Calculating Optimal Patient to Nursing Capacity: Comparative Analysis of Traditional and New Methods

Anna Ware, Zachary Veigulis, Terri Blumke, Peter Hoover, David Arreola, Thomas Osborne

Submitted to: JMIR Nursing
on: April 17, 2024

Table of Contents

Calculating Optimal Patient to Nursing Capacity: Comparative Analysis of Traditional and New Methods

Anna Ware[1] MPH, MS; Zachary Veigulis[1, 2] MSci; Terri Blumke[1]; Peter Hoover[1] MS; David Arreola[1]; Thomas Osborne[1, 3] MD

[1]National Center for Collaborative Healthcare Innovation VA Palo Alto Health Care System Palo Alto US
[2]Department of Business Analytics Tippie College of Business University of Iowa Iowa City US
[3]Department of Radiology Stanford University School of Medicine Palo Alto US

Corresponding Author:
Anna Ware MPH, MS
National Center for Collaborative Healthcare Innovation
VA Palo Alto Health Care System
3801 Miranda Avenue
Palo Alto
US

Abstract

Background: Optimal nurse staffing levels have been shown to impact patients' prognoses and safety, as well as staff burnout. The predominant method for calculating nurse staffing levels has been Nurse-to-Patient (N:P) ratios and Nursing Hours Per Patient Day (NHPPD). However, both methods fall short in addressing the dynamic nature of staffing needs that often fluctuate throughout the day as patients' clinical status changes, and new patients are admitted or discharged from the unit.

Objective: The VA Palo Alto Health Care System (VAPAHCS) implemented a new Dynamic Bed Count (DBC) calculation in efforts to target optimal staffing levels every hour to provide greater temporal resolution on nurse staffing levels.

Methods: The Dynamic Bed Count (DBC) uses elements from both the NHPPD and N:P ratio to calculate current and target staffing levels, every hour, while balancing across nurse types (registered nurses to nurse assistants) to provide improved temporal insight to staff allocation. The DBC was compared to traditional N:P methods of calculating patient capacity at the VAPAHCS, to assess optimal patient capacity within their acute care ward from January 1st, 2023, through May 25th, 2023. Descriptive statistics summarized patient capacity variables across intensive care units (ICUs), medical surgical-ICUs, and acute care units. Student's t-tests were used to analyze differences between patient capacity measures.

Results: Hourly analysis of patient capacity information displayed how the DBC provided improved temporal resolution on patient capacity. Comparing the DBC to the N:P ratio, we found the patient capacity as determined by the N:P ratio was, on average, higher than that of the DBC across VAPAHCS acute care units and the medical surgical-ICU. This suggests that calculating patient capacity using N:P ratios alone could lead to units taking on more patients than the DBC suggests the unit can optimally handle.

Conclusions: As a new patient capacity calculation, the DBC provided additional details and timely information about clinical staffing levels, patient acuity, and patient turnover. Implementing this calculation into the management process has the potential to empower departments to further optimize staffing and patient care.

(JMIR Preprints 17/04/2024:59619)
DOI: https://doi.org/10.2196/preprints.59619

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✔ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**

Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v

Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Title: Calculating Optimal Patient to Nursing Capacity: Comparative Analysis of Traditional and New Methods

Running Title: Calculating Optimal Patient to Nursing Capacity

Authors:
1. Anna D Ware[1]
2. Zachary P Veigulis[1,2]
3. Terri L Blumke[1]
4. Peter J Hoover[1]
5. David Arreola[1]
6. Thomas F Osborne[1,3]

Affiliations:
1. National Center for Collaborative Healthcare Innovation, VA Palo Alto Health Care System, Palo Alto, CA, USA
2. Department of Business Analytics, Tippie College of Business, University of Iowa, Iowa City, IA, USA
3. Department of Radiology, Stanford University School of Medicine, Stanford, CA, USA

Author Contributes: Conceptualization: AW, TB, ZV, TO; Methodology: AW, ZV, TB, TO; Data Curation: TB, DA; Formal Analysis: AW, ZV; Writing – original draft: AW, ZV; Writing - review & editing: ZV, AW, TB, DA, PH, JF, TO.

