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Improving Nursing Staffing Methodology and Nursing Sensitive Outcomes with the Addition of a Patient Centered Acuity Measure

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Running Head: TROUBLED OUTCOME RISK, NURSE STAFFING

Improving Nursing Staffing Methodology and Nursing Sensitive Outcomes with the Addition of
a Patient Centered Acuity Measure

Presented to the Faculty of the School of Nursing

The George Washington University

In partial fulfillment of the
requirements for the degree of
Doctor of Nursing Practice

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Abstract

Background: Assigning the correct nursing resources to hospitalized patients positively impacts patient outcomes. The current process for matching nurses to patients is highly variable and involves a combination of simple ratios, historical workload data, and expert opinion but lacks objective measurement of the patient's condition. **Objectives:** This project evaluated change in selected quality indicators and the daily unit-level management of nursing resources after implementing the Troubled Outcome Risk (TOR) into existing nursing staffing methodology in a Department of Veterans Affairs hospital. **Methods:** TOR provides objective measurement of individual patient allostatic load. Daily calculation of TOR scores for each patient on the study unit and nursing staffing methodology were used by charge nurses to determine assignments. Nursing sensitive indicators including length of stay, transfers to intensive care unit, hospital acquired pressure ulcer (HAPU), 30-day readmissions, and nursing surveillance indicators including rapid response team activation and cardiac arrests were compared before and after implementing TOR. **Results:** There was a reduction of HAPU rates that exceeded the stated goal after implementation of TOR. Other indicators did not meet project goals. Prior to implementation of TOR, nurse assignments clustered in specific locations; after implementation 16.7% were without regard to location. None of the results were statistically significant; yet we observed a small-medium effect size between intervention and assignment change. **Conclusions:** The implementation of TOR did not result in significant differences in nursing sensitive outcomes, however charge nurses appear to have changed staff nurse assignments using TOR as an addition to existing methodology. Future study with a larger sample over a longer period of time may yield different results.

Problem Statement and Background

Nursing leadership desires to match nursing resources with patient need in the most efficient and cost-effective manner while simultaneously providing the highest standard of care. Nurse staffing has four distinct stages: budgeting, scheduling, rescheduling and assignment (Acar & Butt, 2016; Punnakitikashem, 2007). Budgeting and scheduling are high level processes that project nurse resources in the future, and are well understood. In contrast, rescheduling occurs in real time because of changes in patient load or available staff, and assignment is the purview of the unit level charge nurse matching patients to specific nursing staff (Acar & Butt, 2016). These two components essentially happen at the point of execution with the least experienced management level staff, but are arguably the most critical to patient outcomes.

There are multiple methods with high variability used to make these decisions, but most require the nursing leader to determine which patients are “average,” then assign resources based on deviations from average using their unique clinical judgement. Similarly, regarding direct patient care, expert clinicians develop the ability to see a complete picture in which only small parts are relevant; novices see the complete picture as a series of equally important parts (Benner, 1984). Gladwell (2005) describes this expert ability as “thin slicing.” When applied to typical nurse staffing methodologies, expert nurse leaders will make different decisions than novice leaders creating a disparity depending on the level of experience and adding undesirable variability. The Department of Veterans Affairs uses a program called the Nurse Staffing Methodology which uses expert nurses at both the unit and facility level to determine the budgeting and scheduling components of the nurse staffing process. The outcome of this process is an average of nurse hours per patient day (NHPPD) which nurse managers use to develop

schedules. The process of rescheduling and assignment occurs at the charge nurse level on each shift, and uses NHPPD as a guideline on how to assign the correct nurse with the correct number of patients. Missing from the equation is an objective measure of the individual patient's actual acuity.

Purpose

The purpose of this project was to assess if implementation of the Troubled Outcome Risk (TOR) patient acuity measure with existing Nurse Staffing Methodology processes on a mixed medical surgical unit at a Veterans Health Affairs (VHA) hospital impacted nursing sensitive indicators.

Quality Improvement Objectives

We monitored quality indicators before and after the addition of the TOR patient acuity measure to existing Nursing Staffing Methodology processes with the following goals:

- Reduce mixed medical surgical unit length of stay (LOS) by 0.5 days
- Reduce mixed medical surgical unit transfers to intensive care unit (ICU) by 10%
- Reduce mixed medical surgical unit hospital acquired pressure ulcer (HAPU) by 10%
- Reduce all cause 30-day readmissions by 10%
- Increase Rapid Response Team (RRT) mixed medical surgical unit activations by 10%
- Reduce mixed medical surgical unit cardiac arrest (code blue) activations by 10%

- Increase mixed medical surgical unit nursing staffing schedule flexibility
(measured by assignment to either room 4 or 8 and room 13 or 14 in the unit)

Significance

Current methods for determining the right supply of nurses to patient demand focus primarily on the process of scheduling. Patient acuity measures used to help inform scheduling are determined from historical averages for a particular unit. These averages are translated into a workload measure such as NHPPD which drives the unit's schedule and helps forecast manpower needs and personnel budget. Each shift uses this projection to allocate specific nursing resources to specific patients. If there are not enough resources projected, or there are errors in allocating resources on the shift, length of stay, nosocomial infections, pressure ulcers, and mortality rates all increase (Hill, 2017; Needleman, Buerhaus, Pankratz, Leibson, Stevens and Harris, 2011; Cho, Ketefian, Barkauskas and Smith, 2003). Needleman et al (2011) suggested that nurse staffing models that are dynamic enough to align nurses to patient needs and census rather than static systems are preferable and could reduce unwanted outcomes. Both Needleman et al (2011) and Hill (2017) suggest that patient acuity was the determining factor in overall mortality.

