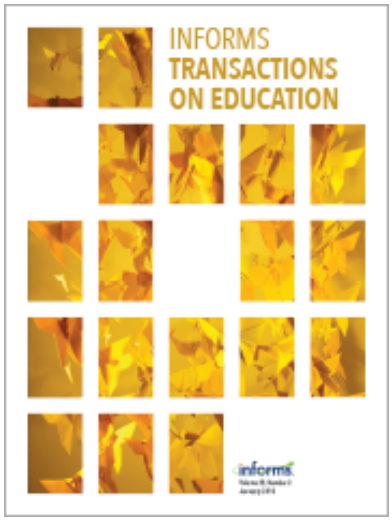

INFORMS Transactions on Education

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Case—Developing Data-Driven 24/7 Nurse Staffing and Shift Scheduling Plans

Akhil Singla, Jiaqi Lei, Sanjay Mehrotra

To cite this article:
Akhil Singla, Jiaqi Lei, Sanjay Mehrotra (2026) Case—Developing Data-Driven 24/7 Nurse Staffing and Shift Scheduling Plans. INFORMS Transactions on Education

Published online in Articles in Advance 29 Apr 2026

. https://doi.org/10.1287/ited.2025.0139cs

https://pubsonline.informs.org/journal/ited

INFORMS TRANSACTIONS ON EDUCATION
Articles in Advance, pp. 1–4
ISSN 1532-0545 (online)

Case

Developing Data-Driven 24/7 Nurse Staffing and Shift Scheduling Plans

Akhil Singla,[a] Jiaqi Lei,[a] Sanjay Mehrotra[a,*]

[a] Industrial Engineering and Management Sciences, Northwestern University, Evanston, Illinois 60208
*Corresponding author
Contact: akhilsingla@u.northwestern.edu, https://orcid.org/0009-0004-9210-8744 (AS); jiaqilei2026@u.northwestern.edu (JL); mehrotra@northwestern.edu, https://orcid.org/0000-0003-1106-1901 (SM)

Received: April 7, 2025
Revised: July 22, 2025; October 17, 2025
Accepted: November 27, 2025
Published Online in Articles in Advance: April 29, 2026

https://doi.org/10.1287/ited.2025.0139cs

Funding: This work was supported by the Division of Civil, Mechanical and Manufacturing Innovation [Grant CMMI-0928936].

1. Introduction

Dr. Gupta is the fictitious chair of operations for the Department of Hospital Medicine (HM) at a large hospital in Illinois with a 550-bed facility that treats an average of approximately 160 patients daily in its HM unit. The hospital is committed to providing high-quality, timely care to its patients, which is only possible if doctors are adequately supported by sufficient nursing staff. Dr. Gupta is concerned about the high costs associated with managing such a large nursing workforce, especially in light of reports from colleagues about nurse shortages due to occasional patient overload. Hospitals are continually challenged to align staffing levels with unpredictable patient volumes while keeping costs under control. This document outlines the background of workforce management in hospitals and explains the challenges involved in efficiently managing nurse staffing and scheduling plans.

2. Workforce in Healthcare

Healthcare is a labor-intensive industry, and service providers—such as doctors and nurses—are expensive. Dr. Gupta notes that a significant portion of patient care costs is attributable to wages; specifically, nearly 50% of overall hospital expenses are due to nurse wages. The goal of hospital workforce management is to ensure that staff are utilized efficiently to provide high-quality care. The first step involves identifying and eliminating unproductive activities to improve workflow. This can be achieved through careful process mapping of the tasks that staff perform during patient care. Examples of such activities include unnecessary walking, inefficient data entry for medical records, and communication delays in care coordination.

The use of technology can reduce many of these inefficiencies. For instance, computer interfaces can be redesigned to provide easier access to data, auto-fill features can streamline data entry, texting can serve as an alternative to paging, and barcode scanners can improve medication administration. These improvements not only reduce the time required to perform tasks but also minimize errors and enhance communication.

In addition to these information technology (IT)-oriented enhancements, system improvements can be achieved through effective supply-demand matching. Healthcare resource needs fluctuate over time. In the HM unit, patients arrive randomly, and their arrival rates vary throughout the day. If these fluctuations are significant, it would be impractical to staff the unit with the same number of nurses every hour. Moreover, because nurse shifts are typically short, complex staffing patterns arise. Dr. Gupta's objective is to employ an operations-thinking approach that enhances supply-demand matching.

3. Supply-Demand Matching of Workforce: A Challenge

3.1. Patient Demand Uncertainty

The number of patients requiring care at the HM unit fluctuates continuously, changing every day and even from hour to hour. On some days, the patient volume is manageable because there is sufficient staff to provide

timely treatment. On other days, the patient volume may greatly exceed what the staff can handle, putting the HM unit at greater risk of delivering suboptimal care and incurring medical errors that lead to adverse events. If the unit remains understaffed for a prolonged period, doctors and nurses become dissatisfied, further compromising treatment quality and resulting in higher staff turnover. Currently, Dr. Gupta notes that hospital administration relies on historical patient volume data to estimate a fixed daily demand for future staffing and shift scheduling decisions. Accurately forecasting patient volume dynamics provides valuable information for the unit to utilize its staff and resources effectively, enabling it to consistently deliver high-quality and cost-effective care even during periods of high or low patient volume.

