service definition, i.e. the type of services to provide, the vision, mission and values. The definition of admission policies is also a long-term decision to make in order to clear up the conditions and situation enabling a patient to get accepted. Moreover, determining the type and capacity of human and material resources (i.e. capacity planning) as well as the type of employees' contract is a strategic decision that is made based on an aggregate demand forecast and the budget to allocate to the service. Identifying the geographical areas to serve is another important element which determines the spatial distribution of the areas to be considered by the service in order to clarify the beneficial districting strategies to establish. Another crucial decision is the strategic partnerships with different services and organizations (i.e., hospitals, laboratories, pharmacies, logistics service providers, other HHC organizations) allowing to make decisions in terms of the services to own, and those to delegate to the long term partners and enabling a shared network of services aligned and converging to the same objective.

Mid-term (tactical) decisions concern the planning decisions impacted on a horizon of several months such as the definition of the staff composition: the number of teams, the size of each team, the skills required and their allocation to each team. Another tactical decision is known as the districting problem. It consists of partitioning a geographic area into multiple sectors enabling a better organization in terms of staff and patients clustering and the routing and scheduling of visits). The partitioning should consider several features such as: Would the organization provide the service in an urban or rural area? What modalities of transport could be used? Do the HHC service need to be closer to hospitals? Laboratories? Would each district be an autonomous unit? or following a centralized policy? and the allocation of teams to districts according to the needed estimated capacity and skill requirements. Finally, detailing the strategic partners into eventual tactical collaborators is a matter of high importance.

The operational level includes the HHC routing and scheduling problems, which are VRP problems with multiple variants i.e. with time windows, periodic routing, multiple depot traveling salesman with time windows, periodic routing with time windows etc. The aims are to plan the routing of staff according to their schedules, the allocation of staff to patients and visits, managing the flows and availability of material resources from different organizational partners. Aside from the management of last-minute hazards with predefined contingency plans such as the caregiver non-availability, the road blockage, the appearance of urgent cases, cancellations etc.

In the literature, the operational level is the widely tackled level, while mid- and long-term decisions received far less attention from the research community. This could be explained by the ease of quantifying a short term forecast in addition to the fact of treating actual demands in the short-term planning. Moreover, most studies are case studies that are treated according to specific micro conditions which would allow a short-term planning.

4. System Performance Aspects

Depending on the problem studied, one or several indicators are either minimized or maximized in order to improve the quality of the HHC service. This section seeks to review the different performance indicators used in the HCC literature.

One of the widely considered indicators used to evaluate the routing and scheduling problems, is the caregivers traveling. It is defined as the rate of traveling in the daily operations of a caregiver. To have an efficient routing of the staff, the routes have to be chosen so as to minimize the cost, time and the distances. This indicator is correlated to the policy used to dispatch teams over districts (e.g. Single districts versus Multiple districts (Cissé, et. al. 2017). The distances between houses (caregivers and correspondent patients) in each district can have different impacts on traveling. Also the typology of the network (e.g. whether it is urban or rural), the modality of transport used, the rush and peak hours, are all characteristics that can have an impact on the caregivers traveling.

Another very important aspect is the workload balance that impacts directly the quality of the service provided. From a management perspective, it is crucial to have an equitably shared workload with a minimum amount of breaks in order to allow a good productivity and punctuality rate and avoid as much as possible the additional costs of the overtime. This feature could be quantified by the deviation from the average workload, a maximum staff utilization rate, or an average of the assigned services / patients to each worker (Grieco et. al. 2021). Another related parameter is the continuity of care also termed as patient-nurse loyalty (Nickel, S., and al. 2012) or employee regularity (Gamst, and Jensen 2011), which is defined as the consistency of the caregiver, i.e. a patient is treated by the same caregiver during the entire period of the delivery. It provides numerous advantages such as a linked information flow, a relationship based on trust and confidence. Nonetheless, in some cases the continuity of care challenges the workload balance and the assignments based on specific skills requirements especially in heavy projects that require robust historical data with rarely existing skills, in this case the continuity of care is crucial while the skills required for the project are rare which would definitively impact the workload of the caregiver. This feature could only be meaningful if a relatively long planning horizon is considered.

Not to mention the contract design and definition of the workers; the salary expenses of a full time worker is not the same as part time or a subcontracted employee. This leads to finding a trade off between minimizing the cost generated by the total coregivers number and satisfying the increasing demands.