This project introduced a patient-centered acuity measure, the Troubled Outcome Risk (TOR), with the existing staffing methodology process in the Veterans Health Administration (VHA). The TOR is a clinical decision support (CDS) tool designed to measure individual patient's acuity using readily available electronic medical record (EMR) data (Howard, 2016). Current VHA staffing methodology involves essentially two steps: projections based on both

historical precedent, and expert opinion (VHA Directive 1351, 2017). This project added objective and dynamic measurement of patient-specific acuity to the existing process.

Nurse staffing, specifically registered nurse (RN) hours per patient day, has been associated with mortality. Needleman et al (2011) found that the risk of death in the hospital increased for patients that were exposed to shifts that were 8 hours or more below daily target unit level staffing. Cho et al (2003) found that each additional hour of RN time per patient day decreased the odds of hospital acquired pneumonia, length of stay and mortality while increasing the odds of HAPU. This increase in HAPU was thought to be related to an increase in skin assessments and subsequent improved detection of HAPU by RNs (Cho et al 2003).

Excessive nursing workload has also been implicated as a factor in readmissions. Nurses are responsible for conducting discharge planning, patient education and assessment of patient's knowledge of their disease process and plan of care, care coordination, and complication surveillance (McHugh, Berez and Small, 2013). Similarly, Giuliano, Danesh and Funk (2016) found that increased nurse staffing allowed nurses to identify changes in patient conditions that required intervention, which facilitated transition to outpatient care, and positively impacted the 30-day readmission rate of heart failure patients.

Nursing surveillance combines routine patient monitoring activities with acute observation, analysis and interpretation of objective data (Giuliano, 2017). Increased nurse surveillance improves the ability to identify patients at risk for adverse events and intervene to mitigate the risk (Giuliano, 2017). The use of nursing surveillance versus standard monitoring showed a large difference in mean time to activation of RRT: 152 minutes for surveillance versus 443 minutes for monitoring (Giuliano, 2017). When nursing surveillance was performed

12 or more times per day, there was a significant decrease in failure to rescue events when compared to nursing surveillance performed less than 12 times per day (Fasolino and Verdin, 2015). Improvement in nurse resource allocation with the addition of a patient acuity measure could improve nursing surveillance, leading to improved quality of care.

Literature Review

We conducted comprehensive literature searches to find relevant evidence. CINAHL search for “nurse staffing” AND “acuity” yielded ninety results. PubMed search using the same terms yielded 262 results, plus a second search using the terms “nurse scheduling” AND “acuity” which yielded 159 results. When the exclusion criteria were applied removing obstetrics, pediatrics, and articles not directly concerned with scheduling nurses to work on a particular shift or the use of some identified measure of acuity and when duplicates were eliminated, seventeen articles remained. From these seventeen articles, six contained studies relevant for this project. An additional search using “nursing surveillance” yielded 41 results in CINAHL and 66,106 results in PubMed. This was refined to “nursing surveillance” AND “staffing” AND “English” AND “patient outcomes” resulting in 231 results. From this sample, four additional articles were selected using exclusion criteria from above with relevance to this project. Finally, a search using PubMed with the search term “nursing surveillance” and “readmission” yielded 609 results resulting in four additional articles. A total of 14 articles relevant to this project were identified and reviewed.

In the literature, there are two important concepts regarding different nurse staffing rubrics: equality and equity. Equality is a situation where everyone gets the same thing in the same amount. Equity represents fairness and giving everyone what they need to be successful;

some require more resources to be on an equal footing with others (Kumar, 2017). In the context of nurse staffing assignments, nurse to patient ratios are an example of equality, whereas assignments made based on nurse skill, experience level and individual patient need are examples of equity.

Efforts to improve safe staffing have primarily focused on mandated nurse to patient ratios, but these efforts do little to incorporate the dynamic needs of individual patients (Gray and Kerfoot, 2016). To provide a more accurate measurement for nurse staffing, factors such as the geography of the unit, access to the EMR and patient acuity are required, however there is a high level of variability between units making standardization impossible (Gray and Kerfoot, 2016). There is no standard for measuring patient acuity in hospitalized patients. There are also challenges with patient acuity based staffing because of limitations in reporting tools that would support staffing modifications throughout the shift (Gray & Kerfoot, 2016).

Myny et al (2012), defined workload as a function of time, complexity and volume of interventions in a specific timeframe, and found poor consistency in the methods used to determine nurse workload in their cross-sectional study. Different methods including use of proxies for nursing workload such as NHPPD, midnight census, and nurse-to-patient ratios were cited as examples indicating this inconsistency (Myny et al, 2012). When determining which items most impacted nursing workload, Myny et al first did an integrative review involving focus groups and found 94 different factors. From this, Myny et al regrouped the data into 28 measurable elements and using a self-administered questionnaire, queried 864 nurses on which elements impacted staffing the most. Based on results of this questionnaire, interruptions were found to have the highest impact, and they hypothesized that these interruptions had a serious

impact on the mental load of the nurse (Myny et al, 2012). A component of TOR is a measure of individual patient complexity, which also impacts the mental load of the nurse.

