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ORIGINAL ARTICLE

The implementation of an evidence-based staffing platform to optimize nurse staffing and patient care in Saudi Arabia

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ABSTRACT

Background: Optimal nurse staffing is essential for delivering high-quality, patient-centered care. Traditional staffing approaches often fail to reflect real-time patient acuity, potentially leading to suboptimal outcomes and increased operational costs. Evidence-based strategies are therefore needed to align staffing with patient needs and ensure efficiency.

Objectives: To optimize nurse staffing using an evidence-based acuity platform, with the aim of improving patient outcomes and reducing staffing-related costs.

Methods: This quality improvement study was conducted at Care Medical Al-Rawabi, Saudi Arabia, from January to June 2024. A Lean Six Sigma framework guided the intervention across five phases: Define: Inefficiencies in existing staffing practices were identified. Measure: Data on patient acuity, staffing levels, and overtime hours were collected. Analyze: Pareto charts were used to determine root causes of staffing inefficiencies. Improve: A standardized acuity-based tool was introduced to match staffing with patient complexity. Control: Ongoing monitoring ensured sustained performance and process refinement.

Results: Following the implementation of the evidence-based staffing platform, the hospital achieved a zero peripheral IV site infiltration rate for five consecutive quarters. The incidence of patient falls and hospital-acquired infections declined to levels below international benchmarks, indicating enhanced patient safety. Additionally, there was a significant reduction in overtime costs, resulting in savings of 1,211,755 Saudi Riyals. The platform also contributed to improved patient assignment scores and increased registered nurse (RN) job satisfaction. Notably, the proportion of nursing care hours delivered by RNs reached 98.97%, exceeding the international benchmark of 74.81%.

Conclusion: The evidence-based staffing platform led to measurable improvements in patient safety, nurse workforce utilization, and cost efficiency. Its implementation supports the strategic alignment of staffing practices with patient needs in high-acuity healthcare settings.

Keywords: Evidence-based staffing platform, nurse staffing, patient care, in Saudi Arabia.

Introduction

The nursing profession is a vital component of the healthcare delivered in hospitals. They represent almost half of the healthcare workers [1]. Thus, ensuring optimal nurse staffing is a crucial factor in delivering optimal care. It has been shown that suboptimal nurse staffing could result in missed care [2]. Moreover, it is

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associated with an increase in patients' falls, infections, length of hospital stay, and mortality rates [3,4]. For instance, Lasater et al. [5] found that each additional case assigned to the nurse above the optimal patient-to-nurse ratio was associated with 12% higher mortality rates. Furthermore, additional workload and work-related stress on nurses could lead to job dissatisfaction, burnout, and absenteeism, leading to a vicious circle of nurse shortage and increased workload [6,7].

Achieving optimal nurse staffing is challenging. This is attributed to many factors, including the nurse shortage, patients' complexity, and rising healthcare costs. For instance, patients might have multiple co-morbidities, making it difficult to assign the appropriate number of nurses [8,9]. Additionally, in Saudi Arabia, the rate of nurse turnover in Saudi Arabia has reached 20% [10]. Thus, leading to a higher cost arising from nurse training and orientation or temporary nurse assignment [8]. Moreover, in addition to the higher cost, assigning a higher percentage of non-registered nurses (RNs) is usually associated with higher rates of infection [11].

Traditional staffing usually relies on measuring nurses' workload according to the number of patients, the working hours per patient, and the minimum nurse-to-patient ratio. However, the accurate determination of workload is difficult as it relies on many factors, including patient acuity, nurse skill, and available resources. Thus, the optimal nurse-to-patient ratio might vary between units [8]. Furthermore, although the use of acuity tools has been shown to improve the delivered care and nurse staffing, many of the tools used are not validated to be used for nurse staffing [12,13]. Moreover, some tools determine patient acuity but fail to incorporate the other factors related to the workload. Thus, there is a need for an evidence-based method for appropriate nurse staffing [8].

We aimed to optimize nursing staffing through an E-enabled Evidence-Based Staffing platform, enhancing efficiency, improving patient outcomes, and reducing costs. This platform will leverage advanced data analytics, evidence-based practices, and a standardized, evidence-based acuity tool to provide real-time insights and recommendations for optimizing staffing levels based on safe staffing guidelines from the Saudi Patient Safety Center, reducing costs, and ensuring optimal patient care.

Methods

Study design and setting

This is a quasi-experimental study with data collection in the pre- and post-intervention periods. The study was conducted at Saudi Arabia from January 2024 to June 2024. The implementation of the staffing platform took place in May 2024. The platform was applied to schedule the nurses working in the hospital wards, including the ICU, CCU, general ward, maternity, and pediatric wards. The project was conducted as a quality improvement initiative within the healthcare organization. The institutional approval was obtained per local policy requirements.

Intervention

We implemented a staffing optimization platform using the Lean Six Sigma methodology: Define, Measure, Analyze, Improve, and Control (DMAIC) framework. This involved:

The define phase

Identifying the problem of inefficient staffing practices used for nurse staffing and the need for an evidence-based approach.

The measurement phase

Collecting data on staffing levels, patient acuity, overtime hours, and agency staffing costs.

