Final Report

Impact of Unit Level Nurse Workload on Patient Safety

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Abstract

Purpose
Study aims were to test associations between daily nurse staffing in adult medical-surgical units and hospital acquired pressure ulcers, patient falls and other significant events. This study integrated a measure of workload, admissions, discharges and transfers to explore how the "pace" of patient care impacted patient safety.

Scope
This 2-year AHRQ Working Conditions and Patient Safety study built on the work of the California Nursing Outcomes Coalition (CalNOC) to engage acute care hospitals in using ANA nursing indicators for reporting staffing, patient safety and quality indicators in a research, repository development and benchmarking project. In 25 acute care, not-for-profit California hospitals participants in the CalNOC, the sample included urban and rural sites with an average daily census from 100 to 400 plus. Most patients' principal diagnosis was medical (66%).

Methods
A prospective, descriptive correlational design tested associations between daily unit level nurse staffing, skill mix, hours of care, contract hours of care, workload and patient outcome measures. Falls were "unplanned descents to the floor".

Results
Registered Nurse (RN) Hours of Care was significantly associated with outcomes. In addition, percent RNs with BSN or higher was associated with fewer falls. Unit activity index and hospital complexity (measured by bed size) were also significant predictors of falls. Percent of patients with hospital acquired pressure ulcers was significantly associated with mean staffing ratio and with percent days with the staffing under 100% for week PRIOR to the prevalence study. Greater percent certified RNs was associated with lower percent of restrained patients.

Key Words
Acute care; nurse staffing, patient falls, hospital acquired pressure ulcers, patient care safety.

Study Purpose

The *Unit Level Nurse Workload Impacts on Patient Safety Study* was a 2-year descriptive correlational study that leveraged the capacity of the California Nursing Outcomes Coalition (CalNOC) to engage acute care hospitals statewide in voluntarily using American Nurses' Association (ANA) nursing quality indicators for reporting standardized nurse staffing, patient safety and standardized quality metrics in a collaborative repository development and benchmarking project. CalNOC, one of the first six ANA state-based nursing quality research and development projects, was created to advance improvements in patient care quality and safety through development of a statewide nursing quality database, and to conduct studies examining the effects of nurse staffing on the outcomes of patient care. CalNOC is the largest ongoing statewide prospective nursing quality measurement research and development project in the nation, and a major contributor of data to the ANA's National Database for Nursing Quality Indicators (NDNQI). This study capitalized on the existing CalNOC quality measurement, reporting and benchmarking infrastructure. Drawing from CalNOC's statewide convenience sample of acute care adult medical-surgical units, this study traced unit-level, daily, direct care nurse staffing in 77 units, drawn from 25 hospitals, over a two (2) month period and examined the association between the structure of direct care daily staffing, workload intensity (patient admissions, discharges, & transfers) and key nurse sensitive patient safety outcomes.

Primary study aims were to:

1. Test associations between measures of *unit level daily staffing* including, hours of care per patient day (HPPD), ratio of required to actual HPPD, caregiver skill mix, use of contract workers, RN years of experience on adult acute care medical surgical units, *the incidence of patient falls, prevalence of hospital acquired pressure ulcers and restraint use, and significant clinical events*.

2. Test associations between *unit level daily workload intensity* (Admissions, Discharges, and Transfers Index) on adult acute care medical surgical units, *the incidence of patient falls, prevalence of hospital acquired pressure ulcers, restraint use and significant clinical events*.

3. Test associations of daily variation in *measures of unit level staffing and workload intensity, (patient admissions, discharges, & transfers)* on adult acute care medical surgical units, and *the incidence of patient falls, prevalence of hospital acquired pressure ulcers, restraint use and significant clinical events*.