Acar and Butt (2016) studied a 29-bed general medical/oncology unit in a 380-bed hospital and using a direct observation method and personal digital assistant devices equipped with work measurement software over a 12-week period. They identified 45 distinct nursing activities which they analyzed for frequency in the daily workload. They found that when charge nurses make daily assignments, they attempt to balance the workload by distributing acuity evenly, and by minimizing the effect of other duties which interrupt workflow. Their system involved assigning standard acuity scores based on special needs of patients such as isolation, diabetic ketoacidosis, specialty high risk medication, laboratory trending, and status as a step-down patient. The study concluded that using a mathematical programming technique could generate a workload-balanced assignment result that rivaled charge nurse derived assignments (Acar & Butt, 2016). Although the authors used a standard acuity score as opposed to a more dynamic score like the TOR, they did find that this model could match skills used by experts when determining nursing workload.

Garcia (2017) conducted a retrospective analysis of over 28,000 assessments in a 455-bed hospital to describe variable acuity among a population of patients with heart failure to determine if nursing assessments could be used for decision support related to staffing. Garcia found that using a standard acuity measure for all patients and assuming uniform nursing skills (such as implied by fixed nurse-to-patient ratios) make it difficult to plan for and calculate the cost of nursing care for individual patients. This ultimately impacts budgeting and resourcing. Acuity systems based on diagnosis, nursing tasks, etc. which are traditionally gathered manually are

both inefficient and subject to artificial increases in acuity scores over time. This study used a proprietary EMR acuity measure in conjunction with a nursing taxonomy. The author found that patients with congestive heart failure on general medical units had highly variable acuity, some which rivaled acuity in critical care in some instances indicating that acuity should be measured rather than assumed (Garcia, 2017).

Utilizing a combination of proprietary acuity calculation software with a specific set of indicators, Sir, Dundar, Steege, and Pasupathy (2015) studied 45 staff nurses working in the inpatient oncology and inpatient surgery units over a four-month period (over 5,000 patients) to determine how acuity affected workload as perceived by staff nurses. They attempted to identify associations between the acuity calculation software and perceived workload by individual nurses, develop a process to characterize the associations, and develop a model using the combination to generate workload balancing and nursing optimization outputs. Using a survey in association with the software, they found that the impact of acuity on workload varied widely between nurses; balancing workload based only on acuity did not actually change nurse's perception of a balanced workload, but the combination of acuity measure and survey measure did effectively balance workload (Sir et al, 2015).

Giuliano, Danesh and Funk (2016) studied the impact of nurse staffing data on 30-day readmissions for heart failure from 661 cardiology and heart surgery hospitals using a comparison of the nurse staffing index to readmissions. The nurse staffing index includes both in- and outpatient nursing full time equivalents divided by the adjusted average daily census. The median staffing index was 1.5 in the sampled hospitals. The authors considered hospitals with a staffing index of less than 1.5 as low staffing, and greater than 1.5 as high staffing.

Giuliano and colleagues found a significant difference ($P=0.021$) between the low and high staffing hospitals, with the low staffing hospitals having a higher excess readmission rate for patients with heart failure compared to those with high nurse staffing.

Several studies found increased rates of 30-day readmission for both surgical and medical conditions if the patients were discharged to a nursing home rather than directly home (Ammori, Navale, Schiltz and Koroukian, 2018; Jacobs, Noyes, Zhao, Gibson, Murphy, Sethi and Ochs-Balcom, 2018; Ohnuma, Shinjo, Brookhart and Fushimi, 2018). Further, Fernandes-Taylor et al, (2018) found that postoperative vascular surgery patients discharged to a skilled nursing facility (SNF) had a higher likelihood of surgical wound infections, respiratory and gastrointestinal complications and mortality. Fernandes-Taylor et al suggested that SNFs may be able to reduce these complications through nursing intervention and surveillance activities such as early identification of wound complications, mobilization, daily weights to assess fluid balance, and deep breathing and incentive spirometry. They also observed that patients with mobility devices (a surrogate for frailty) had a lower risk of wound infection and readmission due to the need for greater nursing resources to accommodate their needs. More appropriate application of nursing resources using a patient centric staffing methodology in hospitalized patients could identify those needing additional nursing care and could prevent the need for nursing home transfer.

The literature review revealed several areas needing further study. Fixed ratios do help ensure baseline staffing requirements, but do not fully address patient and nurse needs. Using the concept of equity as opposed to equality may be a more accurate way of ensuring the right staff assigned to the right patient. A standard measure for all patients such as an average acuity for the ward does not effectively assess requirements because it does not consider how individual

patient conditions change over the course of their hospital stay. The process for setting basic budget and manpower resources is better understood than the actual assignment and reassignment of nurses by the charge nurse from shift to shift. Charge nurses learn by experience to balance workload and consider both interruptions and skill level or expertise when making assignments, but the process varies widely and lacks standardization. There is little research done in this area. Consideration of how nurses themselves perceive the impact of acuity on their individual patient assignments better balances workflow. Few if any studies have evaluated using real-time patient acuity measures to determine nurse staffing, and the effects this might have on nurse sensitive indicators.

Theoretical Foundation

The American Association of Critical Care Nurses (AACN) Synergy Model describes characteristics of the patient, nurse, and system and how each contributes to outcomes (AACN, 2013). In describing characteristics of the patient, there are eight categories: resiliency, vulnerability, stability, complexity, resource availability, participation in care, participation in decision making, and predictability (Swickland, S. Swickland, W., Reimer, Lindell and Winkelman, 2014). Characteristics of the nurse include: clinical judgment, advocacy and moral agency, caring practices, collaboration, systems thinking, responding to diversity, facilitation of learning, and clinical inquiry (Swickland et al, 2014). Finally, characteristics of the system include outcomes of recidivism and cost/resource utilization (Swickland et al, 2014).