3.2. Balancing Nurse Overstaffing and Understaffing

Ideally, Dr. Gupta would like to have exactly the right number of nurses to meet patient care needs. We want neither too few nurses nor an excess of nurses at any given time. Having extra nurses on the floor increases care costs, whereas having too few nurses jeopardizes patient safety (due to potential mistakes) and reduces job satisfaction, which can lead to burnout and high turnover. Patient safety issues are particularly critical in healthcare staffing because, in extreme—but not uncommon—cases, understaffing can lead to errors that cause fatalities (e.g., due to ignored vital signs, incorrect medication doses, or delayed treatment). However, even with highly accurate patient census forecasts, it is impossible to perfectly match the available number of nurses to the exact number needed for patient care. This is because patient census estimates fluctuate hourly, and nurses work in 8- or 12-hour shifts.

Dr. Gupta shares that hospitals typically ensure their staff members are not overworked. For example, a common patient-to-nurse ratio rule might specify that, on average, the number of patients per nurse must not exceed four. Thus, if a unit has 40 patients, it would require 10 nurses. Management also considers metrics such as hours spent per patient visit (HPPV) when evaluating the efficiency of care units. For instance, the nurse administrator of a specific unit might negotiate a target of HPPV = 3.0 for direct nursing care hours, indicating that, on average, about three nursing hours are dedicated to each patient visit. Duty rules may also specify that a nurse cannot work more than 16 consecutive hours—even if paid overtime—and that there must be at least a 12-hour gap between shifts.

The *nurse staffing and shift scheduling problem* involves assigning an adequate number of nurses to staff a unit while complying with these duty rules. Such a problem can be modeled using a mathematical optimization framework.

3.2.1. Operational Constraints.

Dr. Gupta emphasizes that an effective nurse staffing plan must account for several operational constraints that directly impact both patient care quality and cost efficiency. These constraints include the following:

- **Core Staffing Requirements:** The HM unit must always have a minimum number of nurses present to ensure safe and effective care. For example, the unit might require at least three nurses on duty at all times. This core team typically includes specialized roles such as a charge nurse—who is responsible for overall coordination and decision making on the floor—and triage nurses, who manage patient assessment if a dedicated triage area is available. Additionally, technical nurses, who have lower levels of training compared with registered nurses, provide essential support to the core team. These roles are crucial for maintaining smooth operations and rapid response in a high-pressure environment.
- **Staff Mix:** The nursing workforce is composed of several categories, each with unique responsibilities, cost implications, and scheduling constraints. Registered nurses, employed directly by the hospital, form the backbone of the team. Floating nurses provide flexibility by working across multiple units, while agency nurses—hired through external agencies—offer temporary support during peak periods with limited-duration shifts. Technical nurses, with less formal training, perform essential supportive functions. Strategically, employing agency nurses can help manage surges in patient volume without incurring the full cost of additional full-time hires. However, because of training and overhead costs, agency nurses are generally assumed to cost about 30% more than full-time registered nurses. For instance, if an eight-hour shift costs \$X, a four-hour shift might be priced at approximately \$0.65X.
- **General Efficiency Metrics:** Hospitals commonly use established staffing ratios and efficiency metrics to ensure both patient safety and operational effectiveness. One key metric is HPPV, which reflects the average number of nursing hours spent on direct patient care, documentation, and shift hand-offs. Staffing ratios can vary significantly by unit and hospital; for example, some hospitals maintain a 5:1 patient-to-nurse ratio in hospital medicine units, whereas emergency department units might operate with a 3:1 ratio. These benchmarks are crucial for evaluating performance against industry standards and ensuring that staffing levels are both safe and cost-effective.
- **Demand Coverage:** Ensuring that an adequate number of staff are available at all times is a central operational constraint. The hospital's objective is to cover patient care and emergent situations without incurring excessive staffing costs. This requires dynamic scheduling that can adjust to the fluctuating nature of patient arrivals, ensuring that there are

enough nurses on duty during high-demand periods while avoiding overstaffing during slower periods.

Beyond staffing ratios and cost considerations, hospitals monitor a range of performance indicators to assess overall care quality and operational efficiency. These include adverse events (such as patient shock, patients leaving without being seen in the HM, and 90-day readmission rates), as well as staff satisfaction and turnover rates. By keeping a close eye on these metrics, hospital management can identify areas needing improvement, adjust operational practices, and ultimately enhance both patient outcomes and employee well-being.