The analysis phase

Using Pareto charts to identify root causes of inefficiencies such as an ineffective patient acuity scoring system, inefficient scheduling, staff shortages, absenteeism and sick leave, new staff orientation, staff turnover, weekend and holiday shifts, and inefficient communication.

The improvement phase

A standardized, evidence-based acuity tool was designed to accurately assess patient complexity (Supplementary file). An E-enabled platform was implemented to provide real-time insights and recommendations for optimal staffing, aligned with the Saudi Patient Safety Center's safe staffing-to-patient ratio guidelines. This integrated approach aims to improve staffing efficiency, reduce costs, and enhance patient care.

The control phase

Monitoring performance and making adjustments to maintain optimal staffing levels and patient outcomes. This is done by comparing the platform's performance against industry benchmarks; providing comprehensive training programs to equip staff with the skills and knowledge necessary to effectively utilize the platform; conducting periodic audits to assess data quality and identify areas for improvement; conducting regular meetings, surveys, and focus groups to gather feedback and address concerns; and involving stakeholders in decision-making processes to ensure the platform aligns with their needs and priorities.

Data collection and statistical analysis

We collected qualitative and quantitative data. The qualitative data involved feedback from stakeholders. The measured outcomes included the percent of nursing hours, the recruited nurse hours per patient, job satisfaction, appropriate patient assignment, and the incidence of adverse events [patient falls, peripheral IV site infiltration, catheter-associated urinary tract infections (CAUTI), and ventilator-associated pneumonia

(VAP)]. The saved cost was directly calculated from the number of reduced overtime hours. We collected data from the National Database of Nursing Quality Indicators (NDNQI) from 2020 to 2024 to compare the results with those of other hospitals. The NDNQI provides quarterly performance reports with national comparison data on various nursing quality indicators, including nurse staffing, patient falls, and RN job satisfaction [14]. We used the benchmarking charts generated by the NDNQI to compare the quarterly performance of our hospital to other hospitals registered in the NDNQI. These reports employed time-series charts with comparative distribution bands to visualize the metric. The quantitative data were summarized and compared using descriptive statistics, including the frequency, percentage, mean, standard deviation, and percentiles. Using Excel, a Pareto chart was conducted for the root-cause analysis. The bars represented individual causes, while the red line denoted cumulative contribution to total overtime.

Results

Causes of inefficiencies

As a part of the DMAIC approach, we analyzed the causes of overtime. As shown in Figure 1, the main causes of overtime included inefficient scheduling and acuity scoring, along with staff shortage and turnover. These represented 80% of the causes of overtime load. Meanwhile, new staff orientation, sick leave and absenteeism, weekend and holiday shifts, and inefficient communication represented 20% of the causes of overtime.

Staffing and patient assignment

The data from 2022 Q3 to 2024 Q2 showed that our hospital was superior to the facilities in the percentage of total nursing hours supplied by RN. The hospital maintained an average of 97.7 RN hours, exceeding the facilities (74.22) and surpassing the 90th percentile benchmark (85.71). Overall, the average percentage of total nursing hours supplied by RN in our hospital ranged from 96.34 in 2023 Q2 to 98.97 in 2024 Q2, while it ranged from 73.81 in 2024 Q2 to 74.72 in 2023 Q1. In 2024 Q2, RN coverage in our hospital reached 98.97% of the total nursing hours, exceeding the mean (73.81%) and the 90th percentile of (85.32%) (Figure 2).

The data from 2022 Q3 to 2024 Q2 showed that our hospital was superior to the facilities in the total number of RN hours per patient day. The hospital had an average of 8.54 hours compared to 8.21 hours in hospitals. Overall, the average number of RN hours per patient day in our hospital ranged from 7.37 in 2022 Q4 to 9.35 in 2023 Q2, while it ranged from 8.08 in 2022 Q4 to 8.35 in 2023 Q2 in the peer group. In 2024 Q2, the average number of hours in our hospital reached 8.91, which is higher than other (Figure 3).

The data showed that our hospital was superior to the other facilities in appropriate patient assignment. The hospital had an average of 4.98 points in 2023 and 5.30 points in 2024, facilities had a mean score of 4.86 in 2023 and 4.94 in 2024. Overall, the appropriate patient assignment score in facilities ranged from 4.58 in 2021 to 4.94 in 2024. Our hospital had improved patient assignment scores from 4.98 in 2023 to 5.30 in 2024 (Figure 4).

