Home Care Staff Planning and Scheduling: An Integrated Operations Management Perspective

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Abstract
The Home Health Care (HHC) sector continues to grow at an increasing rate across the globe. As such, developing proper health care management systems and operations strategies is essential for survivability, growth and competitiveness of healthcare systems. As labor is the most critical asset in the home care organizations, it is crucial to obtain an in-depth understanding of HHC operations, from an operations management view point, with specific emphasis on staff planning and scheduling. The aim of this paper is to provide a taxonomic analysis of HHC staff planning and scheduling decisions, from an operations management perspective. We identify from various cases in the literature, the core activities characterizing staff planning and scheduling. We then present a taxonomic analysis of these activities, and propose an integrated approach to decision making. A conceptual modeling framework is then proposed to assist the decision maker in solving problems in HHC staff planning and scheduling.

Keywords
Home health care, home care, staff planning, staff scheduling, operations management

1. Introduction

In the health care industry, the Home Health Care (HHC) is an increasingly growing sector across the world [1] [2] [3]. Home care services, for instance, should attend to patients with acute illness, chronic illness, permanent disability, or terminal illness, and provide post-hospitalization treatment, post-operation treatment [4]. The services provided may include nursing, therapy activities, medical and social services, house cleaning, and drug deliveries. In particular, staff planning and scheduling is a major concern to health care operations planners. This is necessitated by the fact that labor costs constitute the greatest portion of the total operations costs of most healthcare organizations [5] [6] [7]. Labor is the most critical asset in the home care organizations, thus, must be utilized effectively and efficiently. As such, it is essential to develop novel healthcare operations planning and management systems for survivability, growth and competitiveness in the global business environment. To achieve this goal, it is crucial to obtain an in-depth understanding of HHC operations, from an operations management view point, with specific emphasis on staff planning and scheduling.

The operations of the HHC organizations are uniquely complex [8] [9]. Novel approaches and perspectives are needed as most health care services move into home care settings. The complexity of home care operations is aggravated by a number of factors: (i) patient's homes are incorporated as components of the conventional healthcare supply chain, (iii) resources, human and materials have to be allocated and managed effectively, (ii) patients have personal time windows in which they should be treated, (iii) care givers have their own preferred time windows or shift times, (iv) many social aspects have to be considered, such as patient-nurse loyalty which seeks to ensure long-term relationships between patients and specific care givers. Additional restraints exist in specific homecare staff planning, scheduling and control.

The aim of this paper is to provide a taxonomic analysis of HHC staff planning and scheduling decisions. First, we identify from various cases in the literature, the core activities characterizing staff planning and scheduling. Second, we present a taxonomic analysis of the activities. A conceptual modeling framework is then proposed to assist the decision maker in solving HHC staff planning and scheduling problems. Research opportunities are identified and highlighted for the operations management community.

The next section presents a taxonomic analysis of previous studies in the literature. Section 3 provides conceptual models derived from the taxonomic analysis. Section 4 presents research opportunities

from the operations management view point. Finally Section 5 concludes the paper.

2. Taxonomic Review and Analysis

This section provides a taxonomic review analysis of staff planning and scheduling in the homecare setting. The analysis is based on a study of existing empirical and hypothetical research in the literature. We present our research methodology, and identify key decision activities and their relationships.

2.1 Research Methodology

A wide selection of sources of existing studies were used to compile the relevant HHC literature, such as EBSCO Inspec, ISI Web of Science, Ei Compendex, ScienceDirect, and bibliographic studies such as in [5] and [6]. The main keywords used in the search process are "home health care," "homecare scheduling," "home healthcare worker scheduling", and "home care patient assignment." This helped to reduce retrieval of irrelevant studies while eliminating studies whose major focus was not staff planning and scheduling. In addition to this, we carried out an investigation on the common staff planning and scheduling activities in healthcare organizations in Zimbabwe. An outline of the activities is presented.

2.2 A Taxonomic Analysis

From our study, there are three observable levels or categories of decision making activities, based on the planning horizon, that is, long-term, medium-term, or short-term, as shown in Table 1. Long-term planning is done on an annual basis, involving such decisions as capacity planning and long-term staffing policies. While medium-term planning may be on weekly or monthly basis, short-term planning is concerned with on-going, daily activities.

