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Nurse–patient assignment models considering patient acuity metrics and nurses' perceived workload

Mustafa Y. Sir [a], Bayram Dundar [b], Linsey M. Barker Steege [c], Kalyan S. Pasupathy [a,*]

[a] Health Systems Engineering, Robert D. and Patricia E. Kern Center for the Science of Health Care Delivery Mayo Clinic, Rochester, MN, United States
[b] Industrial and Manufacturing Systems Engineering University of Missouri, Columbia, MO, United States
[c] School of Nursing University of Wisconsin – Madison, Madison, WI, United States

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ABSTRACT

Patient classification systems (PCSs) are commonly used in nursing units to assess how many nursing care hours are needed to care for patients. These systems then provide staffing and nurse–patient assignment recommendations for a given patient census based on these acuity scores. Our hypothesis is that such systems do not accurately capture workload and we conduct an experiment to test this hypothesis. Specifically, we conducted a survey study to capture nurses' perception of workload in an inpatient unit. Forty five nurses from oncology and surgery units completed the survey and rated the impact of patient acuity indicators on their perceived workload using a six-point Likert scale. These ratings were used to calculate a workload score for an individual nurse given a set of patient acuity indicators. The approach offers optimization models (prescriptive analytics), which use patient acuity indicators from a commercial PCS as well as a survey-based nurse workload score. The models assign patients to nurses in a balanced manner by distributing acuity scores from the PCS and survey-based perceived workload. Numerical results suggest that the proposed nurse–patient assignment models achieve a balanced assignment and lower overall survey-based perceived workload compared to the assignment based solely on acuity scores from the PCS. This results in an improvement of perceived workload that is upwards of five percent.

1. Introduction and background

The rising costs of healthcare and prevalence of medical errors compel the healthcare industry to more closely scrutinize the cost structure of its operations. To that end, human factors engineering and operations research methods have been widely applied to healthcare to address safety and cost/efficiency problems [1,2]. Approximately 40% of healthcare personnel cost belongs to nursing [3]. Further, according to the Bureau of Health professions, the shortage of full-time equivalent registered nurses is expected to exceed 800,000 nurses by the year of 2020 [4]. Therefore, it is important to focus on the work environment of nurses to improve their job satisfaction and retention, and thereby decrease healthcare cost by increasing efficiency. As reported by Battisto et al. [5], the reasons why nurses leave their current jobs include safety concerns, performing complex job responsibilities such as medication administration, navigating documentation systems, working in an inefficient environment, and musculoskeletal injuries. In a survey conducted [6], 74% of nurses highlighted stress and overwork as a main concern while 62% emphasized musculoskeletal injuries. Ebright et al. [7] claim that 83% of nurses agree that improving nurses' environment and workload promotes nurse retention.

Though lacking a universally accepted definition, workload is generally considered to be a measure of the relationship of the amount of resources demanded by a task situation – the "demands" – to the amount of resources a person has available to complete the task – the "capacity" [8]. Workload can include mental components, which are largely related to a workers' attention capacity and information processing and time demands of a task. Or, workload can be defined primarily as a physical construct relating strength, endurance, and postural demands of a task to energy capacity and biomechanical features of the worker [8].

Current legislative mandates (e.g., California Bill AB 394), that define fixed nurse-patient assignment ratios, are criticized by practitioners and researchers because they fail to account for acuity levels of patients and result in unbalanced distribution of workload

* Corresponding author.
E-mail addresses: Sir.Mustafa@mayo.edu (M.Y. Sir), bd5zc@mail.missouri.edu (B. Dundar), LSteege@wisc.edu (L.M. Barker Steege), PasupathyK@mayo.edu (K.S. Pasupathy).

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among nurses [9]. Translation of our understanding of workload to improve the work environment is much desired. Incorporating information from such analyses into decision support tools and optimization models would result in improved work schedules and conditions and more balanced distribution of workload among nurses.

While assignment is among the classical optimization problems, nurse–patient assignment has not been extensively studied in the operations research literature. On the other hand, nurses scheduling or rostering problems [10–13] and nurse budgeting have been widely studied to reduce costs and improve working conditions and therefore satisfaction of nurses [14]. The ultimate aim of nurse scheduling problems is to assign nurses to certain shifts to decrease healthcare staffing cost, negative patient outcomes, and improve nurse satisfaction [15]. Other work has focused on identifying appropriate nurse–patients ratios with an aim to ameliorate nurses' work condition and improving quality of patient safety and care [16,17,9,18,19].