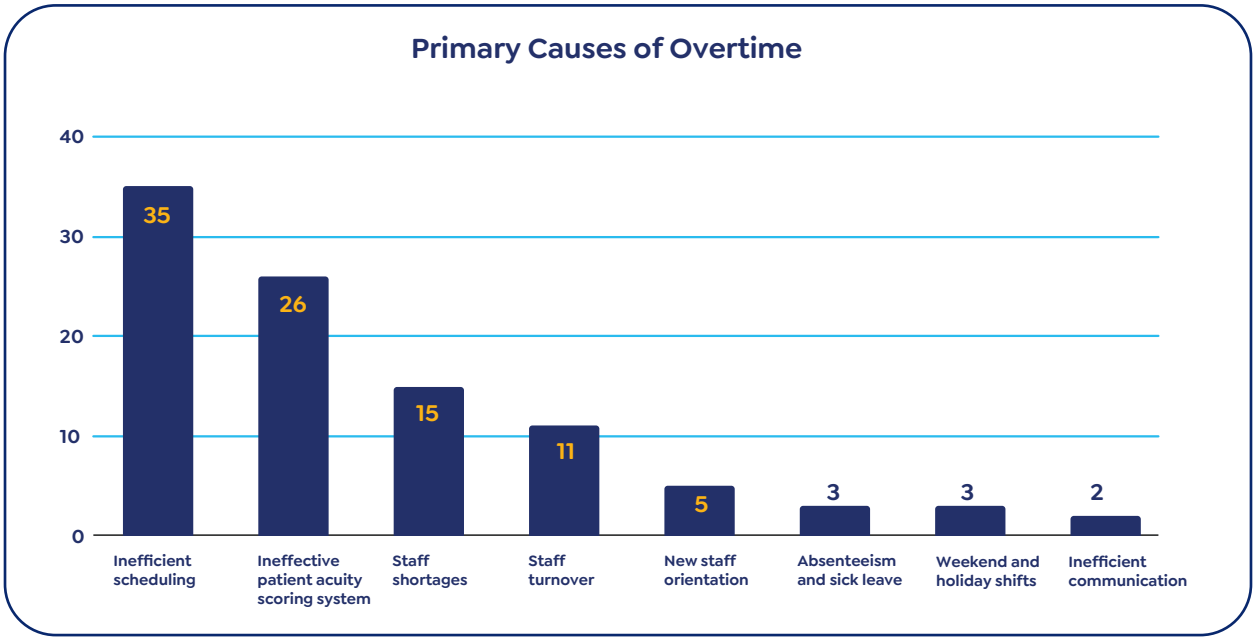

Figure 1. Pareto analysis of overtime causes.

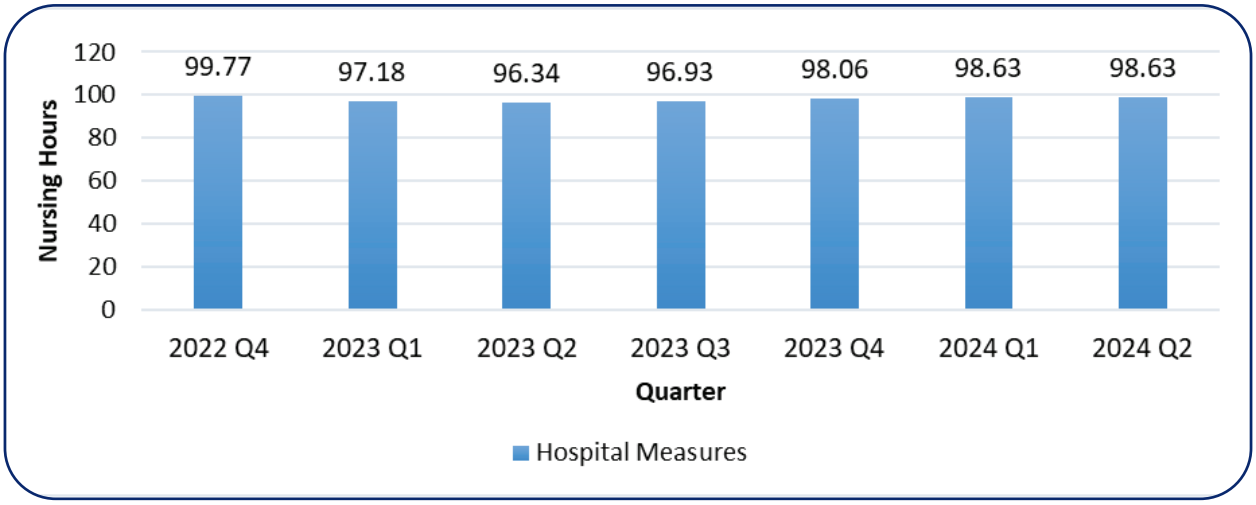

Figure 2. Percent of Total Nursing Hours Supplied by RNS compared to International Benchmark. Percent of Total Nursing Hours Supplied by RNS compared to International Benchmark.

