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The therapist assignment problem in home healthcare structures

Meiyan Lin[a], Kwai Sang Chin[b,c,*], Xianjia Wang[d], Kwok Leung Tsui[b]

[a] Department of Systems Engineering and Engineering Management, City University of Hong Kong, Kowloon Tong, Kowloon, Hong Kong
[b] Department of Systems Engineering and Engineering Management and Centre of Systems Informatics Engineering, City University of Hong Kong, Kowloon, Hong Kong
[c] School of Management, Wuhan University of Technology, Wuhan 430070, China
[d] School of Economics and Management, Wuhan University, Wuhan 430072, China

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ABSTRACT

Staff planning in Home Health Care (HHC) context is challenging due to the complexity, such as, unavailability of resources, variation in patient health conditions, and diversity of continuity of care (COC) and patient's priority (PP). This necessitates the implementation of adequately effective models and intelligent systems to improve the robustness of care plans that run with limited input from the support staff. The work proposed an effective, simple, compatible and extensible model for the therapist assignment problem (TAP). The model aims at maximizing the assignment rate of demand, subject to the constraints of workload capacity limitation and available time selection clash. It helps the HHC structure managers to make proper decisions through preferred time periods (PTPs) selections and weight allocations. The analysis of the PTPs claims that the HHC structures applying the TAP model should offer a selection of at most five PTPs to each patient for the sake of effectiveness and efficiency. Following this suggestion, optimal solutions for all instances can be provided within 0.4 s. The weight allocations depend on the various requirements for COC and PP. The analysis of results suggests that the HHC structures can adopt PP in the TAP model without hesitation. However, it also advises that they should pay attention on the adoption of COC, because it has a visible effect on the assignment rate of demand with the lower COC levels and the utilization rate of therapists, while slightly affecting the computational time of the TAP model and the total number of assigned demands. The work offers the HHC structures a demonstration of the core part of an effective planning system to help them make better decisions that satisfy patient demand, achieve high quality of service, and enhance efficiency.

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1. Introduction

1.1. Background

Home health care (HHC) implies a wide range of care services, including nursing care; physical, occupational, and speech-language therapy; and medical, paramedical, and social services, which can be given to patients at home rather than in hospitals or nursing homes (Medicare.gov, 2016). These services help patients to improve their health condition and their living independence, assist patients in staying at home, and promote the optimal level of well-being of patients to avoid hospitalization or admission to long-term care institutions (Ellenbecker, Samia, Cushman, & Alster, 2008). HHC is economically attractive to an impoverished government because costs are lower than for nursing homes and residential care (Kok, Berden, & Sadiraj, 2015). For instance, the Department on Ageing of Illinois spends approximately US$650 monthly only for HHC, an amount is significantly lower than the US$3510 spent for people in nursing homes (Kielstra, 2009). HHC is a growing sector within the healthcare domain, influencing the global economy. In the United States, approximately 3.5 million Medicare beneficiaries received HHC from 12,613 agencies and cost roughly US$17.9 billion in 2013(MedPAC, 2015). The Hong Kong Government, for example, has increased the annual Elderly Health Care Voucher amount to HK$2000 per elderly (aged 70 or above) to encourage older people to select private healthcare services (GovHK, 2015). Moreover, the demand for HHC is continuously increasing because of aging populations (Christensen, Doblhammer, Rau, & Vaupel, 2009; Lin, Chou, Liang, Peng, & Chen, 2010), dramatic changes in the needs of chronic diseases, development of innovative technologies for HHC (e.g. Ambient Assisted Living System (Botia, Villa, & Palma, 2012)), and a growing pressure on governments to contain healthcare costs (Stabile et al., 2013).

* Corresponding author.
E-mail addresses: meiyanlin2-c@my.cityu.edu.hk (M. Lin), mekschin@cityu.edu.hk (K.S. Chin), wangxj@whu.edu.cn (X. Wang), kltsui@cityu.edu.hk (K.L. Tsui).

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Abbreviations

PTP	Preferred Time Periods
COC	Continuity of Care
EVAP	Evacuation Vehicle Assignment Problem
GAP	Generalized Assignment Problem
HHC	Home Health Care
OT	Occupational Therapist
PP	Patient Priority
PT	Physical Therapist
TAP	Therapist Assignment Problem
FCOC	Full Continuity of Care
PCOC	Partial Continuity of Care
NCOC	No Continuity of Care
ADL	Activities of Daily Living
WA_I	The weight allocation criteria relate to the case where the HHC structures consider neither COC nor PP.
WA_II	The weight allocation criteria refer to the case where the HHC structures only consider PP.
WA_III	The weight allocation criteria claim the case where the HHC structures only consider COC.
WA_IV	The weight allocation criteria state the case where the HHC structures consider PP is more important than COC.
WA_V	The weight allocation criteria state the case where the HHC structures consider COC is more important than PP.

These trends force the HHC structures to explore means eagerly to reduce cost, improve service quality, and enhance productivity.