Corresponding Author: Anna D. Ware, MPH; Anna.Ware@va.gov; 3801 Miranda Ave, Palo Alto, CA, USA, 94304

Word Count: 1,979

Funding: Not applicable

Data Sharing Statement: Due to US Department of Veterans Affairs (VA) regulations and ethics agreements, the data utilized for this assessment are not permitted to leave the VA firewall without a Data Use Agreement. However, VA data can be made available to researchers with an approved IRB and VA authorized study protocol. For more information, please visit https://www.virec.research.va.gov or contact the VA Information Resource Center at VIReC@va.gov

Abstract

Background: Optimal nurse staffing levels have been shown to impact patients' prognoses and safety, as well as staff burnout. The predominant method for calculating nurse staffing levels has been Nurse-to-Patient (N:P) ratios and Nursing Hours Per Patient Day (NHPPD). However, both methods fall short in addressing the dynamic nature of staffing needs that often fluctuate throughout the day as patients' clinical status changes, and new patients are admitted or discharged from the unit.

Objective: The VA Palo Alto Health Care System (VAPAHCS) implemented a new Dynamic Bed Count (DBC) calculation in efforts to target optimal staffing levels every hour to provide greater temporal resolution on nurse staffing levels.

Methods: The Dynamic Bed Count (DBC) uses elements from both the NHPPD and N:P ratio to calculate current and target staffing levels, every hour, while balancing across nurse types (registered nurses to nurse assistants) to provide improved temporal insight to staff allocation. The DBC was compared to traditional N:P methods of calculating patient capacity at the VAPAHCS, to assess optimal patient capacity within their acute care ward from January 1st, 2023, through May 25th, 2023. Descriptive statistics summarized patient capacity variables across intensive care units (ICUs), medical surgical-ICUs, and acute care units. Student's t-tests were used to analyze differences between patient capacity measures.

Results: Hourly analysis of patient capacity information displayed how the DBC provided improved temporal resolution on patient capacity. Comparing the DBC to the N:P ratio, we found the patient capacity as determined by the N:P ratio was, on average, higher than that of the DBC across VAPAHCS acute care units and the medical surgical-ICU. This suggests that calculating patient capacity using N:P ratios alone could lead to units taking on more patients than the DBC suggests the unit can optimally handle.

Conclusions: As a new patient capacity calculation, the DBC provided additional details and timely information about clinical staffing levels, patient acuity, and patient turnover. Implementing this calculation into the management process has the potential to empower departments to further optimize staffing and patient care.

Key Words: Nurse Scheduling, Nurse: Patient Ratio, NHPPD, Nursing Administration, Workload

Introduction

Nurse staffing levels can impact patients' prognoses and safety,[1] as well as staff burnout, job satisfaction,[2] workplace injury, and illness.[3] A common method for assessing and managing nurse staffing levels is Nurse-to-Patient ratios (N:P), or the mean number of patients cared for by one nurse.[4,5] Target ratios are typically based on the type of clinical environment, however, when the unit's nursing team determines a patient has greater needs, the N:P ratio may be increased.

The N:P ratio is intended as an efficient tool to assess staffing needs.[6] However, it only accounts for registered nurses (RNs) rather than all nursing types and support staff of the unit, including licensed practical nurses (LPNs), licensed vocational nurses (LVNs) and nurse assistants (NAs). [7,8] A more detailed alternative to the N:P ratio, Nursing Hours Per Patient Day (NHPPD), accounts for all nursing types and support staff on the floor, as well as patient complexity, patient turnover, and the presence of higher acuity patients.[9,10] Utilizing NHPPD has been shown to significantly decrease mortality, length of stay, and improve patient outcomes.[5-11,12] However, patient, and therefore staffing needs, are dynamic throughout the day, and standard intermittent tracking of staffing workloads can lead to inappropriate or incomplete staffing adjustments.

The VA Palo Alto Health Care System (VAPAHCS) is one of the largest medical centers in the Veterans Health Administration (VHA), and operates over 800 patient beds, including 3 acute care units and 6 critical care units.[13] Traditionally, the VAPAHCS utilized N:P ratios alone to establish patient capacity and staffing levels for their clinical units. In efforts to optimize nurse staffing, VAPAHCS implemented a new staffing solution that utilizes elements of both the NHPPD and N:P ratio, the Dynamic Bed Count (DBC).

The DBC was developed within the Issio Health Care Workforce Optimization Platform™ through ongoing collaborations with the VAPAHCS charge nurses, nurse managers, and nursing supervisors to calculate optimal staffing levels every hour to provide greater temporal resolution on staffing levels and, therefore, improve the allocation of staff where needed across adjacent units. In this assessment, we compare the DBC to the N:P ratio to describe patient capacity and staffing allocation.

Methods

Setting

We analyzed patient capacity data for three VAPAHCS acute care units, one Intensive Care Unit [ICU], and one Medical-Surgical [Med-Surg] ICU from January 1st, 2023, through May 25th, 2023.