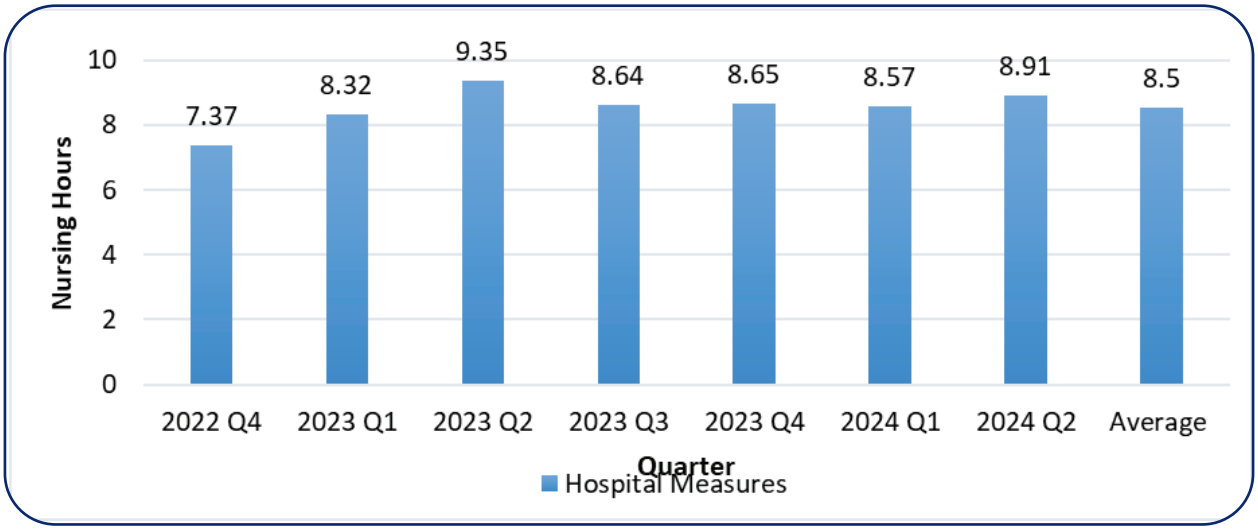

Figure 3. Total RN hours per patient day compared to International Benchmark.

Job satisfaction

The data showed that our hospital was superior to the facilities in job satisfaction. The hospital had an average score of 4.74 points in 2023 and 5.12 points in 2024, while the other facilities had a mean score of 4.42 in 2023 and 4.58 in 2024. Overall, the job satisfaction scores in ranged from 4.09 in 2021 to 4.58 in 2024. Our hospital's patient assignment scores improved from 4.74 in 2023 to 5.12 in 2024, and the performance in 2024 exceeded the 75th percentile benchmark score of 5 (Figure 5).

Adverse patient outcomes

Catheter-based urinary tract infection

The data from 2022 Q3 to 2024 Q2 showed that our hospital had a lower incidence of catheter-associated urinary tract infections per 1,000 catheter days (0.27) compared to the facilities (0.73). Overall, the incidence of CAUTI in our hospital ranged from 0 in 2023 Q4 to 0.49 in 2023 Q1, while it ranged from 0.60 in 2024 Q2 to 0.90 in 2023 Q1 in the other recognized hospitals. In 2024 Q2, the incidence of CAUTI was 0.17 in our hospital compared to a mean incidence of 0.60 in (Figure 6).

Ventilator-associated pneumonia

The data from 2022 Q3 to 2024 Q2 showed that our hospital had a lower incidence of ventilator-associated pneumonia per 1,000 ventilator days (0) compared to (0.39). The hospital achieved zero events from 2023 Q1 to 2024 Q2, which matches the 10th percentile of hospitals. Meanwhile, the incidence of VAP in non- ranged from 0.16 in 2023 Q4 to 0.76 in 2023 Q1. In 2024 Q2, the incidence of VAP in our hospital was zero, while

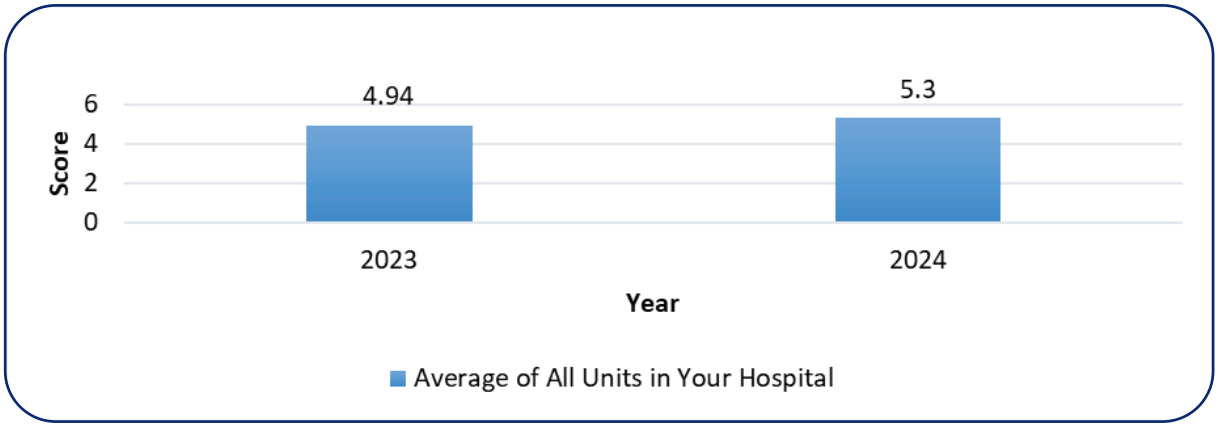

Figure 4. Patient Assignment was appropriate compared to International Benchmark.

