# Identifying and Analyzing Operations Management Strategic Problems in Home Care


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**Abstract** Home care encompasses medical-related care performed by health professionals at patients' homes and non-medical care (cleaning, bed-lifting, cooking, etc.) delivered to people who cannot accomplish these actions autonomously at their own homes. The operations management literature has studied home care mainly as a variant of the well-known vehicle routing problem with time windows (VRPTW). Yet, other strategic, longer term problems related to operations management have not received as much attention. We explore the (still) limited literature on home care operations management strategic problems and give guidance for potential research.

**Keywords** Home care operations · Long-term problems · Strategic problems

## 1 Introduction

Home care is experiencing growing attention from the operations management scientific community. The main reason underlying this interest is the increase of home care patients in many countries. For instance, according to OECD [15] between 2011 and 2015, 14 European countries[1] experienced a 20% combined surge (from 4,5 to 5,4 million patients). In these countries, the most notable growths, in absolute terms, occurred in Spain (from 520,000 to 860,000 patients) and Switzerland (from 250,000

[1] Estonia, Finland, Germany, Hungary, Italy, Latvia, Luxembourg, Netherlands, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, and Switzerland. The rest of the European countries are not included because either the 2011 or the 2015 figure is not available.

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D. De la Fuente et al. (eds.), *Organizational Engineering in Industry 4.0*,
Lecture Notes in Management and Industrial Engineering,
https://doi.org/10.1007/978-3-030-67708-4_11

to 340,000 patients). Population aging, smaller families, and urbanization are behind the demand rise. Furthermore, planners devise and manage caregivers' routing and scheduling assisted by specific software, in which optimization algorithms, developed by operations management researchers, may be implemented so as to improve resource utilization. Finally, from an economic point of view, home care could be cheaper than hospitalization or nursing homes.

The operations management literature has explored home care operations mainly as a static short-term routing and scheduling optimization problem, i.e. assigning caregivers to known and certain patients' requests of service and deciding upon service starting times to optimize a given objective function (for instance, to minimize the total distance traveled). Little attention has been paid to strategic problems. This paper analyzes long-term operations management problems in home care, and points to potential research directions.

## 2 Strategic Operations Management Problems in Home Care

We have reviewed articles and conference papers whose goal was to find and categorize home care operations management problems [1, 5, 7, 9, 11, 12, 14, 17]. Typically, home care problems are classified according to the time horizon of the decisions to be made. This paper is specifically based on Matta et al. [12]. Their classification contains strategic problems (1–5-year time horizon), tactical problems (up to 12 months), operational problems (up to several months), and detailed operational problems (up to several days). Due to the objective of this study, we focus exclusively on strategic problems.

This section is organized as follows: every identified problem is defined and the literature on every specific topic is further examined, extending our review from problem-identifying to problem-specific articles. Finally, potential research directions are sketched.

### *2.1 Global Demand Forecasting*

It refers to the expected annual patient care volumes. Demand is a major concern for home care organizations, due to its intrinsic uncertain nature.

**Literature Review**. Only one article on demand forecasting has been identified [10], which presents a deterministic model to forecast the evolution of the number of patients in home care and other care services in British Columbia. The forecasted events are: patients entering any of the care services, switching between them, or abandoning definitively the care system. The main variables are: age, health status, and income. It does not include patient location forecasting.

**Future Research Directions**. Not only the total number, but also the location of future patients is relevant for Home Care organizations. No paper has attempted location forecasting. We suggest two probabilistic approaches:

- Individual-based method: to calculate, for every time period, the individual probability of a person entering or exiting the home care system, based on his/her characteristics (age, income, etc.). This approach would need data and exact home location on all populations of the studied area and projections on demography and individual's characteristics. The longer the forecasting period, the higher the error (potential patients may change residence, new residents arrive, etc.). Simulations should be conducted and analyzed.
- Region-based method: the studied area would be divided into smaller regions. For every smaller region, relevant variables would be gathered (total population, age pyramid, average income, etc.). A statistical model, based on relevant variables, may compute, for every time period and region, the number of entering and exiting patients. The location would be probabilistically random within the smaller region. Data needs are lower, but also is accuracy. Simulations should be conducted and analyzed.

## *2.2 Capacity Planning*

It answers the question of how many caregivers, at an aggregate level, and of which type (skills, contract type, etc.), the home care organization needs in the long run. It also includes selecting, at a general level, which services will be delivered by internal resources and which will be outsourced.

**Literature Review**. We have not found any paper specifically devoted to capacity planning in home care.

**Future Research Directions**. The capacity planning problem must consider the caregiver's fixed salary because generally a great proportion, if not 100%, of this salary is fixed. Some routing and scheduling papers take it into account (see, for instance, Yuan & Fügenschuh [18]), but their short-term nature limits the applicability for capacity planning. We suggest developing a method that jointly optimizes routing, scheduling, and capacity for long periods, taking as an input the demand forecast. The method must propose the number of caregivers, contract type, skills, working hours, and services to be outsourced. We suggest a heuristic approach, aimed at minimizing the sum of salaries, since the problem is NP-Hard.

## *2.3 Facility Location*

It consists in determining the number and location of operational centers across the region which is to receive home care.

**Literature Review**. Du and Sun [6] propose a discrete-time model with differentiated types of services and caregivers. Its main problem variables are (i) when to open an Operational Center, (ii) in which of the possible locations, and (iii) when to start providing, if at all, each of the possible kinds of services from each Operational Center.