The AACN Synergy Model outlines a continuum from health to illness and recognizes that all patients share similar needs across this continuum (AACN, 2013). The assumption in the model is that the needs of the patient drive nursing practice, and as a result, the nurse is required

to have competencies across the dimensions of the whole patient to provide the most effective patient care (AACN, 2013). Nurse characteristics serve to synergize practice to address the whole patient (AACN, 2013).

The TOR algorithm was designed using the first four patient characteristics from the AACN Synergy Model: resiliency, vulnerability, stability, and complexity and includes evidence-based objective data points for each characteristic. Resiliency is defined as the capacity to return to higher function after insult; vulnerability is susceptibility to stressors; stability is the ability to maintain equilibrium; and complexity is the entanglement of two or more systems (Howard, 2016).

This QI project connected the four characteristics measured by TOR with characteristics of the nurse and system. Nurse characteristics germane to the study are: clinical judgment, systems thinking, and clinical inquiry. Clinical judgment can be enhanced with experience or CDS tools such as TOR. Because the whole patient must be considered when planning and executing nursing care, TOR was used to measure the patient's unique allostatic load which is measured by the four patient characteristics from the AACN Synergy Model. This concept reinforces the nurse's ability to use systems thinking. Clinical inquiry results from the knowledge of these two characteristics allowing the nurse to plan and execute patient-centered interventions to improve patient outcomes.

The system characteristics of outcomes and resource utilization are both of interest. The impact of appropriate nursing resources on patient outcomes is well understood (Hill, 2017; Needleman et al, 2011; Cho et al 2003). The VHA Nurse Staffing Methodology is a resource allocation strategy designed to provide appropriate nursing staff to the appropriate patients

thereby improving patient outcomes. This QI project aimed to enhance this resource allocation strategy with both patient and nurse characteristics described above.

Methods

The design was a quality improvement (QI) initiative approved by the Veterans Administration (VA) Center for Innovation under the Spark-Seed-Spread Innovation Investment program. Historical, retrospective quarterly data on both quality indicators and nursing surveillance indicators were collected before the implementation of TOR and for the quarter after TOR implementation. Where possible, quarterly data was collected from a similar time period to correct for seasonal changes in patient population.

Variables

The variables and clinical characteristics collected for the study are: Mixed medical surgical unit LOS (number of inpatient days divided by the number of discharged patients for both medical patients and surgical patients); mixed medical surgical unit transfers to intensive care unit (ICU) (percent mortality); mixed medical surgical unit HAPU (percent of patients with 2+ greater than 48 hours LOS), all cause 30-day readmissions (percent of patients readmitted). These data were monitored through the VHA Support Service Center (VSSC) database (Table 1) comparing similar quarters from the previous and current fiscal year. RRT activations from mixed medical surgical unit (number per month), and cardiac arrests rates from the mixed medical surgical unit (number per month) were collected by the facility locally (Table 1). In addition, daily charge nurse staffing sheets which include details about the patient, room number, and nurse assigned were collected prior to implementation. These were collected through the implementation period and retrospectively assessed for increased staffing flexibility. Staffing

flexibility was measured by assignment of the nurse to either room 4 or 8 and room 13 or 14 on the charge nurse staffing sheets.

Sample

This QI initiative used data from all adult patients (≥ 18 years of age) in a 15-bed adult inpatient medical/surgical unit at a VHA hospital. Patients with obstetric and psychiatric admissions were excluded. Quality indicators were aggregated number of events with timeframes as follows: LOS-quarterly; Transfers to ICU-quarterly; HAPU-quarterly; 30-day readmissions -quarterly; RRT activations-monthly; Code Blue-monthly; mixed medical surgical unit staffing sheets-each shift.

Intervention

The intervention is TOR, a CDS which uses twenty-four disparate data points from the electronic medical record (EMR) in adult hospital patients as objective measures for the four elements of complexity, stability, vulnerability, and resiliency. Each of the data points have been used in other studies, and a sample of the relevant predictive statistics is in Appendix A. Homeostasis describes body system's ability to reduce variability and maintain a steady environment through homeostatic processes (Logan & Barksdale, 2008). An extension of homeostasis is allostasis, or the physiological adaptations that occur to maintain stability of the system in response to challenges to the system (Logan & Barksdale, 2008). Allostatic load is the point where the system is unable to adapt to the challenges because the load is too great, or systems are failing (Logan & Barksdale, 2008). Objective measurement of allostatic load described by Seeman, Singer, Rowe, Horwitz and McEwen, (1997) involves ten individual indicators representing wear and tear on different systems: cardiovascular activity, adipose

deposition, atherosclerotic risk, glucose metabolism, hypothalamic-pituitary-adrenal (HPA) axis, and sympathetic nervous system activity. Measurement of multisystem functioning using biomarkers indicating subclinical symptoms instead of clinical diagnoses was more predictive in mortality and declining physical functioning in elderly patients (Mauss, Li, Schmidt, Angerer and Jarczok, 2015).