Scope of the Project

Context and Background

The *Unit Level Nurse Workload Impacts on Patient Safety Study* evolved from pilot work by the California Nursing Outcomes Coalition (CalNOC) to build both the measurement infrastructure and the robust data repository necessary to study key clinical and patient safety outcomes. It is important to note the context of this study, undertaken in late 2002 and 2003 as California prepared to implement mandated nurse-patient ratios, arising following a period in which converging forces challenged the integrity of the American health care delivery system. This study was informed by these contextual influences and was designed to examine and describe the impact of direct care staffing on selected measures of patient care safety at the unit level:

- Evolving over nearly two decades, prospective payment and spreading penetration of managed care funding mechanisms resulted in major restructuring of health care delivery systems in an effort to strategically align utilization of services, costs and reimbursement incentives (Aiken, Clarke & Sloane, 2000a; Aiken Havens & Sloane, 2000b; Aiken, Sochalski & Lake, 1997; President's Advisory Commission, 1998; Curran & Mazzie; 1995; Walston, Burns, & Kimberly, 2000; Wiener, 2000; The Advisory Board, 2000a).
- Hospital reorganization and restructuring, in response to regulatory and marketplace imperatives, substantially redesigned inpatient care services resulting in reductions in RN-to-patient ratios, increased demands on direct care RNs due to decentralization of ancillary services and loss of mediating middle management and buffering clinical support services. Simply put, hospitals reconfigured and redeployed their most expensive human resources to achieve critical clinical and cost efficiencies by setting new productivity standards, in an effort to do more with less (ANA, 2000; Foley, 1999; The Advisory Board, 1999; 2000).
- Healthcare economic turbulence incentives drove hospitals to reduce labor costs, increase productivity and expand cost-effective patient volumes. Consequently workload intensity, admissions, discharges and transfers per bed intensified. As a result, fewer nurses provided care for more patients within any given 24 hour period of time (Tillman, Salyer, Corley, & Mark, 1997).

- RN to patient ratios were based upon patient needs, filtered through hospital patient acuity system instruments, revised in response to regulatory mandate and accreditation specifications, moderated by professional judgment and mediated by budgetary constraints; all operating in an evidence vacuum since the scientific basis for determining safe unit level or hospital level nurse staffing ratios, skill mix or experience mix is unknown (Buerhaus, 1997; Buerhaus & Needleman, 2000; Cary, 2000, Herringer, 2000; Wunderlich, Sloan & Davis, 1996; ANA, 2000).
- Consumers, policy makers and the media, faced with compelling evidence, concluded that the health care system exposes patients to iatrogenic risks, errors, omissions and complications which lead to unnecessary suffering and complications, prolonged recovery, extraordinary costs and 44,000 to 98,000 unnecessary deaths per year (Bates et al., 1997; Committee on Quality of Health Care in America, 2001; Presidents Advisory Commission on Consumer Protection and Quality in the Health Care Industry, 1998; Quality Interagency Coordination Task Force, 2000) catalyzing legislative initiatives leading, in 2002, to the nation's first mandatory minimum nurse-to-patient staffing ratios in California.

Associations between Daily Direct Care Nurse Staffing and Clinical Outcomes

Rigorous integrative reviews of research investigating links between hospital nurse staffing and patient outcomes, represented by myriad adverse events, have revealed inconsistent results (Lang et al., 2004; Seago, 2001; Wunderlich, Sloan, & Davis, 1997; Mitchell & Shortell, 1997; Needleman, Buerhaus, Mattke, Stewart & Zelerinsky, 2001) with a preponderance of evidence confirming links between selected nurse-sensitive outcomes and patient safety (Seago, 2001; Lang et. al 2004). Despite methodological diversity in the unit of analysis, inconsistent sources of data for nurse staffing and patient outcomes, these variables have been typically examined as a whole in systematic literature reviews, perhaps blurring insight that might be gleaned from clustering articles based on data source and levels of analyses. For example, in five studies examining staffing and outcomes within a single hospital or across small numbers of institutions (14 or fewer), using *unit-level* staffing and outcomes data generated by the institution (with the exception of patient satisfaction/complaints), a strong and consistent *pattern* of associations between nurse staffing and target adverse clinical events has not been observed (Blegen, Goode & Reed, 1998; Flood & Diers, 1988; Mitchell, Shannon, Cain & Hegyvery, 1996; Moore, Lynn, McMillen & Evan, 1999; Taunton et al, 1994).