**Future Research Directions**. This problem is of low importance because in many settings, visiting tours can start and end at each caregiver's home (neither starting nor ending at any Operational Center). Facility location is a well-known topic: models from contexts other than home care can be adapted (for a review, see [13]).

## *2.4 Districting*

It refers to disaggregating geographic areas to provide the service. Home care companies tend to partition large areas into smaller districts to simplify resource assignment, managing each district independently [12].

**Literature Review**. Districting has been widely studied to establish political optimal areas, and in other contexts, such as sales territories partitioning [2, 8], but has been barely applied to home care. Common starting hypothesis in home care districting, based on Benzarti et al. [2], Benzarti et al. [3], Blais et al. [4], and Gutierrez-Gutierrez and Vidal [8] are:

- Indivisibility of the basic units: Basic units are pre-established geographic areas which are grouped to form districts. The number of districts is a specific number m set by the problem maker.
- Respect of administrative boundaries: Districts must be formed by units from the same administrative area (for instance, the same municipality).
- Maximum total service time difference among districts: This is to be obeyed to avoid workload imbalances. Generally, the condition is expressed in deviation from the mean service time of all districts.
- Maximum number of caregiver changes: When a home care organization is pursuing a continuity-of-care policy (caregiver–patient assignments are permanent, that is, all services to a given patient are always performed by the same caregiver), districting for the first time or redistricting necessarily leads to changes of caregivers–patients assignments. Benzarti et al. [2] present a model in which the total number of those changes is upper bounded.

Problem variables represent to which district every basic unit is assigned. As for objective functions:

- Blais et al. [4] tackle the problem with a weighted multicriteria function to be minimized composed of two terms: the first is a measure of the distance between basic units, and the second a function by which a penalty is incurred whenever

the workload (comprised of caregivers' travel time and service time) of a district lies outside certain arbitrary margins from the average.

- In the first model of Benzarti et al. [2], the objective is to minimize, in absolute value, the maximum difference between each district's workload and average workload; in the second model, the objective is to minimize the weighted sum of the maximum difference between each district's workload and average workload plus the maximum travel time between basic units within the same district. A third model proposes a single criteria objective function to minimize the maximum travel time between basic units of the same district.
- Gutierrez-Gutierrez and Vidal [8] is the only paper, to the best of our knowledge, aimed at providing a Pareto frontier by using several objective functions with variable weights. The first function measures the travel time between basic units within the same district, whereas the second one comprises the sum of the difference, in absolute value, between each district's workload and travel time as compared to the average.

**Future Research Directions**. Basic units' boundaries are always imposed before optimization. Hence, research on defining those boundaries seems promising. Likewise, the number of districts is usually imposed. Only in Gutierrez-Gutierrez and Vidal [8], the problem is solved for different numbers of districts. This practice should be generalized.

Large districts provide more possibilities to optimize routing and scheduling, despite increasing complexity. However, these economies of scale, arising from large districts, may come to an upper bound: a district might reach a size above which significant gains are no further possible. Testing this hypothesis and, if certain, calculating this "right" size for different home care settings (for instance, high and low populated areas) may be a valuable guide for home care organizations.

## *2.5 Fleet Selection and Sizing and Fleet Assignment*

Fleet Selection and Sizing refer to define who is responsible for transportation to, from, and between visits (the organization or the staff) and to select the transportation modes (private, public transport, etc.) so as to balance cost and speed. Fleet assignment consists in assigning vehicles to staff for transportation (when vehicles are owned by the home care organization).

**Literature Review**. We have not found any paper specifically devoted to this problem. Some routing and scheduling papers include the option of setting, before optimization, which transportation means is used by each worker, (see, for instance, [16].

**Future Research Directions**. Two circumstances are important in this regard: (i) no paper treats transportation mode as a problem variable and (ii) new modes are rapidly entering the urban transportation market, either as a "Mobility as a Service" (MaaS)

**Table 1** Suggested research directions on operations management strategic problems for home care

| Problem | Suggested research directions |
|---|---|
| Global demand forecasting | (1) Patient location forecasting: individual-based/region-based |
| Capacity planning | (2) Heuristic methods that provide the number of caregivers, type of contract, skills, outsourced services, etc. Forecasting models are used as input |
| Facility location | (3) Apply facility location models from other contexts to home care |
| Districting | (4) Definition of basic units' boundaries<br>(5) Apply solving procedures for different number of districts<br>(6) Calculate the "right" district size |
| Fleet selection and sizing and fleet assignment | (7) Develop models that suggest the appropriate number and type of owned transportation means<br>(8) Include, in routing and scheduling models, the use of MaaS as a problem variable |

*Source* own elaboration

(Such as bicycle, scooter, motorbike, and car sharing) or as private means, such as electric bicycles and small electric scooters. These modes can provide a cheap and reliable alternative for caregivers' travels. We propose two research topics:

- Ownership of means by the home care organization. A method can suggest an appropriate number of each type and assign it to specific caregivers or specific routes.
- Even though this is not a strategic problem, let us highlight here that including, in short-term routing and scheduling methods, the possibility of using MaaS appears to be a valuable future contribution.

## 3 Summary

Eight potential research directions for operations management strategic decisions on home care have arisen from our analysis, which are displayed in Table 1.

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