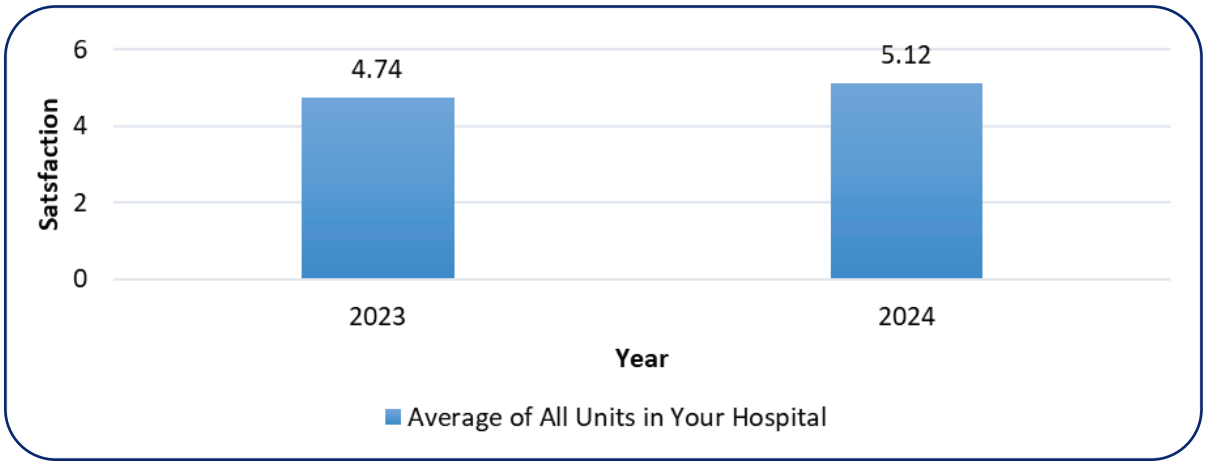

Figure 5. As RNs, we are fairly well satisfied with our jobs on our unit compared to international benchmark.

the mean incidence was 0.16 in the peer group (Figure 7).

Percent of peripheral site IV infiltration

The data from 2022 Q3 to 2024 Q2 showed that our hospital had a lower incidence of peripheral IV sites with infiltrations (0.30) compared to the facilities (0.60). The hospital achieved zero infections from 2023 Q2 to 2024 Q2. However, in 2023 Q1, the incidence of peripheral IV sites with infiltrations reached 1.82, which was high compared to recognized hospitals (0.15). In 2024 Q2, the peripheral site IV infiltrations in our hospital were zero, while the mean incidence was 1.25 in the peer group (Figure 8).

Patient falls

The data from 2022 Q3 to 2024 Q2 showed that our hospital had a lower incidence of patient falls (0.11) compared to the non-Magnet facilities (2.65). Overall, the incidence of falls in our hospital ranged from 0 in 2024 Q1 to 0.36 in 2023 Q2, while it ranged from 2.42 in 2024 Q2 to 2.8 in 2023 Q1 in the other recognized hospitals. In 2022 Q4, the incidence of patient falls in our hospital reached 0.05, which is lower than the 10th percentile of the other recognized hospitals (0.97) (Figure 9).

Cost

The data showed that the implementation of the innovative platform resulted in a significant reduction of overtime hours within the healthcare organization, from 87,073.50 to 68,403.00 at a 100% bed occupancy rate. This reduction has directly eliminated 1,555 man-days of overtime work, equivalent to 1,211,755 Saudi Riyals.

Discussion

Although several methods of nurse staffing have been employed, there is limited data on the outcomes of those methods on the cost and quality of delivered health care [15]. We investigated the outcomes of implementing an evidence-based platform to improve nurse staffing. Our study showed that the implementation of the platform led to improved appropriate patient assignment, patient satisfaction,

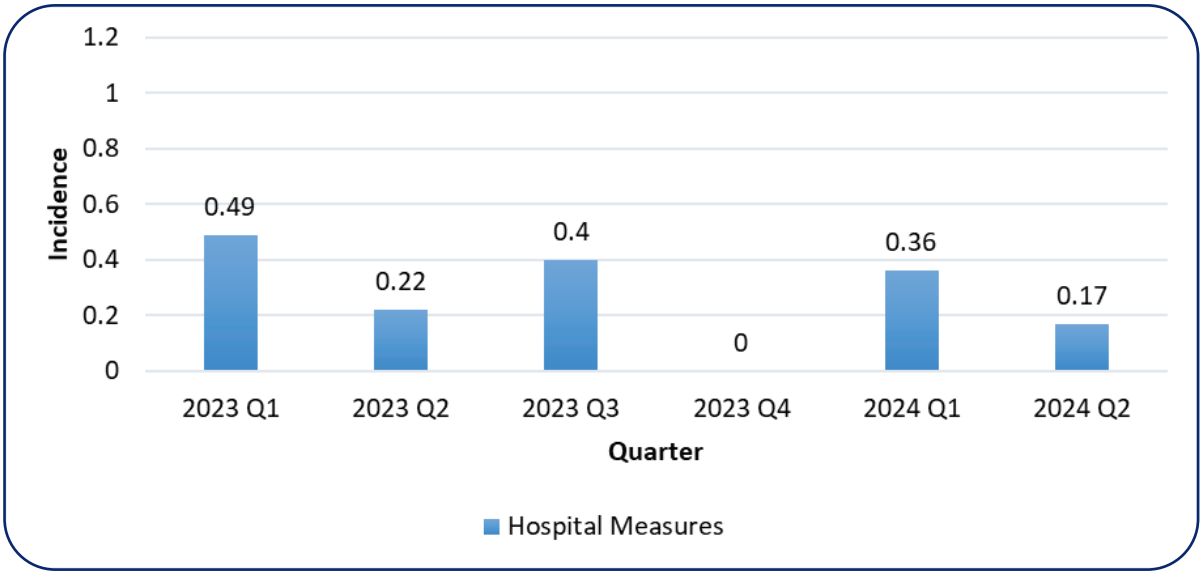

Figure 6. Incidence of CAUTI per 1,000 catheter days compared to International Benchmark.