In contrast, among larger, multi-site studies, in which investigators have used readily available public datasets as sources of staffing and clinical outcome data enabling them to study larger numbers of hospitals but limiting them to *hospital-level* unit of analysis, associations between nurse staffing and patient outcomes are reported. Strong inverse correlations between nurse staffing and patient mortality have been reported (Aiken, Smith & Lake, 1994; Aiken, Clarke & Sloane, 2000; Hartz et al, 1989), as well as adverse clinical events believed sensitive to the quality of nursing care, including nosocomial pressure ulcers, infections, pneumonia, urinary tract infections, deep vein thrombosis and medication errors (ANA Network, Inc., 1997; 2000; Blegen & Vaughn, 1998; Hartz et al., 1989; Kovner & Gergen, 1998) (Note: Blegen & Vaughn ,1998, used staffing data provided by each of 11 hospitals and unit level outcomes data obtained from a secondary data source in their study). As a case in point, while researchers using large administrative datasets have observed links between hospital nurse staffing and nosocomial infections, Taunton et al (1994), using hospital generated data across four large Midwestern hospitals, found no relationship between patient infections and RN unit-level staffing and absenteeism over a six month period. Sovie's (2000) 3 year study examining the impact of restructuring and patient care reengineering on nursing care in 29 University Teaching Hospitals found patient falls, nosocomial pressure ulcers, urinary tract infections and patient satisfaction related to RN hours of care. In contrast, Needleman, Buerhaus, Mattke, Stewart & Zelerinsky's (2001) landmark study of 755 hospitals in 11 states, including California, used public datasets to examine associations between hospital level nurse staffing and 14 meticulously explicated patient outcomes potentially sensitive to nursing (OPSN) in their separate samples of medical and surgical patients. The investigators found strong and consistent associations between nurse staffing and urinary tract infections, pneumonia, upper gastrointestinal bleed, shock/cardiac arrest and length of stay, in medical patients. However, when they examined associations between 14 OPSNs among surgical patients, only failure to rescue, an exploratory variable, was significantly related to nurse staffing. More importantly, among surgical patients, they did not find evidence of an association between staffing and pressure ulcers, deep vein thrombosis, mortality, sepsis, wound infection, or pulmonary failure, all OPSNs associated with staffing previously reported by other investigators. The findings reaffirm the conclusion "large comparisons of hospital outcomes show few structural factors consistently related to lower mortality" (Mitchell & Shortell, 1997). Jackson, Chiarello, Gaynes and Gerberding (2002) concluded, after synthesizing literature examining nurse staffing and health care associated infections "there is compelling evidence of a relationship between nurse staffing and adverse patient outcomes, despite the different approaches".(p. 319-320).

Given CalNOC's unique capacity to collect prospective, hospital generated nurse staffing and patient outcomes data at the unit level, the *Unit Level Nurse Workload Impacts on Patient Safety Study* provided an opportunity to test associations between the structure of hospital nurse staffing as close to the point of care as possible--daily at the unit level. In addition, we used measures considered authoritative indicators of patient outcomes and safety commonly

tracked by acute care hospitals—falls, pressure ulcers, restraint prevalence and significant clinical events. Importantly, CalNOC hospital sites had prerequisite precision in hospital generated data collection and transmission, expediting the study timeline, and minimizing the introduction of error associated with variation in measures or data capture. Because direct care staffing resources are closely tracked and adjusted during shifts of work within each 24 hour day as patient volume and acuity demands require, structural components of nurse staffing, for example, hours of direct care and skill mix, may vary significantly daily on any given patient care unit. CalNOC collects monthly direct care staffing data, derived from daily staffing averages, but the impact of aggregation on measurement sensitivity is unknown. This study traced and analyzed daily variation in staffing with unprecedented precision and examined its effect on patient safety and outcomes significantly improving current CalNOC measurement precision.