Patient Capacity Data

The DBC utilizes two main data sources for its calculation: 1) The VHA's national EHR database, the Corporate Data Warehouse (CDW)[14] and 2) manually tracked data from nursing staff in real-time. The CDW was queried to provide the DBC solution information regarding the unit's patient census. The maximum number of beds the unit can support when fully staffed is referred to as the unit's *Authorized Capacity* (AC) and was obtained through querying the CDW. The AC is a relatively stable metric and would only change based on factors that reduce the overall number of physical beds a unit could successfully support such as construction, or long-term staffing constraints. Per the legacy processes, the N:P ratio was established by the units' nursing supervisors at the beginning of every shift, dictated by California N:P ratio laws,[15] and was captured by charge nurses entering this information into the DBC solution. These metrics (census, AC, and N:P ratio) were captured hourly for each unit within the assessment period.

Dynamic Bed Count (DBC)

The DBC calculation within the Issio Health Care Workforce Optimization Platform ™ is designed to represent the number of available staffed beds in relation to specific types of nursing qualifications needed to support the patients. The DBC utilizes both target and current staffing levels in its calculation, along with other key staffing variables. A description of the DBC calculation is available in **S1**.

The output of the DBC calculation is displayed on a "Patient Capacity Whiteboard" in Issio's Command Center ™ or accessible to charge nurses via a weblink to inform nursing staff when a unit was under, over, or adequately staffed every hour so they can make the necessary staffing adjustments across adjacent units (**S2**).

Statistical Analysis

Analyses were performed using Python (version 3.8.5; Python Software Foundation) in a Jupyter Notebook Environment. Descriptive statistics summarized patient capacity variables while the paired student's t-test determined any significant differences between the N:P ratio and DBC. To further compare N:P ratios and the DBC, we randomly selected 10 datetimes from the unit with the most variance (i.e., standard deviation) in their DBC calculation hour-by-hour during the assessment period. This was done using Python's 'random' library to generate random numbers corresponding to the indices of dates in our dataset, thereby ensuring unbiased data representation and mitigating any selection bias.

This quality improvement and assessment project received a Determination of Non-Research from Stanford IRB (Stanford University, Stanford, CA, USA), #73003.

Results

Over the assessment period, the number of patients in which the different units supported were varied (**Table 1**). For example, the acute care unit 3C had, on average, 23 patients occupying their unit compared to only 10 patients in the ICU. With the exception of the ICU, average DBC was significantly lower in all locations compared to the N:P ratio (**Table 1;** $P < .001$). This was further represented in **Figure 1**, where we can see that the N:P ratio was consistently higher across all acute care units and the medical surgical-ICU during the assessment period.

In the comparison of N:P ratios and the DBC, we evaluated the unit with the most variance within the DBC calculation (displayed in **Table 1**) across the assessment period. This resulted a random sample of 10 datetimes within the acute care unit 3C (**Table 2**). The "Difference" column compares the N:P ratio and the DBC, where a negative value indicates that the unit should have less patient capacity while a positive value indicates the unit could have taken on additional patients. The amplitude of the value defines how many less (negative value) or more (positive value) patients the unit could have handled during any given hour. These data points demonstrate the swing between the quick math "in the moment" patient capacity calculation (N:P ratios) and the standardized, repeatable computation in real-time (the DBC).

Additionally, we graphically represented unit 3C to further display the difference between the N:P ratio and the DBC calculation throughout the assessment period (**Figure 2**). In this graph, we can see the difference (delta) between the two methods where resource allocation could be improved.

Discussion

In efforts to improve nurse scheduling and optimize workload across acute care and critical care units of the VAPAHCS, we implemented the DBC to calculate the optimal workload of each unit every hour. Through comparison of the N:P ratio and the DBC, we found that the N:P ratios implemented by the nursing staff, with the exception of the ICU, resulted in significantly higher calculated patient capacity levels an average than the unit can adequately take on. Inadequate staffing levels could result in an increased risk of burnout and workplace injury among our nursing staff and has been shown to worsen patient outcomes.[16,17,18] Furthermore, when looking at VAPAHCS unit 3C hour-by-hour, we found times when the unit could support a higher patient capacity than what was calculated by nursing staff. By accounting for dynamic changes within units with the DBC, nursing supervisors

could allocate staff appropriately across units to improve their function without necessarily having to hire on additional staff.