5. Problems Modeling and Resolution approaches

In the literature, the decisions treated, that are related to the tactical level, are the districting and capacity planning problems. Benzarti et. al. (2013) formulated the districting problem using two mixed integer programming models taking into consideration the workload of caregivers and the compactness. A case study was performed in Canada by (Blais et al. 2003) , in which they partitioned the area into six districts while considering among others the workload balance and the mobility of the care workers. Tabu search technique was used to solve the problem. Lahrichi, N., and al. (2006) conducted a compendious examination of the precedent proposed territorial approach to check the demand satisfaction's rate. They concluded that the service was unable to follow the fluctuations and therefore needs more dynamic allocation of the patient to the caregiver based on the workload.

As for the capacity planning (Angelis, V. 1998) used a stochastic linear programming model in order to maximize the number of accepted clients while respecting the resources and budget limitations. In the same context, (Lanzarone, et. al. 2010) proposes a stochastic model enabling the home care organization to define the future workload by providing for each client the duration and frequency of visits and the total number of patients that could be treated at a period of time. Busby, C. and Carter, M. (2006) also treated the staff dimensioning while considering the uncertainty of the demand. The authors used an integer linear stochastic programming on a two-stage approach. In addition, (Rodriguez et. al. 2015) focused on the staff dimensioning considering the demand to be uncertain. The challenge is to have a trade off between demand's satisfaction and reducing the skills requirements costs. The authors used a two-stage approach with linear integer stochastic programming.

One the other hand, we find that the operational level's problems are the most studied, more precisely the routing and scheduling problems that include the time related criterions which are a complex feature. In essence, defining time windows that coincide with both patients and nurses availability and preferences while respecting the work capacity and services' synchronization (in terms of temporal dependencies between the services needed and the availability of human and material resources) is a challenging target to attend. Time window constraints are often expressed as soft constraints inside hard ones in order to allow a certain flexibility within a limited interval.

Therefore in this paragraph we would provide an overview of the used solution methods which could be classified into two classes; Exact solution methods and approximate solution methods.

Starting with the exact solution methods; (Sevel et. al. 2012) considered a VRP problem with time window while taking into account the preferences as soft constraints and time dependencies. A branch and price exact method was developed to solve the problem on a short planning horizon. In the same context, (Liu et. al. 2017) addresses the VRP problem with lunch breaks that is solved with the Branch and Price technique and decomposed into one master problem and pricing sub problems. Same authors tackled, in (Yuan et. al. 2015), the daily routing and scheduling problem with stochastic times and skills matching constraints using the column generation in the branch and price solution method. Bachouch et al. (2009) addressed the problem of the drug's delivery on a daily basis while constraining it with minimizing the traveled distance and respecting the time windows. In this matter they compared four strategies of delivery starting and formulated the problem using the mixed integer programming. As for the studies tackling the allocation problem with time window on a general perspective that could be adapted for HHC we found (Dohn et al. 2009) who used a column generation approach injected in the branch and price solution method. Moving to the medium term operational planning, (Trautsamwieser and Hirsch 2014) used the branch and price and cut and variable neighborhood search to solve the allocation of staff to clients while respecting the skills requirement, the time windows, care workers breaks, maximum working time and their weekly inactivity times. Wirnitzer et. al. (2016) formulated the rostering of caregivers to clients on a repeatedly weekly basis while maximizing the continuity of care i.e. minimizing the number of workers per patient. They used mixed integer programming formulations with hard constraints. Moreover, (Cappanera and Scutellà 2014) developed a linear integer programming to joint allocation, scheduling and routing models on a weekly basis while focusing on balancing the workload, continuity of care and skills matching.