Table 1. Categories of decision making activities

Category	Planning Activities	References
Long-term planning	Staff planning, Staff capacity planning, Develop staffing policies, and scheduling policies	[3] [4] [10] [11] [12] [13] [14] [15] [23] [26] [28] [29]
Medium-term planning	Determine staff requirements or staffing levels Develop staff schedules for senior or core staff	[12] [13] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [30] [31]
Short-term planning	Daily assignment of tasks Re-scheduling, Re-rostering, attending to staff variances	[2] [8] [9] [15] [18] [25] [27] [32]

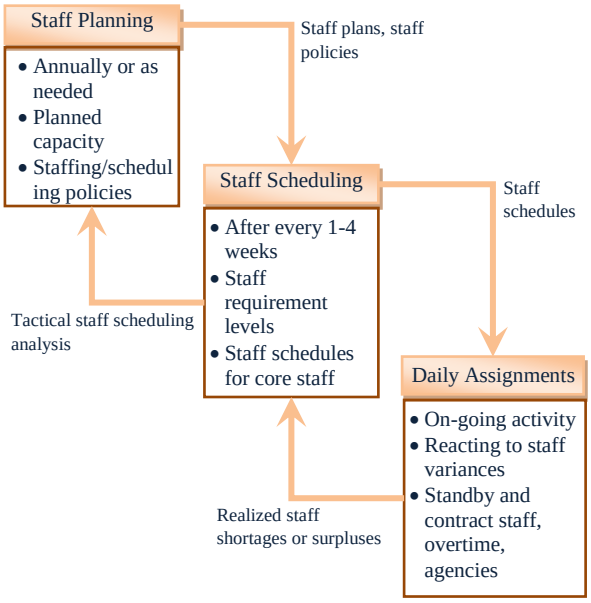

Figure 1. Integrated staff planning and scheduling framework

However, in our view, these three-level activities are interrelated and intertwined, such that the decision maker has to approach the problem in a more integrated fashion. Figure 1 presents the proposed holistic integrated framework for decision making in staff planning and scheduling, showing interaction and feedback structure of the three decision levels from an operations management and systems point of view.

On an annual basis, the operations planner generates staff plans and policies which will be used as top level input to medium-term staff scheduling. In the process generating staff schedules, the scheduler makes short-term analysis of schedules and feeds back to the staff planner. The staff schedules are the input to the daily task assignment decisions. Daily issues involving staff variances or shortages, contract staff, and overtime are attended to by the scheduler. An analysis of these variances is used as feedback to staff scheduling activities.

As opposed to conventional sequential approaches, the proposed integrated approach offers a number of advantages in real-world HHC staff planning and scheduling:

- The integrated feedback mechanism ensures that disparities are considered by decision makers, reducing the impact of future uncertainties.
- The integrated feedback mechanism enhances continuous improvement of healthcare service operations.

- The integrated approach ensures cooperation of decision makers at all levels, from a systems point of view.
- Staffing problems are solved holistically, rather than through the conventional silo approach (or sequential approach).

Deriving from the integrated approach to staff planning and scheduling, we propose a conceptual framework for model development at different levels, and suggest appropriate solution approaches for each level

3. Conceptual Modeling

Our conceptual modeling framework considers that the HHC staff planning and scheduling problem has two main objective approaches: (i) single objective, that is, minimize staffing costs or maximize profits, and (ii) multiple objective, that is, maximize healthcare service quality, staff schedule quality, and organizational satisfaction. The application of these objective approaches depends on the pertinent constraints, especially time window constraints and time horizons restrictions.

We base our model classification on two dimensions: (1) time horizon, consisting of three gradations, that is, long-term, medium-term, and short-term horizon, and (2) time window constraints pre-specified by patients, consisting of two gradations, that is, with time windows, and without time windows. As a result, we obtain six model approaches in all, as outlined in the next section.

3.1 Models

Figure 2 presents a matrix classification of models for decision support in HHC staff planning and scheduling. The explanations of the models are as follows:

Model 1. The objective of this model is to maximize the satisfaction of long-term organization expectations in terms of building the capacity and developing staffing policies in anticipation of future staffing requirements. Capacity planning is carried out considering the prevailing time window constraints, at aggregate levels. Usually, geographical settings are taken into account, considering the aggregate distances and the likely staff workloads due to healthcare demand. Districting problems often model staffing problems considering geographical locations of clinics [14], together with likely locations of future home care service demand, and their time windows, at an aggregate level [21].