As seen in previous research, the N:P ratios fall short of fully grasping a true picture of optimal workload. In one study, researchers found that the N:P ratio cannot properly capture admissions and/or discharges of patients, or where nurses work as a team.[19] For example, the N:P ratio implies that each nurse has responsibility for a set group of five patients. However, that is often not the case. A nurse's patient load changes as patients are admitted and discharged during a shift. This can result in a nurse starting their shift with the five patients who are eventually replaced by five other patients later in the shift as they are admitted/discharged. Additionally, N:P ratios only account for RN staffing types and no other support staff on the floor. This is an important aspect of the team dynamic that is often present in healthcare units, such as those seen in the VAPAHCS acute care ward.

The NHPPD can be seen as a marked improvement on N:P ratios, and is endorsed by the National Quality Forum to measure appropriate nurse staffing levels.[10] It is known to reliably increase the quality of care for patients.[5-6] The NHPPD staffing measure utilizes a “bottom up” approach to classify units into one of seven categories as determined by patient complexity, intervention levels, presence of high dependency beds, and patient turnover.[7-8] It has been implemented in the long-term care clinics within VHA, where researchers found that higher NHPPD levels were inversely associated with falls resulting in major injury.[14] However, NHPPD is still limited at incorporating real-time changes in patient capacity within different units across the hospital system that the DBC was able to capture every hour.

Tools such as the DBC calculations can be powerful in helping charge nurses better understand the rationale behind the load balancing of staff. By including staffing types and patient acuity, the DBC can help charge nurses determine the most effective combination of staffing types to deliver high quality and cost-effective patient care. This is especially important in the face of rising demand for health services and shortages of nurses and other healthcare workers.[20,21] Additionally, the diversity of staffing models in our healthcare system is essential to determine which staff members should be included in the staffing calculations to reflect personnel who deliver direct care relevant to patient outcomes.

It should be noted that nursing staff allocation across multiple units based on the DBC can present cultural challenges. For example, although all units are part of the same healthcare system, sending personnel from a well-staffed ward to an understaffed ward can be undesirable to the unit losing personnel, and can be a stressful experience for the transferred nurse due to unfamiliarity to the adjacent unit.[22] However, this challenge can be mitigated through cross-training, or implementing a “buddy system” across units, which in turn can increase job satisfaction.[23] Increasing “float pools” is another strategy to mitigate this issue and has also been shown to significantly reduce turnover and overall staffing costs.[24]

The DBC's strength lies in its development, which stemmed from continuous collaborations with VAPAHCS nursing leadership. These collaborations ensured a comprehensive understanding of crucial data points for accurate capacity assessment and validation of the calculation's precision. Each variable can change at a moment's notice and can have a major impact on a unit’s capacity. This information, as soon as it is changed, must be presented to “need to know” parties, like nursing supervisors and patient flow coordinators, so quick and accurate decisions can be made about floating staff to areas where they are needed. With the overall complexity differences between N:P ratios and DBC, it is easy to understand why N:P ratios take place on the floor “in the moment” but with technology that can account for the additional complexities easily, accurately, and quickly, we

can see improved accuracy in the staffing decision-making processes.

This assessment has some limitations. First, these findings are only relevant for the VAPAHCS Acute Care Ward during the assessment period. Our findings could vary for other time frames, and in other units. Future assessments will be needed to test the implementation of the DBC on any improved patient outcomes.

In conclusion, we believe that a new calculation such as the DBC, as presented here, could be a marked improvement from the N:P ratio for the VAPAHCS Acute Care Ward. Implementing this calculation into an online report that supervisors could use to allocate nursing staff could significantly improve the workflow of our health care system.

Acknowledgements: We would like to thank the Issio Solutions™ team for their assistance in developing the calculation behind the DBC that is used in their Healthcare Workforce Optimization Platform™.

Conflict of Interest Statement: Authors declare that there is no financial interest, personal interest, competing interests, or belief that could affect objectivity.

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the U.S. Department of Veterans Affairs or the United States Government.

Table 1. Average patient capacity and occupancy characteristics by Palo Alto VA Health Care System's acute care unit, mean (SD)

			Patient Capacity Calculations		
Acute Care Unit Locations, mean (SD)	**Patient Census**	**Authorized Capacity***	**Dynamic Bed Count**	**Nurse-to-Patient Ratio**	***P-value***
2A	18.6 (3.8)	27.0 (0.0)	17.5 (2.9)	20.5 (2.1)	<.001
3C	23.2 (4.5)	34.0 (0.0)	21.6 (4.2)	28.6 (3.2)	<.001
4A	14.1 (4.4)	18.0 (0.0)	14.3 (3.5)	16.7 (4.2)	<.001
Intensive Care Unit	9.5 (2.0)	15.0 (0.0)	11.2 (1.8)	11.2 (1.5)	.401
Med- Surg Intensive Care Unit	9.7 (2.1)	15.0 (0.0)	9.0 (2.1)	12.3 (1.5)	<.001
All Units	15.0 (6.4)	21.8 (0.0)	14.7 (5.4)	17.8 (6.9)	<.001

Med-Surg = Medical Surgical

*Authorized Capacity is the maximum number of beds the unit can support when fully staffed.