The TOR was developed to provide a measure of the complex interplay between physiologic systems and their impact on the individual patient. TOR data represent a snapshot of major metabolic, hematopoietic, and inflammatory processes, plus direct measures of physical processes and processes indicative of overall wear and tear. TOR measures complexity using 13 separate physiologic measures: Number of diagnoses; number of medications prescribed; serum sodium; serum potassium; serum creatinine; hemoglobin, hematocrit; white blood cell (WBC) count; number of immature forms of WBC (“bands”); platelet count; glucose; C-reactive protein; and lactate. Vulnerability (susceptibility to stressors) is measured using four data points: Age; fall risk score (in this study, the Morse Fall Scale); weight; and mean arterial pressure. Stability (the ability to maintain equilibrium) is measured using respiratory rate; heart rate; systolic blood pressure, temperature; and pulse oximetry. Resiliency, (the capacity to return to higher function after insult) is measured using two physiologic measures: high density lipoprotein and albumin. Because of the difference in measurement scales for these physiologic processes, TOR normalizes each value into a scale from zero (normal value) to three (highly abnormal). Thus, a serum sodium level of 140 is a TOR score of zero, but serum sodium of 110 or higher than 160 equates to a score of three; a serum potassium of 5.0 is a zero TOR score, but a serum potassium of 2.4 or 7.0 equates to a TOR score of three.

QI Measures of Success

To measure the impact of the addition of TOR to existing Nursing Staffing Methodology, the QI initiative collected data on HAPU, 30-day readmissions, LOS, ICU transfer rate from VSSC data, and existing daily staffing sheets, code blue and RRT activation logs from the facility. Historical measurement of the previously identified QI goals/indicators were compared to post innovation implementation data.

Data Collection

Data collection consisted of reviewing pre-intervention metrics from retrospective VSSC data listed above for a quarter pre-innovation intervention phase and a quarter after innovation implementation.

Procedure

The TOR score for each patient was calculated by the nurse staffing coordinator each day and posted on the secured local SharePoint site. The nurse staffing coordinator worked on a separate, VHA supported pilot of the TOR and training on procedures on calculating the score, use of the different aspects of the score and securely storing information. The local privacy officer reviewed and approved the process.

Training for the charge nurses on the mixed medical surgical unit on the use and interpretation of TOR scores was completed in July 2018. After training, charge nurses were given access to the local SharePoint site to review and incorporate TOR scores in conjunction with their daily staffing decisions.

Training on the use of TOR was provided to the Nursing Staffing Methodology Coordinator, which involves data mining for 24 measures in the EMR and placing it on the SharePoint spreadsheet. The initial pilot included a limited number of calculations for 4 patients over a 5-day period to prove the feasibility of the QI project. Lessons learned were applied to the process. The next steps involved the integration of the TOR calculations into normal workflow of the Nursing Staffing Methodology Coordinator. Since the VSSC data access was already obtained, no additional requests were required. Charge nurses required training on the use of TOR for daily staffing assignments in conjunction with the existing Nursing Staffing Methodology data, the use of the total score and implications for significant changes in TOR scores for individual patients. Charge nurse were given access to the TOR data on a secure SharePoint site. TOR data was presented for all patients admitted on the SharePoint and also on the daily staffing sheet. Patients were listed in separate columns to ease comparison.

The TOR algorithm is a Microsoft Excel worksheet located on a secure SharePoint site at the study hospital. The spreadsheet includes tabs for raw data entry, and a summary page with scores for each of the four major categories of complexity, stability, vulnerability and resiliency as well as a total score for each patient. Charge nurses used the summary page TOR data which included the four-individual component and total scores for each patient, and displays the prior week's TOR scores for each patient. At the beginning of their shift they used the TOR scores to augment the daily nurse assignment process. The TOR was also documented on the daily staffing sheet for the unit.

Data analysis

Changes in rates between pre- and post-intervention were used to determine effectiveness of the intervention for all goals except nursing staffing schedule flexibility. Descriptive statistics were used to assess for changes to mixed medical surgical unit nursing staffing schedule flexibility as shown in Tables 4 and 5. These data were analyzed using SPSS software.

Data were compiled from historical VSSC data prior to implementation including: mixed medical surgical unit LOS (number of inpatient days divided by the number of discharged patients); mixed medical surgical unit transfers to intensive care unit (ICU) (percent mortality); mixed medical surgical unit HAPU (percent per quarter), 30-day readmissions (percent per quarter).

Data was compared using similar time periods and time of year to correct for seasonality. There were 32 patients in the pre-intervention period, and 85 in the post intervention period. These same VSSC data was collected for appropriate time period after implementation of TOR. RRT activations from the mixed medical surgical unit (number per month), and cardiac arrests rates from the mixed medical surgical unit (number per month) were collected by the facility locally for two months pre- and post- TOR implementation. Daily charge nurse staffing sheets were collected prior to implementation, and through the implementation period to determine increased staffing flexibility. All patient data were stored on the local SharePoint controlled by the Nursing Staffing Methodology Coordinator. Data analysis used de-identified data from VSSC (Table 1).

Timeline

After Institution Review Board review determined the project was QI, active TOR calculations by the nursing staffing methodology coordinator began in September 2018 and ran

for one month. This limited active data collection period was due to the time constraints presented by manual data collection and entry from the EMR. Retrospective data collection began in September 2018 as well and continued two months after TOR implementation. An additional week was added to compile data prior to data analysis (Table 6).

Ethical Considerations

Charge nurses were given the opportunity to use TOR in the context of QI and as the end users of the tool, and help determine future use. Since none of the individuals conducting the QI initiative work for the researcher or staffing methodology coordinator, there was no risk for non-participation for those charge nurses that choose not to participate. Patient safety was a concern. The study design used TOR as a supplement to existing staffing processes to inform rather than replace the existing rules and regulations. The use of TOR as a supplemental tool reduced the risk.