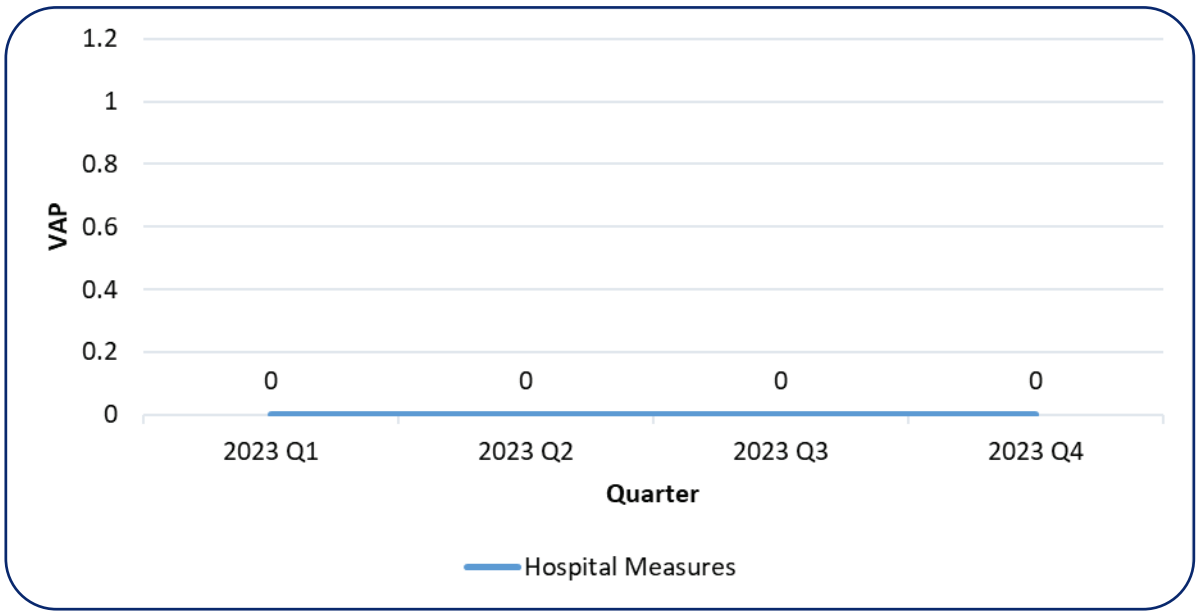

Figure 7. Ventilator Associated Pneumonias Per 1000 Ventelator Days compared to International Benchmark.

and reduced healthcare costs. It also led to a higher percentage of working hours being delivered by RNs and a lower incidence of patient falls, catheter-associated urinary tract infections

The traditional staffing methods either rely on subjective assessment or benchmarking comparison. Thus, relying only on volume-based approaches by assigning the nurses based on the number of patients without taking into account patient needs [15]. Incorporating acuity tools is essential to ensure appropriate and equal workload distribution [16,17]. On the other hand, it has been argued that using acuity tools could result in more overtime hours compared to other less complex staffing methods [15]. However, in our study, we found a significant reduction in overtime hours within the healthcare organization, from 87,073.50 to 68,403.00 at a 100% bed occupancy rate. Similarly, Vortherms et al. found that the implementation of the acuity tool reduced overtime working hours [18]. This could be attributed to the high level of staffing and appropriate patient assignment.

The reduction in overtime hours is considered important since it has been linked to missed care and compromised patient safety [19]. Indeed, Min et al.