Table 2. Random sampling of hours within the Acute Care Unit 3C showing the differences between calculated patient capacity as determined by the N:P ratio and the Dynamic Bed Count calculation.

Acute Care Unit Location	Date Time	Patient Census	Patient Capacity Calculations		Difference Dynamic Bed Count vs. N:P Ratio
			N:P Ratio	Dynamic Bed Count	
3C	1/1/2023 7:00	21	30.0	18.7	-11.3
3C	1/9/2023 22:00	29	25.0	20.5	-4.5
3C	2/12/2023 16:00	15	30.0	32.2	2.2
3C	2/19/2023 18:00	15	30.0	25.8	-4.2
3C	3/2/2023 16:00	29	25.0	25.8	0.8
3C	3/5/2023 15:00	22	30.0	26.4	-3.6
3C	4/8/2023 22:00	21	25.0	17.6	-7.4
3C	4/13/2023 6:00	20	26.0	29.3	3.3
3C	5/3/2023 8:00	26	28.0	17.8	-10.2
3C	5/24/2023 13:00	24	29.0	20.3	-8.7

N:P = Nurse to Patient Ratio

Figure Legends:

Figure 1. Average Patient Capacity across the Palo Alto VA Health Care System's Acute Units, January 1st, 2023, through May 25th, 2023

F1L: In this graph, the yellow lines depict the authorized bed count, which is the maximum number physical beds a unit could successfully support. The blue lines represent the average patient census for each unit location. The red lines depict the average Dynamic Bed Count calculation for patient capacity while the green lines represent the average N:P ratio across the assessment period for each acute care unit.

Figure 2: Average N:P Ratio and Dynamic Bed Count calculations across the Palo Alto VA Health Care System's Acute Unit 3C Location, January 1st, 2023, through May 25th, 2023

Figure 2L: The analysis of patient capacity metrics over the study period revealed an upward trend in the N:P Ratio, indicated by the green line, suggesting an increase in nursing resources relative to the number of patients. In contrast, the Dynamic Bed Count, shown in red, demonstrates a slight downward trend. Notably, the shaded regions around the trend lines, which represent the standard error, suggest greater variability in the Dynamic Bed Count than in the N:P Ratio. The divergence in trends between the two metrics underscores the complexity of healthcare resource management and the need for strategies that optimize staffing levels.