At the suggestion of chief nursing officers, this study also examined nursing workload measurement. While systems for computing nursing-to-patient care resource allocation are not new, the literature suggests that a new paradigm is needed to account for "clinical turbulence"—the "unstable and rapidly changing environment, [that] has been a major feature of the past decade, and will continue in the turmoil associated with health care reform" (Salyer, 1995, p. 12). A prominent feature of clinical turbulence is workload intensity or the number of patient admissions, discharges and transfers (ADT) within the unit over a 24-hour period. Rapid pace of patient turnover, (patient admissions, discharges, & transfers), an indicator of workload intensity, may be a factor affecting patient safety because of its impact on "self-evaluation quality of interpersonal relationships and communication" (Salyer, 1995, p. 19). The numbers of admissions and discharges from a unit have been associated with a negative impact on nursing process implementation and the quality of technical skills performance by nurses (Salyer, 1995). At the behest of CalNOC clinicians and their leaders, this study design recognized and quantified the impact of workload intensity (patient admissions, discharges, and transfers), and examined associations between nurse staffing and outcomes.

Conceptual Perspective for the Study

The conceptual perspective guiding this study was grounded in the knowledge that the potential to compromise patient safety through human error is inherent in nursing practice and medical care (Kohn, Corrigan & Donaldson, 1999; QUIC, 2000; Reason, 1990). Reason's (1990) principles of human performance and human error production support prima facie acceptance that the potential for latent error in a system far exceeds actual errors. Actual errors and their impact on patient safety that reach or exceed the threshold for recognition and reporting may be viewed as the "tip of the error iceberg". Errors captured in hospital's official adverse event data, incident reports and sentinel event documentation then, are evidence of a system interacting with the inherent risks presented by the patient, the patient's disease process, and an extraordinarily complex interaction of diverse health care providers, technologies and materials (Leape et al., 1991) converging in the form of active, injurious error and patient injury. Reported errors represent a fraction of the actual errors occurring in health care with unknown impacts on quality, costs and outcomes (Kohn, Corrigan & Donaldson, 1999, 1999; Presidents Advisory Commission on Consumer Protection and Quality in the Health Care Industry, 1998; Quality Interagency Coordination Task Force, 2000). The view that nurses are "quality and safety monitors in health care", (Foley, 1999, p.5), by virtue of their universal proximity and continuous presence at the patient's bedside where a significant proportion of preventable errors take place (Leape, et al., 1991) suggests they may be uniquely positioned to anticipate and observe precursors to error, to intervene to rescue patients on the brink of an adverse event and to describe patterns of patient care and system performance that interact to endanger patients (Benner, Hooper-Kyriakidis and Stannard ,1999). Clearly, nurses may also be a source of error. For the purposes of this study, it was posited that daily unit level configuration of nurse staffing and workload may buffer patients from the effects of latent error and resulting injury or compromise patient safety when variance beyond a shift level safety threshold, which may be significant factors in patient safety. Undertaken over a 60-day period, this study permitted examination of indicators of patient safety and outcomes that were sensitive to the immediate impact of staffing, as well as a pattern of staffing.

Setting

This study was conducted by the California Nursing Outcomes Coalition (CalNOC) research team in collaboration with participating hospitals statewide. Since its inception in 1996, CalNOC has successfully confronted inherent challenges to the integrity of multisite quality report card efforts identified by Jennings et al (2001) including indicator measurement standardization, feasible data retrieval, strategic relevance, and linking the work to the contemporary demands of clinical nursing. CalNOC's evolution and methods have been reported elsewhere (Brown, 2001; Donaldson, 2001; Aydin 2004; Donaldson, 2005). CalNOC's mission is to, 1) build and sustain the CalNOC nursing staffing and quality database repository, 2) conduct research to advance evidence-based administrative and clinical decision-making and, 3) provide data to resolve public policy and clinical dilemmas in patient care delivery influenced by nurse staffing and quality. The research team for CalNOC is coordinated by the Principal Investigator for this study and based in the Center for Research and Innovation in Patient Care, University of California San Francisco, School of Nursing.