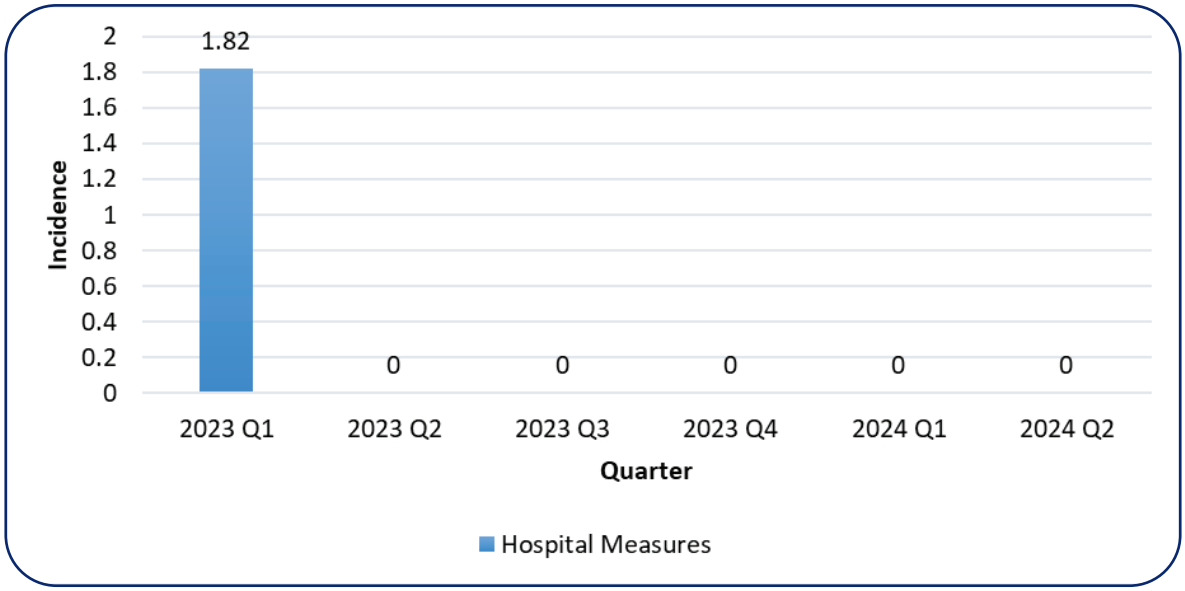

Figure 8. Peripheral IV site infiltration incidence compared to International Benchmark.

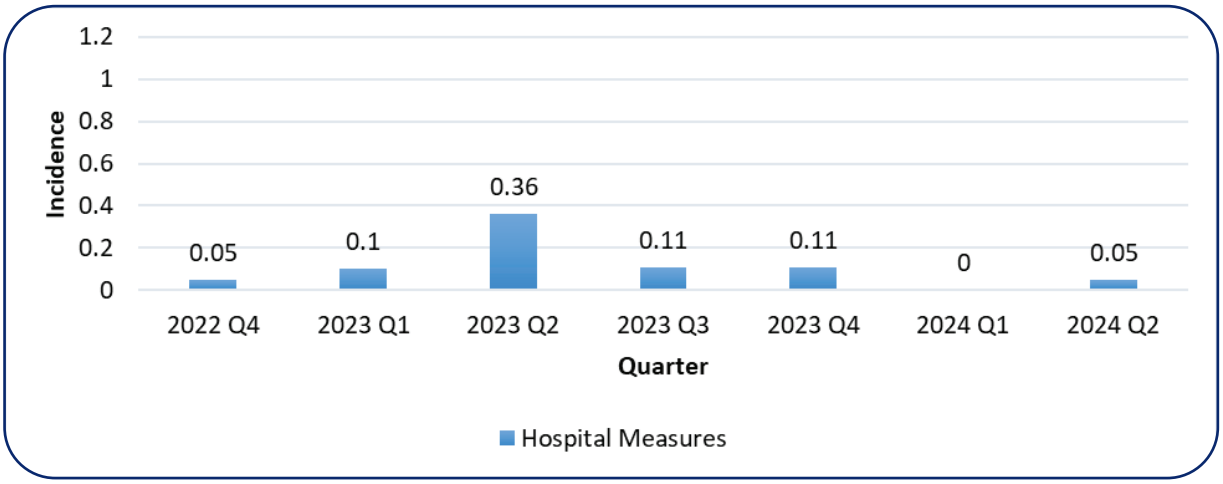

Figure 9. Patient fall incidence per 1,000 patient-days compared to International Benchmark.

[20] showed that increased overtime working hours were linked to reduced alertness.. Moreover, the level of nurse staffing also impacts the quality of delivered care. For instance, Needleman et al. found that hiring RNs below the required level by 8 hours was associated with an increase in death rate by 2% [4]. Similarly, Griffith et al. [21] found that each additional hour provided by an RN within the first 120 hours of patient admission was associated with a 3% reduction in the risk of death. After the implementation of our platform, the percentage of working hours provided by RNs in our hospital reached 98.97% RN hours, exceeding the mean (73.81%) and surpassing the 90th percentile benchmark (85.32%). This signifies the high quality of care provided by our hospital.

In our study, we found that the reduction in overtime hours has eliminated 1,555 man-days of overtime work, equivalent to 1,211,755 Saudi Riyals. This highlights the significant amount of reduced cost due to proper patient assignment, even when the care is administered by an RN. Overall, the cost of delivered healthcare is not only dependent on the number of hours but also on the staff level. For instance, increasing the number of RNs without changing the number of hours assigned for patient care is associated with a major reduction in cost. This could be explained as high rates of complications associated with hiring non-RNs could increase the cost due to the incidence of complications and the increased length of hospital stay [22]. For instance, Yang et al. [11] found that when all the nurses were registered, the cost was lower compared to the 76 % RN and 92 %

RN groups . Thus, higher staffing levels could provide lower costs.