References

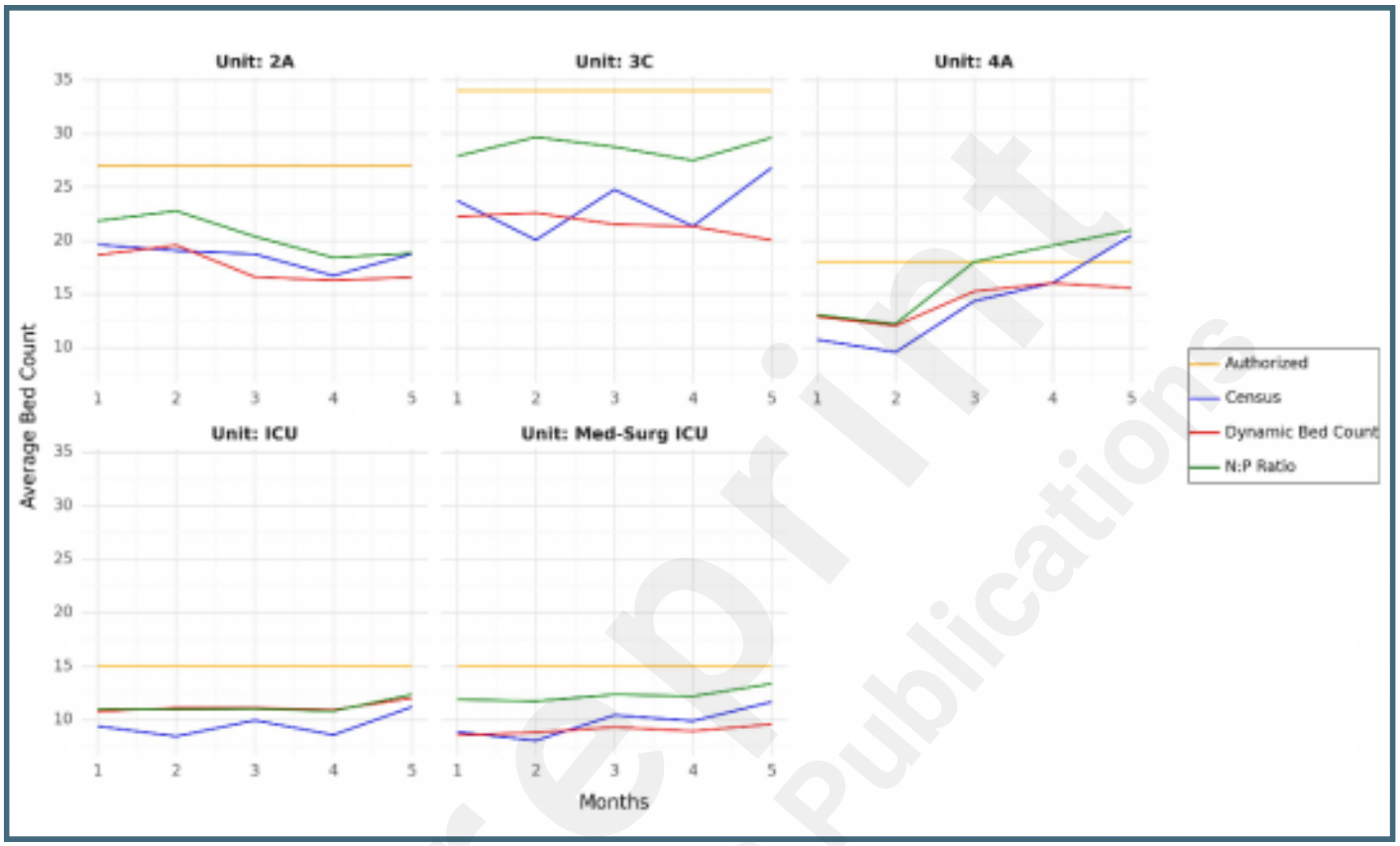
[1] Kim Y., Kim J., Shin S.A. Relationship between the legal nurse staffing standard and patient survival after perioperative cardiac arrest: A cross-sectional analysis of Korean administrative data. Int. J. Nurs. Stud. 2019;89:104–111. doi: 10.1016/j.ijnurstu.2018.09.012.
[2] Chen YC, Guo YL, Chin WS, Cheng NY, Ho JJ, Shiao JS. Patient-Nurse Ratio is Related to Nurses' Intention to Leave Their Job through Mediating Factors of Burnout and Job Dissatisfaction. Int J Environ Res Public Health. 2019 Nov 29;16(23):4801. doi: 10.3390/ijerph16234801. PMID: 31795420; PMCID: PMC6926757.
[3] Leigh JP, Markis CA, Iosif AM, Romano PS. California's nurse-to-patient ratio law and occupational injury. Int Arch Occup Environ Health. 2015 May;88(4):477-84. doi: 10.1007/s00420-014-0977-y. Epub 2014 Sep 13. Erratum in: Int Arch Occup Environ Health. 2015 May;88(4):485-6. PMID: 25216822; PMCID: PMC6597253.
[4] Halm M., Peterson M., Kandels M. et al. (2005) Hospital nurse staffing and patient mortality, emotional exhaustion, and job dissatisfaction. Clinical Nurse Specialist 19 (5), 241–251.
[5] Phillips J, Malliaris A, Bakerjian D. Nursing and Patient Safety | PSNet [Internet]. Patient Safety Network. 2021 [cited 2023Aug.31]. https://psnet.ahrq.gov/primer/nursing-and-patient-safety.
[6] Choi J. & Staggs V.S. (2014) Comparability of nurse staffing measures in examining the relationship between RN staffing and unit-acquired pressure ulcers: a unit-level descriptive, correlational study. International Journal of Nursing Studies 51 (10), 1344–1352.
[7] Ajami S, Ketabi S. An analysis of the average waiting time during the patient discharge process at Kashani Hospital in Esfahan, Iran: a case study. Health Inf Manag. 2007;36(2):37-42. doi: 10.1177/183335830703600207. PMID: 18195405.
[8] Ernst, KM, McComb, SA, Ley, C. Nurse-to-nurse shift handoffs on medical–surgical units: A process within the flow of nursing care. *J Clin Nurs*. 2018; 27: e1189–e1201. https://doi.org/10.1111/jocn.14254
[9] Twigg D., Duffield C.: A review of workload measures: a context for a new staffing methodology in Western Australia. International Journal of Nursing Studies 2009; 46: pp. 131-139.
[10] Twigg D, Duffield C, Bremner A, Rapley P, Finn J. The impact of the nursing hours per patient day (NHPPD) staffing method on patient outcomes: a retrospective analysis of patient and staffing data. Int J Nurs Stud. 2011 May;48(5):540-8. doi: 10.1016/j.ijnurstu.2010.07.013. Epub 2010 Aug 8. PMID: 20696429.
[11] Drennan J, Duffield C, Scott AP, Ball J, Brady NM, Murphy A, Dahly D, Savage E, Corcoran P, Hegarty J, Griffiths P. A protocol to measure the impact of intentional changes to nurse staffing and skill-mix in medical and surgical wards. J Adv Nurs. 2018 Dec;74(12):2912-2921. doi: 10.1111/jan.13796. Epub 2018 Aug 29. PMID: 30019346.