Alternatively, most papers addressed the defined operational problems with approximative solution methods. First, we would cite the daily planning horizon. For instance, (Mankowska et. al. 2014) developed a mathematical model formulation to determine the daily routing of nurses. The skills matching and time windows were considered, as well as the interdependencies between services and synchronization. The greedy heuristic was used to have an initial solution then improved by variable neighborhood search. Maintaining the performance of the service during the times of natural disasters was the focus of (Trautsamwieser et. al. 2011) who tried to generate robust algorithms for the service's operations planning which would minimize the traveling and waiting times while respecting the breaks and working time limitations. The massive real life data was treated by a variable neighborhood search heuristic. Furthermore, (Redjem and Marcon 2016) proposed to treat the routing problem under restrictions linked to the coordination, time windows and precedence constraints.A two stage heuristic was used, enabling to first make a preallocation of the worker to the service then, and in order to respect the precedence restriction shifting and swapping was used. The population-based algorithm is found in (Akjiratikarl et.al. 2007) who used the Particle Swarm Optimization to find optimal routes allowing the minimization of total distance traveled and being aligned to the time window limitation. First solution generated is the earliest start time and minimum distance then global and local search procedures are used. Also, the genetic algorithm was developed in (Liu, R., and al. 2013) as a second solution method alongside with the tabu search. The problem is considered as a pickup and delivery with time windows and was modeled via two mixed integer programming formulations. Bredström and Rönnqvist (2008) tackled the vehicle routing and scheduling problem by employing multiple heuristics of the column generation. The problem was considered with time windows and temporal restrictions. On numerous stages, they used the relaxed mixed integer programming then a restricted mixed integer programming. In addition to (Bertels and Fahle 2006) who added soft and hard constraints for the time windows and the preferences. They used multiple heuristics on two stages i.e. the constraint programming, linear programming and the tabu search as a meta heuristic.

The next item is the multiple planning horizon from several days to a month. In order to plan weekly routes of the physical therapists and their assistants while minimizing the travel costs and adding the constraint that some patients

must be examined by the therapists at least once, (Bard, J., and al. 2014) employed a Greedy Randomized Adaptive Search Procedure on numerous steps. Alternatively, (Bowers et. al. 2014) proposed a traveling salesman problem algorithm, which was Clarke and Wright. The employed algorithm was embedded in a discrete event simulation. Their study aimed to minimize the traveling costs while taking into account the continuity of care and the patient's satisfaction. (Liu et. al. 2014) addressed the problem as a periodic VRM with time windows, and added three types of demand; the transportation of drugs and material resources, special drugs distribution and blood samples delivery. The challenge was to choose the day of visits for each patient and for each day the possible vehicle routes while reducing the maximal traveling cost. The authors used a hybrid method including the Tabu search as well as local search procedures.

Table 1. Problems decisions and their considered features in the literature

	Capacity planning	**Districting**	**Allocation of staff**	**Routing and scheduling**	**Material resource management**
Time windows			--Dohn, A., Kolind, E. and Clausen, J. 2009 --Trautsamwieser, A. and Hirsch, P. 2014	--Sevel, M., Rasmussen, J., Dohn, A. and Larsen, J. 2012 --Mankowska, D., Meisel, F. and Bierwirth, C. 2014 --Redjem, R. and Marcon, E. 2016 --Akjiratikarl, C., Yenradee, P. and Drake, P. 2007 --Bredström, D. and Mikael Rönnqvist, M. 2008 --Bertels, S. and Fahle, T. 2006 --Liu, R., Xiaolan, X. and Thierry, G. 2014	--Bachouch, R., Fakhfakh, M., Guinet, A. and Sonia Hajri-Gabouj, S. 2009 --Liu, R., Xiaolan, X., Augusto, V. and Rodriguez, C. 2013
Temporal dependencies				--Sevel, M., Rasmussen, J., Dohn, A. and Larsen, J. 2012 --Mankowska, D., Meisel, F. and Bierwirth, C. 2014 --Redjem, R. and Marcon, E. 2016 --Bredström, D. and Mikael Rönnqvist, M. 2008	
Maximum working time			Trautsamwieser, A. and Hirsch, P. 2014	--Cappanera, P. and G.Scutellà, M. 2014 --Trautsamwieser, A., Gronalt, M. & Hirsch, P. 2011	
Workload balance		--Benzarti, E., Sahin, E. and Dallery, Y. 2013 --Blais, M., Lapierre, D. and G Laporte, G. 2003	Lahrichi, N., Lapierre, D., Hertz, A., Talib, A. and L. Bouvier, L. 2006	Cappanera, P. and G.Scutellà, M. 2014	
Travel time				Trautsamwieser, A., Gronalt, M. & Hirsch, P. 2011	
Wait time	Busby, C. and Carter, M. 2006			Trautsamwieser, A., Gronalt, M. & Hirsch, P. 2011	
Travel cost				--Bard, J., Shao, Y. and Jarrah, A. 2014 --Bowers, J., Cheyne, H., Mould, G. & Page, M. 2014 --Liu, R., Xiaolan, X. and Thierry, G. 2014	
Travel distance		--Lahrichi, N., Lapierre, D., Hertz, A., Talib, A. and L. Bouvier, L. 2006		Akjiratikarl, C., Yenradee, P. and Drake, P. 2007	Bachouch, R., Fakhfakh, M., Guinet, A. and Sonia Hajri-Gabouj, S. 2009
Overtime				--Bard, J., Shao, Y. and Jarrah, A. 2014 --Rodriguez, C., Garaix, T., Xie, X. and Augusto, V. 2015	
Number of patients	--Lanzarone, E., Matta, A. and Scaccabarozzi, G. 2010 --Angelis, V. 1998				