Peripheral site IV infiltration, CAUTI, patient falls, and ventilator-associated pneumonia are key indicators of optimal patient care [14]. Indeed, their incidence is associated with an increase in the length of hospital stay and death rates [22-26]. In our study, we found that the incidence of CAUTI decreased to 0.17% in the second quarter of 2024, which is lower than the mean incidence in the other hospitals. Meanwhile, patient falls have reached 0.05, which is lower than the 10th percentile of hospitals. Additionally, the incidence of ventilator-associated pneumonia was zero in 2023. Moreover, the incidence of IV site infiltration was zero over the past five quarters. This signifies the high quality of care delivered in our hospital compared to other recognized hospitals. This could be attributed to the percentage of care delivered by RNs. For instance, Staggs et al. [27] found that higher non-RN staffing was associated with a higher incidence of falls. Moreover, Yang et al. [11] showed that the staff with 76% and 92% RN had more incidence of UTI compared to the staff with 100% RN.. This aligns with our findings, as we had 98.97 % of hours provided by an RN.

We found that the main causes of overtime involved staff shortage and turnover. Indeed, the rate of nurse turnover in Saudi Arabia has reached 20% [10]. The contributing factors to nurse turnover involve job dissatisfaction, burnout, and high workload [28,29]. Thus, efficient scheduling and reduction of overtime hours could improve job satisfaction. Indeed, we found that the job satisfaction score had improved. This could be explained by the reduced overtime hours. Similarly, Al-Dweik et al. [12] found that job satisfaction has improved following the implementation of the acuity tool. Interestingly, although our hospital has not yet achieved Magnet accreditation (which is typically associated with higher job satisfaction and lower staff shortages) [30], our intervention resulted in job satisfaction scores that were higher than those reported in hospitals. This highlights the significant impact that an evidence-based staffing platform can have.

Strengths and limitations

Our study has several strengths. First, the platform was implemented at a large hospital in Saudi Arabia, including a large number of wards and a diverse population. To the best of our knowledge, this is the first evidence-based platform to be implemented in Saudi Arabia. The implementation led to a major reduction in working hours and achieved an appropriate patient staffing score superior to that reported by recognized hospitals. We compared our hospital to other hospitals to ensure validity and reliability, and our hospital's performance demonstrated superiority.

Our limitations include the short period of implementation since the project was only implemented in the second quarter of 2024. Thus, we plan for long-term assessment, data monitoring, improvement, and stakeholder involvement. Additionally, the project was implemented at a single hospital in Saudi Arabia. Thus, we plan to further implement the platform in other hospitals to improve staffing and reduce working hours and their associated costs. We calculated the cost directly from the reduced overtime hours. However, the cost of implementing the project was not calculated. Thus, a cost-effectiveness analysis might be essential before implementing the platform in other hospitals, especially the small ones with a low rate of overtime hours. The platform was implemented using the optimum staffing guidelines, and the optimum nurse-staffing ratio was used according to the Saudi Arabian Ministry of Health. This input might need to be modified when implementing the platform in other countries.

Implications and sustainability plan

Our study has provided evidence of the efficiency of implementing an evidence-based platform to schedule nurse staffing to improve key patient outcomes and staff satisfaction. The substantial cost savings (over 1.2 million Saudi Riyals) from reduced overtime provided evidence on the effect of efficient staffing practices on improving the cost of healthcare while improving patient care. Also, surpassing international benchmarks for RN-provided nursing hours (98.97%) highlights the platform's effectiveness in ensuring that patient care is supplied by highly qualified staff. This is evident in achieving a zero IV infiltration rate for an extended period and reducing falls and infections below international benchmarks. This signifies the importance of nursing optimization, which is critical for patient safety. The increase in RN job satisfaction and patient assignment scores suggests that matching nurse expertise and workload appropriately reduces burnout and improves the work environment. Additionally, the successful implementation of this model in a Saudi Arabian hospital provides a valuable guide for other healthcare institutions in the region aiming to improve care quality.

Our sustainability plan involves regular updates and maintenance, continuous evaluation, staff training, stakeholder engagement, and sustainability reporting. We plan to schedule regular maintenance, updates, security fixes, data validation, and data quality audits to maintain platform performance and ensure data integrity. Evaluation of the platform will be done through benchmarking comparisons and receiving feedback from stakeholders through meetings, surveys, and focus groups. Stakeholders will be involved in decision-making. Also, comprehensive staff training will be scheduled. Transparency could be achieved through comprehensive tracking and reporting on the platform's performance. Thus, ensuring the platform's adequate performance, improving patient outcomes, and reducing costs.

Conclusion

Our study showed that the implementation of an evidence-based platform to schedule nurse staffing led to a reduction in overtime working hours and improved nurse-to-patient assignments. Additionally, it resulted in reduced costs, improved patient outcomes, and higher job satisfaction.

List of abbreviations

CAUTI	Catheter-associated urinary tract infections
DMAIC	Define, measure, analyze, improve, and control
RN	Registered nurse
UTI	Urinary tract infection
VAP	Ventilator-associated pneumonia

Conflict of interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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Author(s) contribution

Ahmed Zaki Mustafa: Conceptualization of the study, study design, data interpretation, and critical revision of the manuscript. Shiv Bhagwan Dhayal: Methodology development, supervision of data accuracy, and manuscript editing. Kanchana Ramachandran: Assisted in patient recruitment, ethical approval process, and validation of data. Dania Amer Alhijjawi: Manuscript drafting, referencing, formatting, and final proofreading before submission. All authors read and approved the final version of the manuscript.

Consent for publication

Not applicable.

Consent for participation

Not applicable.

Ethical approval

Not applicable.

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