[12] Min A, Scott LD. Evaluating nursing hours per patient day as a nurse staffing measure. J Nurs Manag. 2016 May;24(4):439-48. doi: 10.1111/jonm.12347. Epub 2015 Nov 17. PMID: 26576931.
[13] About us. Veterans Affairs. Published May 1, 2023. Accessed August 2, 2023. https://www.va.gov/palo-alto-health-care/about-us/
[14] US Department of Veterans Affairs . Corporate data warehouse (CDW). URL: www.hsrd.research.va.gov/for_researchers/vinci/cdw.cfm.
[15] Coffman JM, Seago JA, Spetz J. Minimum nurse-to-patient ratios in acute care hospitals in California. Health Affairs. 2002 Sep;21(5):53-64.
[16] Brown LM, Gauss CH, Billings P, Minor L, Moore JT, Sawyer LM, Sparks D, Sullivan SC. Nurse Staffing and Veteran Outcomes in the Veterans Health Administration's Community Living Centers. J Nurs Care Qual. 2023 Oct-Dec 01;38(4):297-303. doi: 10.1097/NCQ.0000000000000700. Epub 2023 Feb 24. PMID: 36827702.
[17] Brown LM, Gauss CH, Billings P, Minor L, Moore JT, Sawyer LM, Sparks D, Sullivan SC. Nurse Staffing and Veteran Outcomes in the Veterans Health Administration's Community Living Centers. J Nurs Care Qual. 2023 Oct-Dec 01;38(4):297-303. doi: 10.1097/NCQ.0000000000000700. Epub 2023 Feb 24. PMID: 36827702.
[18] Milstein R, Schreyoegg J. The relationship between nurse staffing levels and nursing-sensitive outcomes in hospitals: assessing heterogeneity among unit and outcome types. Health Policy. 2020;124(10):1056–1063. doi:10.1016/j.healthpol.2020.07.013
[19] Spetz J., Donaldson N., Aydin C. & Brown D. (2008) How many nurses per patient? Measurements of nurse staffing in health service research. Health Services Research 43 (5), 1674–1692.
[20] Doyle, J.M. and Streeter, R.A. (2017), Veterans' Location in Health Professional Shortage Areas: Implications for Access to Care and Workforce Supply. Health Serv Res, 52: 459-480. https://doi.org/10.1111/1475-6773.12633
[21] Juraschek SP, Zhang X, Ranganathan V, Lin VW. United States Registered Nurse Workforce Report Card and Shortage Forecast. Am J Med Qual. 2019 Sep/Oct;34(5):473-481. doi: 10.1177/1062860619873217. PMID: 31479295.
[22] Walden, Angie M. MSN, RN; Moyse, Tonya MSN, RN; Meyer, Josalyn R. MSN, RN, NE-BC; Whitaker, Brent MS, MSN, RN, ACSM; Briskin, Isaac MA; Albert, Nancy M. PhD, CCNS, CCRN, NE-BC. Enhancing the caregiver float experience. Nursing Management (Springhouse) 51(7):p 14-20, July 2020. | DOI: 10.1097/01.NUMA.0000669108.28985.67
[23] Wright, P.D. and Bretthauer, K.M. (2010), Strategies for Addressing the Nursing Shortage: Coordinated Decision Making and Workforce Flexibility. Decision Sciences, 41: 373-401. https://doi.org/10.1111/j.1540-5915.2010.00269.x
[24] Straw, Christen N. DNP(c), MSN, RN, CNL, OCN. Engagement and retention in float pools: Keeping the team above