A primary means of achieving these objectives is the optimal usage of available human resources. The main issues of HHC human resource planning are the human resource dimensioning (Benzarti, Sahin, & Dallery, 2013; Busby & Carter, 2006), the assignment of patients to operators (Carello & Lanzarone, 2014; Hertz & Lahrichi, 2009; Lanzarone, Matta, & Sahin, 2012; Yalcindag, Matta, & Sahin, 2012), and the scheduling and routing for each operator (Akjiratikarl, Yenradee, & Drake, 2007; Cappanera & Scutellà, 2013; Elbenani, Ferland, & Gascon, 2008; Kergosien, Lenté, & Billaut, 2009; Mankowska, Meisel, & Bierwirth, 2014; Nickel, Schröder, & Steeg, 2009; Rasmussen, Justesen, Dohn, & Larsen, 2012; Shao, Bard, & Jarrah, 2012; Trautsamwieser & Hirsch, 2011). Effective staff planning has become the essential means to avoid process inefficiencies, treatment delays, and quality deterioration to maintain profitability, as the HHC structures (i.e., service providers) typically have a large number of patients and have to deliver services to many different locations. In practice, the delivery of service and the feasibility of plans are usually affected by random events, such as variation in patient health conditions (Lanzarone, Matta, & Scaccabarozzi, 2010), unavailability of resources, and long durations of transportation between patients' homes (Lanzarone & Matta, 2014). Moreover, the existence of certain constraints, such as continuity of care (COC) (Gulliford, Naithani, & Morgan, 2006) and burnout level of operators (Gandi, Wai, Karick, & Dagona, 2011), distinguishes HHC resource planning from the planning problems encountered in production and services systems. Despite the complexity required for planning in most HHC structures, effective staff planning is not supported by proper skills, methodologies, and tools needed for managing the logistics and organizational activities of care delivery. Therefore, the implementation of adequate, effective planning models and tools for the HHC structures is necessary to improve the robustness of plans with limited input from the support staff. The human resource assignment problem has attracted increasing attention from researchers and providers because it is of very importance to ensure efficiency and effectiveness, so that planning results can serve as a proper and solid base for the next step, which is obtaining optimal schedules and routes. This study analyzes and discusses the therapist assignment problem considering the different COC and patient priority (PP) levels, the total assigned demand, and the workload utilization of therapists.

1.2. Therapist assignment problem (TAP)

This study addresses a particular segment of the HHC industry that provides physical, occupational, and other therapies for patients. The patient is provided with the suitable therapy services by capable therapists according to the estimation of his/her health condition. Usually, districts are considered independent of one another when assignments are planned; thus, a therapist is assigned to a patient based on the compatibility of his/her skills to the patient's pathology as well as his/her geographical area (Lanzarone & Matta, 2014). A key issue in the assignment problem is the need to retain the COC for patients. A number of the HHC structures are eager to retain the COC to ensure that patients are satisfied with their services. However, other HHC structures do not adopt this concept, which means each visit is provided by any appropriate therapist who has sufficient available capacity in the required time period. Operators assignment under the different COC requirements consists of assigning each newly admitted patient to his/her preferred therapist from the capable ones based on the COC levels he/she requires (Carello & Lanzarone, 2014).

In this work, the therapist assignment problem (TAP) is described from two perspectives, that is, patient and therapist or demand and supply. A patient demand is categorized on the basis of the different PP and COC levels, which are related to pathologies and that patient's eagerness to the COC. A therapist supply is classified according to the main therapy skills of the therapist. Under the assumption that each therapist works as a full-time employee and refuses to work overtime, the total supply of therapists is set unless the HHC structure recruits new therapists. The limited supply of therapists along with the increasing rehabilitation service demand has overexerted the service provider's ability to provide timely and high-quality treatment. Therefore, decisions should be made to enhance the utilization of therapists and improve patient satisfaction. Currently, those in the rehabilitation industry plan the assignments manually with one or two days to resolve the details.

One goal of the TAP, from the perspective of supply, is to maximize the workload utilization rate of therapists under overtime bans. The concept of the utilization rate of each operator in each period was formulated and calculated by researchers in recent years (Lanzarone et al., 2012; Yalcindag et al., 2012). This maximization under overtime bans is important mainly to protect therapists from burnout, which is related to the care volume exceeding the contract capacity of each operator. As a prolonged response to chronic job-related stressors, burnout is a syndrome that can affect a broad range of professions (Gandi et al., 2011); it causes decreased job performance and reduced job commitment, resulting in stress-related health problems and low career satisfaction of workers. At the same time, such objectives guarantee that providers can satisfy as many patients as possible and deliver high-quality service to each patient while following laws and regulations. Another goal of the TAP, from the perspective of demand, is to maximize the satisfaction rate of patients (Borsani, Matta, Beschi, & Sommaruga, 2006) by meeting patient requirements that involve the different COC and PP levels. A demand category with the higher COC or/and PP level/s is associated with a higher weight to be satisfied first in the TAP model. The flexibility of weight allocations can help the HHC structures to have enhanced knowledge on which strategy can fit their current situation.

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