Chapter 13
The Optimal Workforce Staffing Solutions With Random Patient Demand in Healthcare Settings

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ABSTRACT

Staffing planning is paramount for cost-efficient workforce management. An accurate assessment of the required staffing level for the specific time period is an integral part of the hospital budgeting and planning process. Daily fluctuations of patient census create staffing planning challenges to many organizations. There is a growing trend for hospitals to use data analytics for determining the optimal staffing solutions. The dynamic nature of the staffing process creates two types of issues: (1) overstaffing vs. the planned budgeted level, which hurts operations margins, or (2) understaffing, which requires costly overtime and/or premium pay that also hurts margins and causes substandard quality of care. The goal of this chapter is providing an overview and examples of application of the methodology called the "newsvendor" framework. This methodology helps to develop the optimal nursing and other skill mix staffing solutions that minimize the total cost of over- and understaffing occurrences within the specified time period for the units with random patient census fluctuations.

INTRODUCTION

The current demand for more efficient use of healthcare resources, cost reduction, and patient safety improvement stimulates developing the novel operations management solutions. Workforce management has emerged as the one with the biggest impact on cost efficiency and quality of care in the USA. Indeed, labor cost typically absorbs about 54% of total hospital's operating revenue (Herman, 2013). Therefore, an accurate assessment of the required staffing that matches the highly variable patient demand is an integral part of the hospital's budgeting and planning process. Healthcare administrators must accomplish multiple clinical and quality goals while simultaneously developing realistic staffing plans and budgets.

Random fluctuations of patient demand present staffing planning challenges to many hospitals. There is a growing trend for using data analytics to address these challenges.

The objective of this chapter is providing an overview and examples of application of the data analytics methodology called the "newsvendor" framework. This methodology helps to determine the optimal staffing solutions for the specified time periods for hospital units with randomly fluctuating daily patient census.

BACKGROUND

The newsvendor model is the widely used analytic model in which the optimal inventory level is determined for a specified time period. Historically, it originates from the problem in which a newsvendor has to decide on the optimal stocking quantity of the newspaper (a single product) to be ordered from the publisher in some defined ahead time period; hence it is called the newsvendor problem. If too many issues are ordered there will be some financial loss due to unsold inventory. If not enough issues are ordered there will also be some financial loss due to unmet customer demand. The problem is determining the optimal quantity order that will minimize the total financial loss due to both over- and understock during some time period.

The newsvendor framework has been widely applied to problems in which decisions should be made on the fixed supply level with an uncertain (random) demand. Such problems are often occurring in supply chain management, retail, transportation, manufacturing, banking, and many other industries (Choi, 2012; Arikan, 2011; Porteus, 2002). Motivated by the importance of various practical applications of the newsvendor model, the entire special issue of the Decision Sciences journal (Chen et al., 2016), and the review paper (Qin et al., 2011) were dedicated to its novel advances and applications.

At the same time, the use of the newsvendor framework was rather limited in healthcare management for planning and budgeting the hospital units' staffing while patient demand is uncertain.

For example, in the handbook of newsvendor problems, which is the first handbook dedicated exclusively to the state of the art in this area (Choi, 2012), the optimal nursing staffing problem with uncertain patient demand was not presented at all. However, this is a fruitful area of application of the newsvendor framework. The long-term nursing staffing plans should be developed on the annual basis. The medium-term staffing plans should usually be developed for a 4-6 weeks period, and be posted 1-2 weeks before the start of the planned period. Because of inevitable occurrences of unforeseen deviations from the planned staffing level, some short-term staffing adjustments should be made shortly before each shift to determine whether overtime, pooled or agency nurses are needed, or if the unit is overstaffed and some nurses are not currently needed. There is a cost associated with flexing staff up or down, along with issues of staff dissatisfaction with the erratic unpredictable schedules. There is an empirical evidence that the frequent staffing adjustments costs are accumulated to significant amounts that were not previously budgeted for. The optimal staffing level determined by the newsvendor model minimizes these accumulated costs, thus making nursing staffing plans and budgets more realistic.

One of a few publications that mention the use of the newsvendor framework for determining the optimal nursing staffing level is Hopp and Lovejoy (2013). These authors included the newsvendor framework as one of the management principles: in a single time period (month, quarter, or year) with uncertain staffing demand, the staffing level which corresponds to the minimal (optimal) possible total cost of under- and overstaffing is given by the solution, *S*, of equation

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