Staffing is an important tactical decision to ensure sufficient number of nurses are scheduled to care for patients. However, staffing models do not inform nurse manager how to distribute workload among nurses in an equitable manner on a given day. Patient census and associated workload change dynamically. Therefore, nurse–patient assignment models are needed as daily decision support tools. Several approaches have been used to evaluate and improve nurse patient assignments such as simulation [14]; simulation-based optimization [20]; heuristic policies [20]; mixed-integer programming models [21]; stochastic programming [22]; and integer linear programs [3].

Many of these previous studies and approaches aim to equitably distribute, or balance, workload as a function of patient characteristics or acuity measures while assigning patients to nurses. However, workload varies by individual based on a given nurse's capacity for dealing with a specific set of demands. Therefore, for a given patient characteristic or acuity level, the workload will vary depending on nurse characteristics. For example, a nurse may have more experience with surgery patients and be more comfortable handling such patients, whereas another nurse might prefer caring for patients with different indicators. Further, because patient acuity levels are based on a set of indicators representing different types of care demands, two patients having exactly the same classification by PCS, patient acuity classification might result in very different perceived workload for an individual nurse. Existing tools and approaches for supporting patient-assignment decisions fail to account for variations in nurse capacity and response to work demands and are therefore somewhat limited in their application to a specific set of staff. For instance, consider the beginning of a shift, where a charge nurse is responsible for assigning nurses to patients in the current census [23]. Consider the hypothetical assignment situation illustrated in Fig. 1. Both assignments are perfectly balanced in terms of distributing objective acuity scores from the PCS (i.e., each nurse is assigned the same amount of acuity). However, Assignment II significantly lowers the perceived workload for most nurses. In this section we develop optimization models that minimizes average perceived workload while simultaneously ensuring that assignment is balanced both in terms of objective acuity metrics as well as perceived workload. These models can be run at the beginning of a shift to aid a charge nurse to make initial assignments. The proposed methods can also be readily extended to update assignments periodically during a shift to account for dynamic changes in the patient census.

The overall aim of this work was to address this gap through the following objectives: (1) identify the associations between patient acuity indicators from a commercial patient classification system and individual nurses' perceived workload; (2) develop a function to characterize the associations between existing patient acuity measures and individual nurse perceptions; and (3) develop and evaluate a more comprehensive workload balancing nurse–patient assignment optimization model accounting for both objective (patient acuity metrics) and subjective (nurse perceptions of workload) factors. To achieve these objectives, a survey study was conducted with nurses from oncology and surgery nursing units at an

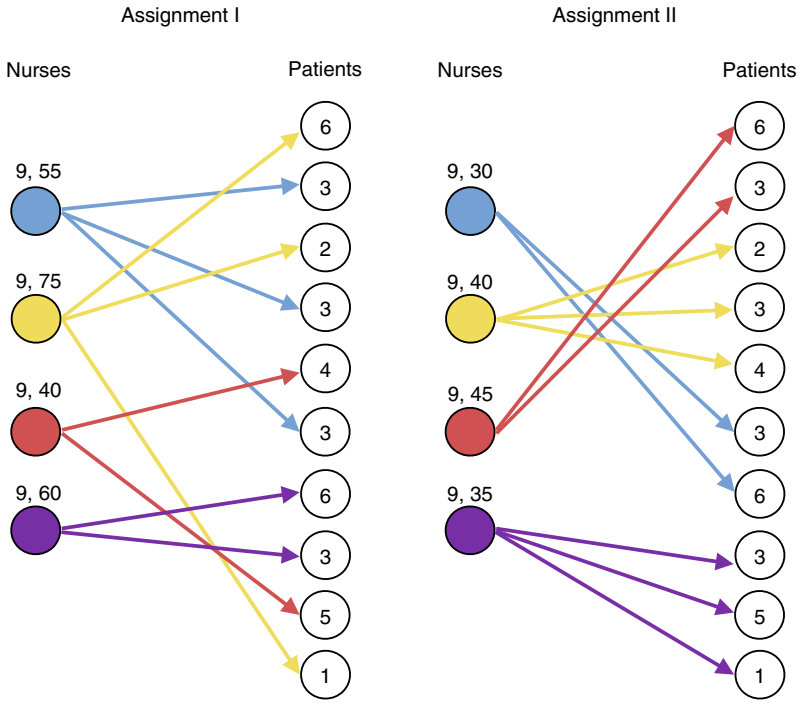

Fig. 1. Two hypothetical nurse–patient assignments for the same patient census. The number inside the circles representing patients are acuity scores. There are two numbers associated with each nurse; the first representing the total acuity score and the second representing the total perceived workload from all assigned patients.