Critical Review: Evaluating nurse staffing levels in perianesthesia care units using discrete event simulation

The paper reviewed here is titled "Evaluating nurse staffing levels in perianesthesia care units using discrete event simulation." It was written by Sauleh Siddiqui, Elizabeth Morse, and Scott Levin and published in the journal Institute of Industrial and Systems Engineers Transactions on Healthcare Systems Engineering in 2017. This paper was chosen because it was co-written by our mentor Dr. Siddiqui and relates closely to problems addressed by our project. For our project, we are creating a patient flow simulation and staff scheduling program for medical-surgical unit. The simulation will be used to develop an accurate patient census estimate. This will then be used to create a program that outputs a nurse schedule that ensures adequate staffing while minimizing costs. The paper gives background on the value of modeling patient flow and discusses some of the possible uses of such a simulation. It also explains methods used to create their simulation that will be a good reference for our work.

The objective of this study was to create a discrete event simulation to model patient flow through a perioperative unit with the goal of creating a new and more accurate way of estimating nurse staffing requirements. The authors cited many reasons why improved understanding of patient flow and corresponding nurse requirement is beneficial to hospitals. They began by describing sources of uncertainty involved in the movement of patients through a perianesthesia unit. These include the fluctuation patient conditions post-surgery that are difficult to predict and the variation in the number of surgeries performed day to day. It went on to state how these uncertainties are typically dealt. Hospital staff generally use historical data to predict the expected number of patients and combine this with nurse-to-patient ratios to determine a necessary staffing level. They also rely on the judgement and experience of a nurse manager who ultimately creates the schedule. The authors make the point that in the past, staffing methods have not taken into account some of the complexities of nurse and patient matching. These include the limit on the number of patient handoffs and the necessity for a time-varying model to accurately model patient flow. This study worked to address these shortcomings and create an improved method for estimating staff requirements.

The paper then proceeded to explain the methods used to implement an improved staffing level estimation. First, the data used in the simulation was described. This data was 4 months of patient information with 3926 preparation and post-anesthesia care unit (PREP/PACU) patient

encounters. Data was available for 4 PREP/PACU units of 1059 bed urban medical center, but the analyses focused on one representative floor that served 15 operating rooms. The authors stated that analyses held across all four floors examined. Hypothetical patients were then simulated using these data. The simulated patient values were chosen from the historical distributions obtained from the four months of information available. The patients in the simulation had parameters for surgery duration, preparation and recovery times, and patient demographics: age, gender, inpatient or outpatient status. These simulated patients were then moved through different areas of the simulation according to their pre-determined durations. The simulation was concerned with staffing in a shared PREP/PACU unit. For the hospital examined, patients could move to and from the PREP/PACU to interventional radiology or operating rooms. They could also leave the PREP/PACU to floor units or to be discharged. Some patients could also move from an operating room to an intensive care unit. Each of these areas was included in the simulation design.

Once the relevant hospital areas were laid out, the paper went on to describe the logic of the simulation. The simulation first created a set of simulated patients stored them in a queue. Each hour of simulation time, a set of patients was introduced into the PREP/PACU area. They were assigned to a nurse based on a series of rules. These rules took into account the acuity (the intensity of care required) of the patient, which was assigned randomly, the number of patients each existing nurse was caring for and the acuities of the already assigned patients. If no nurse met the criteria needed to have the new patient added to their care, a new nurse was created and assigned the patient in question. This way the model accounted for the lack of handoffs allowed on the unit. Instead of considering an ideal assignment for a given set of patients and nurses, it considered how assignments actually occur on a unit. The simulation kept track of both the number of patients on the floor and the number of nurses necessary to care for those patients for each hour of simulated time, which included 11,237 patient encounters.

In analyzing the simulation, the authors first confirmed that the simulation responded consistently over a series of iterations and that the simulation distributions of patient movement matched the historical data available. An F-test for 20 replications of the one-year simulation was performed to ensure consistency and a t-test was done to verify the matching of historical and simulated distributions. They then went on to compare the simulation method of assigning nurses to the nurse-to-patient ratio method. They showed that the nurse-to-patient ratio method

underestimated nursing need by over 20% by the end of the day. Here the simulated nurse need was taken to be the true requirement. This was explained by the limitation on handoffs of patients. The paper then used the simulation to test the effects of changing the patient's total length of stay. This altered the distributions that simulated patient parameters were obtained from and showed the effects on the number of nurses and number of beds needed on the unit. This showed a linear relationship between the length of stay and both the number of beds and number of nurses needed.

The authors then discussed some of the implications of their study and possible areas for further work. Further uses of the simulation proposed included testing alternate interventions and assigning costs to the effects to determine how much money could be saved by a given intervention. They reiterated the increased accuracy of a simulation method in determining nurse staffing need. They discussed the possibility of converting the staffing level output into a schedule that provides an adequate number of nurses while minimizing cost. They stated the need for further investigation into which percentile of staffing level is ideal for the creation of such a schedule. The study clearly showed the value of a patient flow simulation in informing both short-term staffing decisions like scheduling and long-term decisions like hiring. This combined with the fact that the simulation achieved the goal of creating a simple improved census and nurse staffing estimator were advantages of this work. Although their goal was achieved, there were some limitations of the work. For one, the simulated patient parameters were chosen from the distributions independently, so preparation, OR, and recovery times were not linked. This is not consistent with individual patients whose preparation and recovery times are related to the type of surgery and surgical duration. Additionally, the simulation used a random acuity assignment rather than basing it on patient attributes. It also had a limited amount of patient data so analyses involving changes in patient composition were not feasible.

These limitations will be considered and addressed as we develop a patient flow simulation for our project. The unit we are simulating is more general and has influx and efflux of patients to and from a wider range of areas so having the groundwork provided by this paper to build upon will be helpful. We will especially look into using the validation techniques used in the study to verify that our simulation accurately models attributes of the unit. When formulating our scheduling optimization problem, we will also consider the issue raised in this paper about the ideal staffing level. Overall, this paper described many methods for creating and analyzing a

patient flow simulation that will be useful for our project. It also brought up some important considerations that we will need to be take into account for the schedule optimization part of our project.

Works Cited

Sauleh Siddiqui, Elizabeth Morse & Scott Levin (2017): Evaluating nurse staffing levels in
    perianesthesia care units using discrete event simulation, IISE Transactions on Healthcare
    Systems Engineering, DOI: 10.1080/24725579.2017.1346729