water. Nursing Management (Springhouse) 49(10):p 30-36, October 2018. | DOI: 10.1097/01.NUMA.0000546201.01962.0d

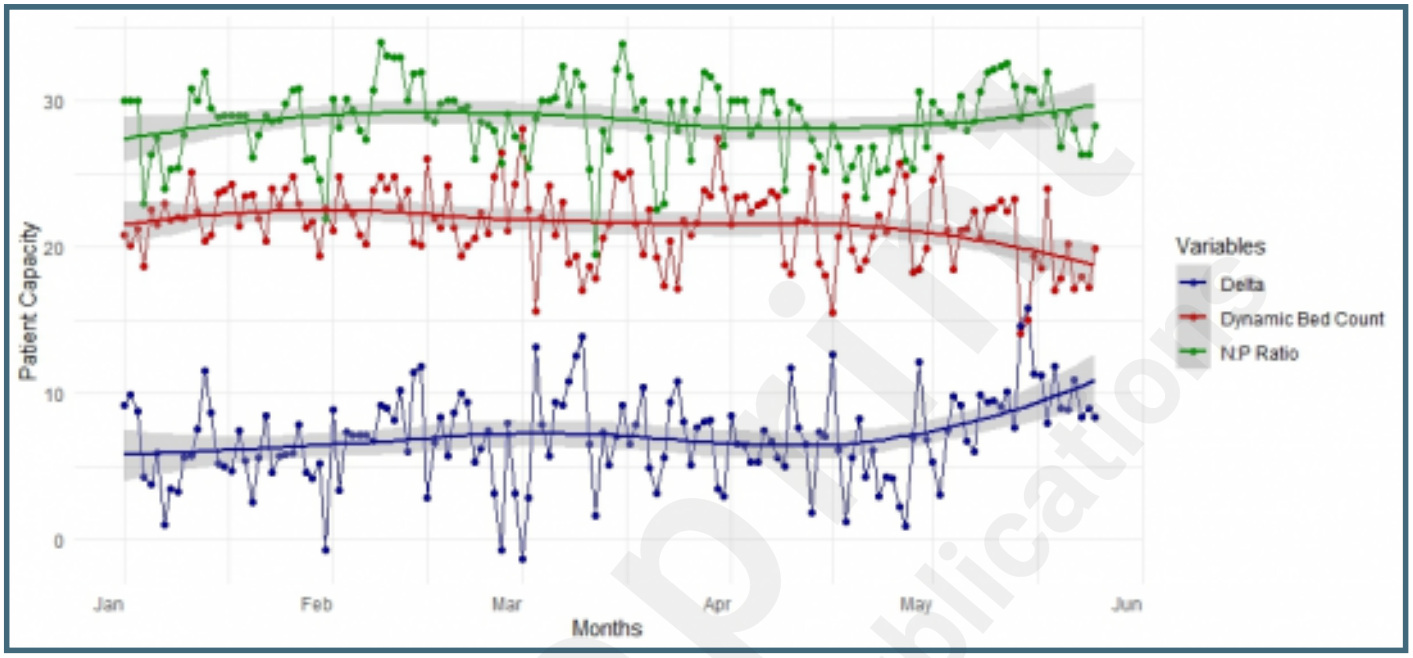
Supplementary Files

Figures

Average Patient Capacity across the Palo Alto VA Health Care System's Acute Units, January 1st, 2023, through May 25th, 2023. In this graph, the yellow lines depict the authorized bed count, which is the maximum number physical beds a unit could successfully support. The blue lines represent the average patient census for each unit location. The red lines depict the average Dynamic Bed Count calculation for patient capacity while the green lines represent the average N:P ratio across the assessment period for each acute care unit.



Average N:P Ratio and Dynamic Bed Count calculations across the Palo Alto VA Health Care System's Acute Unit 3C Location, January 1st, 2023, through May 25th, 2023. The analysis of patient capacity metrics over the study period revealed an upward trend in the N:P Ratio, indicated by the green line, suggesting an increase in nursing resources relative to the number of patients. In contrast, the Dynamic Bed Count, shown in red, demonstrates a slight downward trend. Notably, the shaded regions around the trend lines, which represent the standard error, suggest greater variability in the Dynamic Bed Count than in the N:P Ratio. The divergence in trends between the two metrics underscores the complexity of healthcare resource management and the need for strategies that optimize staffing levels.



Multimedia Appendixes

Supplement 1 Description of the Dynamic Bed Count Calculation.
URL: http://asset.jmir.pub/assets/529c0ae94ebd78712d4bda59a714fe6d.docx

Supplement 2 Depiction of ‘Patient Capacity Whiteboard’.
URL: http://asset.jmir.pub/assets/1732a2b2db76ddc1bc33b5dbcd85109a.docx

CONSORT (or other) checklists

SQUIRE checklist.
URL: http://asset.jmir.pub/assets/327d30f0ea8865ed411d9af30b42a8ab.pdf