Results

Results from VSSC collected data are in Table 2. Results of RRT activation and code blue events are in Table 3. Staffing flexibility data are in Tables 4 and 5. After implementation of TOR, the project demonstrated a reduction of 0.3 days in mixed medical surgical unit LOS, but did not achieve the goal of a 0.5-day reduction. There was no difference in 30-day all cause readmission rates before and after implementation of TOR. There was a greater than 10% reduction in HAPU rate that met the 10% goal, however the sample size was small (n=5 combined) which did not provide ample evidence to determine significance. The total number of RRT and code blue events decreased after implementation of TOR, the changes were not

significant due to small sample size (code blue activations (n=1), RRT activations (n=5)). ICU transfers (n=1) increased from preintervention, but was not significant due to small sample size.

Prior to TOR implementation, staffing was based on location, clustering nurses in specific geographic locations on the unit. After the implementation of TOR, 16.7% of assignments were made without regard to geographic locations to balance patient acuity. This was measured by assignment of the nurse to either room 4 or 8 and room 13 or 14 on the charge nurse staffing sheets. There was no statistically significant difference in staffing assignment changes (assignment of the nurse to either room 4 or 8 and room 13 or 14 on the charge nurse staffing sheets) before and after implementation of TOR in the data ($X^2=2.689$, $p=0.101$) (Table 4). However, the phi (effect size) indicated that there is a small-medium effect size when comparing assignment changes as a result of the intervention. The reason for the non-significance is probably due to the small sample size (low power). We also examined the relationship between shifts and geographic assignment post implementation. Assignment of nurses to room 4 or 8 and room 13 or 14 (increased staffing flexibility) was more likely to occur on day shift: 20.6% had a variation on morning shift; 5.9% had a variation on evening shift. This difference between shifts is also not statistically significant and probably due to small sample size ($X^2=3.202$, $p=0.074$, $\phi=0.217$). Due to the limited sample size, we could not run a logistic regression.

Discussion

Upon completion of the project, local leadership was provided the outcomes of the innovation project, and any lessons learned during implementation. Recommendations were based on the outcomes. Additionally, the VA Center for Innovation was provided results of the

project in accordance with requirements from the Spark-Seed-Spread innovation investment program.

The VHA Office of Nursing Service (ONS), Nursing Operations requested information on productivity models and staffing models used in both in- and out-patient settings. In response to this request, the Program Manager for Nursing Staffing methodology for ONS was briefed regarding this QI project. There was significant interest in TOR to supplement the existing process because the current process lacks objective measurement of patient acuity or allostatic load.

The VHA National Program Director for Pulmonary Critical Care Medicine expressed interest in the TOR's capability to predict undesired outcomes. A possible use case in the intensive care inpatient units was explored and the algorithm was shared to develop a possible interface with the ICU EMR. Initial work began to develop an interface between the ICU EMR and the TOR algorithm and is ongoing.

There were several limitations in this study. The unit was a small medical surgical unit, and the data collection period was short, which limited the sample size. Charge nurses began using TOR scores in the process of daily nursing assignments in September 2018. TOR data was placed on the daily charge nurse assignment sheet with the previous day's TOR score also displayed. Charge nurses modified nursing staffing to ensure that no nurse had more than one patient with an increased TOR score of three or more from the previous day.

Prior to TOR implementation, staffing was based on location, clustering nurses in specific geographic locations on the unit. After the implementation of TOR, 16.7% of assignments were made without regard to geographic locations. This indicated a small-medium

effect size between intervention and assignment change. When we examined the relationship between shifts and assignment variation, we found that the morning shifts had more variations (20.6%) than the evening shifts (5.9%). These results are not statistically significant. Further studies with larger sample sizes are needed to investigate the use of TOR on staffing assignment while controlling for the shifts.

The project demonstrated a reduction of 0.3 days in mixed medical surgical unit LOS, but this did not meet the desired reduction stated in the objective. There was no difference in 30-day all cause readmission. There were changes in HAPU rates that met the 10% goal, however the sample size was small (n=5 combined), and these data should be evaluated using that information. The small sample size also impacted the reduction in code blue activations (n=1), RRT activations (n=5) and ICU transfers (n=1).

Charge nurses and leadership recognized difficulties resulting from manually producing TOR during the leadership presentation. This resulted in delays posting the TOR on the charge nurse assignment sheets and limited its' effectiveness. They indicated that the TOR was a welcome addition to the process, but it would require automation to be of practical use.

Summary

The use of TOR was related to a decrease in LOS of 0.3 days post-implementation, and a slight reduction in 30-day readmission, however neither achieved the project objective goals. Ward transfer increased to 10% from zero, however this represents a difference of one patient in the small sample size. Total HAPU decreased from 1.6% to 1.3%, did meet the objective of reducing HAPU by 10%, however the small sample size also limits the generalizability of this outcome. There was an overall reduction in difference in RRT activations and code blue/cardiac

arrest events between pre- and post-intervention timeframes, but these did not reach statistical significance. The likelihood of a nurse being assigned outside of traditional geographical boundaries because of the addition of TOR to the staffing methodology increased from 0% pre-implementation to 16.7% post implementation, but did not achieve statistical significance.

The average TOR scores decreased from day one to day three of admission (average LOS for the facility) after implementation (pre-intervention TOR increased at discharge by a 0.4; post-intervention decreased by 0.7 at discharge). Although not one of the stated project objectives, this may indicate the addition of TOR to existing nursing staffing methods improves nursing surveillance and reduces patient's allostatic load. More study will be required to determine if this continues with a larger sample over a longer period.