Table 1 (continued) Problems decisions and their considered features in the literature

	Capacity planning	**Districting**	**Allocation of staff**	**Routing and scheduling**	**Material resource management**
Breaks			Trautsamwieser, A. and Hirsch, P. 2014	--Liu, R., Yuan, B. and Jiang, Z. 2017 --Trautsamwieser, A., Gronalt, M. & Hirsch, P. 2011	
Continuity of care				--Wirnitzer, J., Iris Heckmann, I., Meyer, A. and Nickel, S.2016 --Cappanera, P. and G.Scutellà, M. 2014 --Bowers, J., Cheyne, H., Mould, G. & Page, M. 2014	
Demand satisfaction	Rodriguez, C., Garaix, T., Xie, X. and Augusto, V. 2015		Lahrichi, N., Lapierre, D., Hertz, A., Talib, A. and L. Bouvier, L. 2006	--Liu, R., Xiaolan, X. and Thierry, G. 2014 --Rodriguez, C., Garaix, T., Xie, X. and Augusto, V. 2015 --Lahrichi, N., Lapierre, D., Hertz, A., Talib, A. and L. Bouvier, L. 2006	
Budget & ressources limitations	Angelis, V. 1998			Wirnitzer, J., Iris Heckmann, I., Meyer, A. and Nickel, S.2016	
Preferences				--Sevel, M., Rasmussen, J., Dohn, A. and Larsen, J. 2012 --Bertels, S. and Fahle, T. 2006 --Bowers, J., Cheyne, H., Mould, G. & Page, M. 2014	
Skills compatibility	Rodriguez, C., Garaix, T., Xie, X. and Augusto, V. 2015		Trautsamwieser, A. and Hirsch, P. 2014	--Yuan, B., Liu, R. and Jiang, Z. 2015 --Wirnitzer, J., Iris Heckmann, I., Meyer, A. and Nickel, S.2016 --Cappanera, P. and G.Scutellà, M. 2014 --Mankowska, D., Meisel, F. and Bierwirth, C. 2014 --Bard, J., Shao, Y. and Jarrah, A. 2014	
Uncertainty	--Angelis, V. 1998 --Lanzarone, E., Matta, A. and Scaccabarozzi, G. 2010 --Busby, C. and Carter, M. 2006 --Rodriguez, C., Garaix, T., Xie, X. and Augusto, V. 2015			Yuan, B., Liu, R. and Jiang, Z. 2015	

This section highlights that the operational horizon studies are abundant in the literature unlike the strategic and tactical levels that are hardly studied with very few papers. Approximative solution methods with a two-stage approach are widely used in the literature which allow to make the allocations first then to plan the routing of visits.
In Table 1 we classified the papers according to the decisions tackled and the quality features addressed either as constraints (to be strictly respected or, in some cases, a penalization occurs if not respected) or injected in the objective function.

6. Conclusion and future Directions

6.1 Conclusion

The home health care service could be considered as a recent emerging field of the health care systems with relatively low number of providers.

The studies tackling the HHC problems remain few and many areas are still unexplored, especially those related to the long term, generic and global horizons. This could be explained with the pragmatic perspective of answering the needs of a local organization under certain circumstances without considering the periodicity and continuity of the service (Grieco et. al. 2021). Furthermore, the complexity of the service's decision making remains undeniable and empowers the gap between a whole generic Supply Chain Management perspective against a pragmatic specific implementation.

This article provides an overview of the areas tackled in the literature. The first contribution consists of representing the service from an organizational point of view while enumerating the input and output data for each step of the process. The second contribution is a classification of the decisions according to the planning horizon. Furthermore, we tried to summarize the performance criterions considered for the service operations to end up with a classification in, Table 1, of the papers in the literature while considering the decision addressed and the features studied which lead us to conclude that the majority of papers are directed to the routing and scheduling problems.