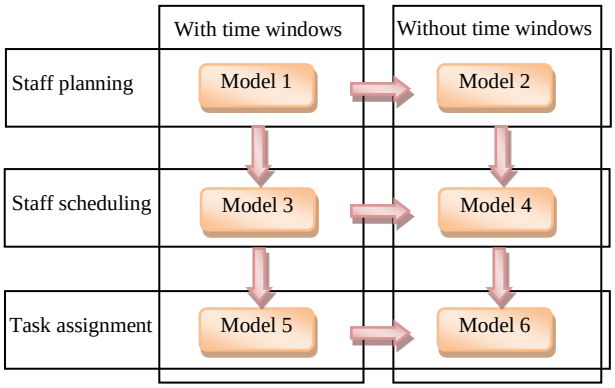

Figure 2. Modeling for HHC planning and scheduling

Model 2. This model is similar to model 1, but assumes that no time window constraints are pre-specified. The model considers that time window specifications are best considered in the medium to short term planning, or the time windows are flexible enough to allow flexible modeling in the future. Where time windows are too uncertain, this model may be worthwhile.

Model 3. The model objective is to schedule the core staff, while minimizing schedule costs and staff shortages, or maximizing profits. Long-term staff plans are used as constraints to this model. In addition, it is crucial to consider time window constraints specified by patients as this will lead high service quality. Problems such as drug distribution, patient assignment may fall into this category.

Model 4. This model is a simplified version of model 3, where time window restrictions are not considered. Practical scenarios of this model include cases where time windows are flexible enough to be ignored during scheduling, or where only a few home care tasks exist, posing insignificant restrictions on modeling.

Model 5. This model pertains to the assignment of duties or tasks on a daily basis. The basic objective is to minimize assignment costs, subject to time window constraints from patients, working times of the healthcare staff, and labor availability. However, the multi-objective case may be more appropriate, where time window constraints are treated as soft constraints that may be violated, but at a penalty cost.

Model 6. This model is a simplified version of model 5. The objective of this model is to minimize task assignment costs, subject to constraints such as labor requirements, staff availability, and other side constraints. In the absence of time window

constraints, job dispatching heuristics can be applied on real-time.

3.2 Solution approaches

In the long-term, dynamic simulation approaches such as system dynamics simulation, fuzzy system dynamics simulation, and other systems thinking based approaches are most viable [33]. This is because such methods take into account the uncertainties and fuzziness prevalent in the long term staffing problem due to complex dynamic features involved. On the other hand, short-term operational decisions such as developing weekly schedules can be solved using heuristics, global optimization techniques, expert systems, and other intelligent decision support systems [17] [19]. Operationally, real-time heuristic task assignment methods are the most viable. The main reason for this is that operational decisions are often affected by unforeseen events such as staff no-show, emergent patient requests, and uncertainties associated with time windows, traveling time when nursing staff visit patients [2] [9]. These uncertain events may call for the application of re-rostering heuristics on real-time basis.

4. Research Opportunities

Research opportunities in this field are widespread. First, it is important to consider uncertainties in the staff planning and scheduling in healthcare in general, and in homecare systems. From a non-stochastic sense, uncertainties arise when specifying future manpower requirements and demand for healthcare services. In the medium term, it is difficult to anticipate manpower requirements considering imprecise staff preferences, patient time window preferences, and management goals [2]. The wishes and preferences of staff, patients and management often evolve over time. Therefore, fuzzy modeling is the most viable approach in this area [34] [35 [36] [37]. Due to the complex combinatorial nature of the problem, the most practical approach is metaheuristic optimization. Interactive decision support systems and rule-based expert systems are also applicable.

Daily task assignment methods need to be explored. For instance, job dispatching heuristic methods that are usually applied in production operations management can also be applied effectively in healthcare task assignment. The application of conventional mathematical programming methods in modeling and solving task assignment problems may be limited in the case of large scale problems. Another viable approach is global optimization, where methods such as genetic algorithms, tabu search, simulated annealing, evolutionary algorithms, and particle swarm optimization can be applied [2] [9] [15] [17].

5. Conclusions

This paper explores and investigates decision making activities in the home healthcare setting. Empirical case examples from the literature, coupled with cases in Zimbabwe are used to come up with a list of decision making activities at different time horizons. Drawing from this experience, we learnt that decision making occurs in the long term, medium term, and short term horizon. However, these decision levels are closely interrelated, and often affected with feedback effects, so much that they should be viewed at in an integrated manner, from a systems view point. Healthcare operations managers should therefore formulate long term strategic policies, develop tactical strategies and tackle operations problems from a systems perspective.

Our contribution focuses on developing an integrated operations management framework and a conceptual modeling framework for decision making in homecare staff planning and scheduling. The modeling framework provides a platform for further development of customized mathematical tools, heuristic methods, metaheuristic methods, and expert systems that can then be fitted as modules at specific decision levels. It is anticipated that the integrated framework will go a long way to assist the decision maker with a systems view on home care operations, as opposed to conventional sequential approaches.

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