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Tables, Figures and Appendices

Table 1: Description of variables

QI Objective	Data Source	Operational Definition
Reduce mixed medical surgical unit LOS by 0.5 days	VSSC LOS	Number of days number of inpatient days divided by the number of discharged patients; (monthly metric for medical and surgical patients separately and quarterly metrics for total combined on the unit)
Reduce mixed medical surgical unit HAPU by 10%	VSSC HAPU	Number of patients with LOS>48 hours with 2+ HAPU divided by number of discharges (quarterly metric)
Reduce mixed medical surgical unit transfers to ICU by 10%	VSSC transfers to ICU	Percent mortality of patients transferred from ward to ICU (quarterly metric)
Reduce all cause 30-day readmissions by 10%	VSSC 30-day readmissions	Percent readmitted-all cause (quarterly metric)
Increase RRT activations from mixed medical surgical unit by 10%	Local log of RRT activations from mixed medical surgical unit	Number per month (monthly metric)
Reduce mixed medical surgical unit code blue activations by 10%	Local log of code blue activations from the mixed medical surgical unit	Number per month (monthly metric)
Increase mixed medical surgical unit nursing staffing schedule flexibility	Local daily charge nurse staffing sheets	Staff flexibility based TOR; defined as nurse assigned either room 4 or 8 and room 13 or 14

Table 2 Pre- and Post-Implementation Results

	LOS (days)	Readmission30day %	mixed medical surgical unit HAPU%	ICUMortality due to transfer%
facility Pre	3.7	8.56	1.6	0
facility Post	3.4	8.49	1.3	10
national Pre	4.38	9.55	1	17.31
national Post	4.28	9.28	1	18.5

Table 3. RRT and Cardiac arrest activation changes

	Jan-Aug 18 (Pre)	Sep-Oct 18 (Post)
RRT activation	4 (0.5/month)	1 (0.5/month)
Cardiac arrest activation	1	0

Table 4. TOR based assignment change

intervention * TORBasedAssignmentChange Crosstabulation					
			TORBasedAssignmentChange		Total
			0	1	
intervention	post	Count	45	9	54
		% within intervention	83.3%	16.7%	100.0%
		% within TORBasedAssignment Change	76.3%	100.0%	79.4%
		% of Total	66.2%	13.2%	79.4%
	pre	Count	14	0	14
		% within intervention	100.0%	0.0%	100.0%
		% within TORBasedAssignment Change	23.7%	0.0%	20.6%
		% of Total	20.6%	0.0%	20.6%
		Count	59	9	68
		% within intervention	86.8%	13.2%	100.0%

	% within TORBasedAssignment Change	100.0%	100.0%	100.0%
	% of Total	86.8%	13.2%	100.0%

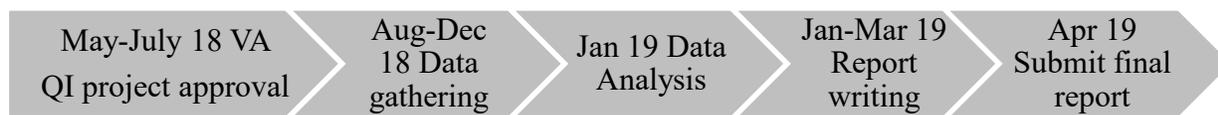
$X^2=2.689$, $p=0.101$, $\phi=0.199$

Table 5. TOR based assignment change by shift

shift * TORBasedAssignmentChange Crosstabulation					
			TORBasedAssignmentChange		Total
			0	1	
shift	evening	Count	32	2	34
		% within shift	94.1%	5.9%	100.0%
		% within TORBasedAssignment Change	54.2%	22.2%	50.0%
		% of Total	47.1%	2.9%	50.0%
	morning	Count	27	7	34
		% within shift	79.4%	20.6%	100.0%
		% within TORBasedAssignment Change	45.8%	77.8%	50.0%
		% of Total	39.7%	10.3%	50.0%
Total	Count	59	9	68	
	% within shift	86.8%	13.2%	100.0%	
	% within TORBasedAssignment Change	100.0%	100.0%	100.0%	
	% of Total	86.8%	13.2%	100.0%	

$X^2=3.202$, $p=0.074$, $\phi=0.217$.

Table 6. Timeline



Appendix A

Examples of individual TOR data point predictive statistics

Age: Risk of death increases in ICU patients from 0.436 in 45-54 year old ($p < 0.01$) to 1.113 in 65-74 year old ($p < 0.01$); Knaus, Draper, Wagner and Zimmerman, 1985

Number of Diagnoses: The number of comorbid diseases significantly increased 1-year mortality in a linear fashion ($p < 0.05$); Charlson, Pompei, Ales, and MacKenzie, 1987

Number of medications: Polypharmacy (> 6 medications) increased 30-day readmission risk by 9.6% ($p < 0.05$); Logue, Smucker and Regan, 2016 and Donze, Drahomir, Williamd and Schnipper, 2013. The number of medications predicted health care changes and ambulatory visits ($R^2 = 13.6\%$ and 15% respectively); Perkins, Kroenke, Unutzer, Katon, Williams, Hope and Callahan, 2004.

Respiratory Rate: Abnormal respiratory rate was associated with increased risk of in-hospital cardiac arrest (OR 3.49, 95% CI, $p < 0.013$); Hodgetts, Kenward, Vlachonikolis, Payne, and Castle, 2002. One or more events of elevated respiratory rate (> 27 breaths/min) predicted in-hospital cardiac arrest (OR 5.56, 95% CI, $p < 0.001$); Fieselmann, Hendryx, Helms and Wakefield, 1993.