6.2 Future directions

In this section we would like to synthesize the different future research directions cited in the literature so far. We propose to classify papers into five classes; Context based directions, the need of more generic models which provide a large decisions' choice panel through multi criteria approaches, human factor management, Stochasticity and dynamicity aspects of the system, and time related approaches.

(Grieco et. al. 2021) invite the researcher to clear up the context of the led research in order to allow future works to smoothly reshape according to their context. The possibility to consider the human behavior's aspect quantified is another context related option that, according to (Sahin and Matta 2014), would lead to a better understanding and management of the system. Finally, the sustainability perspective of such service is of a high importance as cited (Fikar and Hirsch 2016).

Due to the complexity and numerous decisions to make to treat a problem related to the concerned service, the models becomes specific to one certain set of conditions as a case study, therefore a possibility to have a generic model that could be flexible and adaptable to many situations would be very beneficial as affirmed (Cissé et. al. 2017). Moreover, (Grieco et. al. 2021) claimed that the alignment of the system performance aspects among different researches would be of high importance resulting in a classification of models treating decisions at different planning levels with a consistent goal that is the same performance aspects. Finally, yet importantly, the multi criteria approach resulting in a multi decision objective function is indeed necessary to tackle a problem related to such complex service (Sahin and Matta 2014).

Human factor management is an essential pillar to succeed the management of the entire service. In the same loop, (Sahin and Matta 2014) insists on the importance of tackling the assignment and routing of staff from a strategic decision level considering two stages: the specific care project definition as well as the general interrelated activities needing different types of caregivers without ignoring the interconnections between the clinical and logistics flows. Models to enable the choice of the contract design is as well a mentioned direction in (Grieco et. al. 2021). Lastly, the modeling and resolution of HHC routing and scheduling problems in the literature did not take into account the

possibility of a multi modal transportation that would allow according to (Fika and Hirsch 2016) a better optimization especially if we combine different modes and consider public transport (Cissé et. al. 2017).

The service doesn't lack the variability and randomness. Therefore having researches that would take the stochastic as well as the dynamic aspects via quantitative models resulting in forceful operations would have a high benefit (Fikar and Hirsch 2016). Staying in quantified models, (Sahin and Matta 2014) propose to have a quantified model enabling us chosing or a strategic organizational profitable coordination.

Time related future research could be described as the most complex. From a supply chain perspective, (Sahin and Matta 2014) invite researches to consider models for managing supply chains including sourcing and synchronizing of the material resources for various geographically dispersed actors (providers of non-consumable goods, logistic service in charge of delivery (availability), lifespan of some medications, return flows of unspent supplies, emergency contingency plans, equipment failure or shortage scenarios). Zooming to the routing and scheduling problems, (Cissé, et al. 2017) propose multiple time windows outlining all of the patient's available times.

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Biographies

Nada MOUNIB is Ph.D candidate at ENSMR (Ecole Nationale Supérieure des Mines de Rabat, Morocco). After having preparatory classes in Mathematics and physics, she joined EMI, Ecole Mohammadia d'Ingénieur, to pursue her studies in industrial engineering management. During the third year she specialized in Supply Chains Management and got her credentials with Honors.Her current research concerns the Home Health Care service management from an Operations' perspective.

Prof Lina ABOUELJINANE is Assistant Professor at ENSMR (Rabat). She holds a PhD in Industrial Engineering from CentraleSupelec, France (2014) for her work on ambulance multi-period redeployment. Her research interests are in healthcare management with a special emphasis on modeling and optimization of Emergency Medical Services (EMS), Emergency Departments (ED) and Home Health Care (HHC) services using Discrete Simulation-Based Optimization.

Prof Maria LEBBAR is associate professor in the industrial Engineering Department at École Nationale Supérieure des Mines de Rabat. After obtaining her engineering degree from Ecole Nationale d'Ingénieurs de Tunis, she holds a PhD in Industrial Engineering from CentraleSupélec. Her research interests include among others Operational Research, Column Generation, Linear Programming Optimization and supply chain management.

Prof Fouad RIANE is full professor of supply chain and operations management, lean management and Six Sigma. Research Director and Coordinator of the Industrial Engineer Curriculum at the Ecole Centrale Casablanca (ECC). Professor of logistics and supply chain management at Settat Faculty of Science and Techniques (FSTS), University Hassan 1st in Morocco. Full professor at the Catholic University of Mons in Belgium during the period 1996-2010.