3.2.2. Nurse Work-Life Balance Constraints. In addition to meeting operational needs, nurse scheduling must prioritize work-life balance to promote long-term staff satisfaction and prevent burnout. Dr. Gupta emphasizes that a stable and predictable schedule is essential for maintaining a healthy work environment. To achieve this, several key constraints are implemented:

- **Shift Structures and Continuity of Care:** Shifts are scheduled with fixed start times (e.g., 7 a.m., 11 a.m., 7 p.m.) and predefined durations. Nurses typically work the same shift throughout the week, fostering routine, continuity of care, and improved team coordination.
- **Work-Hour Limits:** Strict limits on work hours are enforced to ensure that nurses are not overworked. Registered nurses generally work between 36 and 40 hours per week. In addition, a nurse cannot work two successive shifts in a single day. These limits help maintain staff well-being and prevent excessive fatigue, which is critical for both patient safety and nurse retention.
- **Maintaining Full-Time Nurse Status:** To ensure that registered nurses contribute sufficiently and receive a full wage, a minimum shift duration requirement is enforced. Registered nurses must work a full-time shift that lasts at least eight hours or more (excluding breaks). To qualify as full-time, a nurse must work more than 32 hours per week and at least 72 hours over a two-week period; however, a nurse cannot work more than 80 hours over any two-week period. These requirements not only justify full wage compensation but also promote consistency in scheduling and align with nurse preferences.
- **Lunch Breaks:** The scheduling system distinguishes between full-time and part-time shifts. For example, registered nurses working an eight-hour shift are scheduled for a one-hour lunch break after the first four hours. Although this results in a total on-duty time of nine hours, only eight hours are considered productive work. In contrast, agency nurses typically work flexible, cost-effective four-hour shifts designed specifically to address peak demand periods.
- **Weekend Rotations:** Weekend rotations are balanced carefully to distribute the workload evenly among staff. This approach minimizes disruptions, reduces stress, and ensures that no individual is disproportionately burdened with less desirable shifts.

By integrating these work-life balance constraints, the nurse scheduling framework not only meets patient care requirements but also supports the overall well-being of the nursing staff, leading to improved job satisfaction and better patient outcomes.

4. Staffing and Shift Schedule Planning Considerations

Dr. Gupta seeks assistance in developing efficient staffing and shift scheduling plans that address both hospital operational requirements and nurse satisfaction while ensuring timely and effective patient care. Although the ideal is to meet every constraint perfectly, the hospital is prepared to allow certain relaxations to achieve a practical and cost-effective solution.

4.1. 24/7 Staffing and Shift Scheduling Plan

Dr. Gupta requires a comprehensive staffing and shift scheduling plan that provides continuous coverage 24 hours a day, 7 days a week. This plan involves two primary components: forecasting hourly patient demand and designing nurse shift schedules that incorporate a mix of agency and registered nurses. The forecasting models will generate essential patient volume estimates, which form the basis for the staffing and scheduling plans. The plans must account for the complexities of different shift types and durations, ensuring that staffing levels align with fluctuating hourly demand while minimizing overall costs.

4.2. Allowing Demand Violation While Incorporating Quality of Service

Dr. Gupta recognizes that no prediction model is perfect, and that forecasting errors—whether due to overestimation or overly conservative estimates—can significantly impact staffing and shift scheduling plans. This uncertainty creates a crucial tradeoff: Overstaffing leads to unnecessary costs, whereas understaffing can compromise patient care quality and reduce nurse satisfaction. To address this issue, Dr. Gupta emphasizes the need for flexible staffing plans that allow controlled demand violations. By incorporating mechanisms to tolerate slight deviations from forecasted demand, the hospital needs to balance the costs associated with overstaffing against the risks of understaffing, ultimately ensuring high-quality patient care and enhanced nurse satisfaction.

4.3. Allowing Service Delays

Dr. Gupta has observed that due to the uncertainty in patient volume, it is often difficult to modify shift

assignments immediately during an ongoing shift. This challenge can result in delays in patient service, meaning that some patients may have to wait for support from a nurse. One strategy to mitigate this issue is to allow a controlled delay in fulfilling patient demand. For instance, the staffing and scheduling plan can be designed so that the demand generated during any given hour may be met with a delay of up to one hour, while still ensuring that all demand arising over the course of the day is fully addressed by day's end.

Triaging plays a crucial role in this context. By prioritizing patients based on the urgency of their conditions, triaging enables the system to manage service delays more effectively—ensuring that critical cases receive prompt attention while allowing less urgent cases to experience a brief delay. Integrating this feature into the staffing and shift scheduling plan not only accommodates the inherent uncertainties in patient arrivals but also enhances overall operational flexibility and nurse satisfaction.

5. Next Steps

Dr. Gupta seeks a comprehensive, detailed report that outlines a robust nurse staffing and shift scheduling framework specifically tailored to the unique needs of the hospital. This report should provide actionable recommendations for dynamically adjusting nurse staffing levels to ensure continuous 24/7 coverage while minimizing overall costs and maintaining the highest standards of patient care and nurse satisfaction. Building on insights from patient demand forecasting, operational constraints, work-life balance considerations, and controlled allowances for demand violations and service delays, the report will equip hospital leadership with a strategic, data-driven approach to navigate workforce planning challenges under uncertainty.