Heart Rate, Temperature, systolic blood pressure: Individual critical measures in each of these parameters increases odds of death by 0.92%; presence of three simultaneous critical vital signs with these parameters increases odds of death by 23.6% ($p < 0.05$); Bleyer, Vidya, Russell, Jones, Sujata, Daeihagh and Hire, 2011. Abnormal pulse rate and systolic blood pressure were associated with increased risk of in-hospital cardiac arrest (OR 4.07, 95% CI, $p < 0.001$ and 19.92 95% CI, $p < 0.001$); Hodgetts et al, 2002.

Mean Arterial Pressure: A MAP < 65 mmHg predicted 30-day mortality in ICU patients ($p < 0.001$) with an area under the curve of 0.853 and a 95% confidence interval; 0.772-0.934); Varpula, Tallgren, Saukkonen, Voipio-Pulkki, and Pettila, 2005

Weight: 30-day readmission risk associated with weight loss (OR 1.26; 95% CI 1.09-1.47, $p < 0.0449$); Allaudeen, Vidyarthi, Maselli and Auerbach, 2011. 6-month readmission risk and underweight (BMI < 18.5) OR 12.7, $p < 0.004$, and obese (BMI > 30) OR 2.6, $p < 0.07$; Mudge, Kasper, Clair, Redfern, Bell, Barras, Dip and Pachana, 2011.

Pulse oximetry: Reduced pulse oximetry was associated with increased risk of in-hospital cardiac arrest (OR 4.1, 95% CI, $p < 0.001$); Hodgetts et al, 2002

White Blood Cell count: Counts greater than $12,000/\text{mm}^3$ or less than $4,000/\text{mm}^3$ (OR 1.5, 95% CI); Zhao, Heard, Mullen, Crawford, Goldberg, Frenzl and Lilly, 2012.

Hemoglobin: Less than 12g/dL increased 30-day readmission ($p < 0.05$); Donze et al, 2013. Anemia (also defined as hgb of less than 12g/dL) independently predicted mortality at six months with an odds ratio of 1.96 (95% confidence interval $p < 0.001$); Groenveld, Januzzi, Damman, van Wijngaarden, Hillege, van Veldhuisen, and van der Meer, 2008

Hematocrit: Anemia (defined as hct range of 36.6% to 42.7%) independently predicted mortality at six months with an odds ratio of 1.96 (95% confidence interval $p < 0.001$); Groenveld et al, 2008

Platelets: Thrombocytopenia identified as a variable in diagnostic criteria for sepsis; Dellinger, Levy, Rhodes, Annane, Gerlach, Opal, Sevransky, Sprung, Douglas, Jaeschke, Osborn, Nunnally, Townsend, Reinhart, Kleinpell, Angus, Deutschman, Machado, Rubenfeld, Webb, Beale, Vincent, Moreno, and the Surviving Sepsis Campaign Guidelines Committee including the Pediatric Subgroup, 2013.

Bands: (Immature WBC) greater than 10% (OR 6.08, CI 95%); Zhao et al, 2012.

Albumin: Decreased albumin identified as an indicator of impending organ dysfunction; Dodge, 2010. Six month mortality was negatively associated with increasing albumin (RR 0.35, OR 0.14-0.86); Sullivan, Roberson, Johnson, Mendiratta, Bopp and Bishara, 2007.

Glucose: Hyperglycemia in absence of diabetes identified as a variable in diagnostic criteria for sepsis; Dellinger, et al, 2013. Glucose control reduced new onset kidney dysfunction, ventilator weaning time, and length of stay in the medical ICU ($p < 0.04$; $p < 0.03$ and $p < 0.04$ respectively); Van den Berge, Wilmer, Hermans, Meersseman, Wouters, Milants, Wijngaerden, Bobbaers and Bouillon, 2006.

Creatinine: Elderly patients (> 65 years) with elevated creatinine levels (> 1.5 mg/dl for males or > 1.3 mg/dl for females) had mortality were more likely to develop cardiovascular disease, stroke, congestive heart failure, and symptomatic peripheral vascular disease ($p < 0.001$); Fried, Shlipak, Crump, Bleyer, Gottdiener, Kronmal, Kuller and Newman, 2003. Also, an independent predictor of mortality in cardiac resynchronization therapy patients ($p < 0.032$); Shalaby, El-Saed, Voigt, Albany and Saba, 2008. Also implicated in recognition of sepsis (OR 1.43, CI 95%) Zhao, et al, 2012.

Sodium: Less than 135mEq/L increased 30-day readmission ($p < 0.05$); Donze et al, 2013

Potassium: Identified as indicator of organ dysfunction in APACHE II; Knaus et al, 1985. Also identified as indicator of end organ dysfunction in SAPS; Le Gall, Lemeshow and Saulnier, 1993.

C-reactive protein: Surviving Sepsis Campaign criteria; Dellinger et al, 2013.

Lactate: Greater than 1 mmol/L (OR 6.68, CI 95%); Zhao et al, 2012.

HDL: HDL concentration negatively correlated with cortisol excretion (r^2 0.27 male ($p < 0.01$), - 0.22 female ($p < 0.05$); Fraser, Ingram, Anderson, Morrison, Davies and Connell, 1999. Higher HDLC positively correlated with resiliency as measured by a hardiness measure (DRS-15r) r^2 0.115, $p < 0.004$; Bartone, Spinosa, Robb and Pastel, 2008

Fall Risk: Fall-related injuries account for up to 15% of hospital readmissions and are the leading cause of accidental death in those older than 65 years; Currie, 2008.