Methods

Design

Using a descriptive prospective correlational design and multiple regression analytical strategies, this study examined associations between independent variables measuring the structure of hospital nurse staffing daily, at the unit level, and dependant variables drawn from indicators of patient outcomes and safety commonly tracked by acute care hospitals, as well as regulatory and accreditation agencies—falls, hospital acquired pressure ulcers, restraint prevalence and significant clinical events. Staffing measures studied included hours of direct care per patient day, skill mix of nurse caregivers, percent of contacted or agency staff, ratio of required to actual hours of care, and RN years of post-licensure experience. This study also computed patient turnover (patient admissions, discharges, and transfers), a key factor in nurse staffing workload, and integrated it into the linear regression analyses of associations between nurse staffing and outcomes. The impact of variation in staffing and workload intensity (patient admissions, discharges, & transfers) were traced and analyzed to examine the impact of variation on patient safety and outcomes.

This study was undertaken in four phases. Phase I focused on hospital and unit recruitment from among CalNOC hospitals, completion of Federal Wide Assurances and human subjects review by each hospital and completion of necessary data management programming and systems development to support data collection. Customary CalNOC confidentiality and HIPAA Business Associate Agreements were the foundation upon which human subjects protections were obtained. Each CalNOC hospital receives a unique facility code number after submitting a signed confidentiality agreement to participate in CalNOC's database repository. All documents subsequently identify hospitals by facility code number only and code number links to hospital names were securely maintained at UCSF School of Nursing and Cedars-Sinai Medical Center.

In Phase I, the project coordinator worked closely with each hospital as they customized daily data capture systems for this study. Phase II, beginning in September 2002, focused on initiating and sustaining data collection for 60 consecutive days following a 30 day "run in" period. In response to the request of participating hospitals, this phase was extended 7 months, concluding in June 2003, to enable small cohorts of sites to roll through the 60 days of data collection at a time best suited to the demands and challenges of their concurrent strategic imperatives. Upon the completion of 60 days of data collection, sites resumed their usual pattern of CalNOC monthly data capture/submission. Phase III focusing on data analysis began in July 2003 and included the development of a preliminary report to participating hospitals for data verification and final data cleaning, entry, and aggregation. Data were analyzed according to the plan described below. Results of Phase III then led to a new and unanticipated Phase IV of the work: consultation with national experts in the emerging field of unit level, nested clinical data analyses, purchase of analytic software (MLwiN) at the recommendation of our consultants and further analyses.

Variables, Operational Definitions and Data Collection

Table 1 presents an overview of independent and dependent variables.

Table 1 Variables and Operational Definitions

Independent Variables	Definition	Data Specifications
Hours of Nursing Care	Productive hours worked by direct care nursing staff (RNs, LVNs, others)	Hospitals report hours worked by RNs, LVNs, and others (i.e., aides and other direct care providers) who have direct patient care responsibilities/ assignments on the defined unit and are included in the staffing matrix. Direct care providers not included in the staffing matrix but who are assigned to at least 50% direct care are included.
Ratio of Required to Actual Hours of Care	Extent to which the unit meets its own staffing requirements based on patient acuity, allocated hours of care and staff resources; ratio of required hours of care per shift per unit & actual worked hours of care.	Hospitals report required and actual worked hours per unit. The ratio is expressed as a percent per day for each unit.
Skill Mix	The number of RN, LVN, and NonRN/LVN care hours as a percent of total care hours per day, per unit.	Hospitals report the numbers and type of staff per unit per day; calculated from hours of nursing care submitted by hospitals.

Percent Contract or Agency Nurses	The number of non-employee RN, LVN, and NonRN/LVN care hours as a percent of total care hours per day, per unit.	Hospitals report the numbers and type of non-employee contract or agency staff used per day per unit; calculated from hours of nursing care submitted by hospitals.
Patient Days	Total patient days for each unit for each day.	Hospitals report the total number of patient days for each unit for each day. For observation patients on inpatient units, one unit of service is counted as one patient day.
RN Experience	Years of experience of RN staff per day, per unit	RN Staff survey unit during the run-in period and then data extrapolated per unit. Data were collected at the individual nurse level and compiled at the nursing unit level of analysis by CalNOC.
Workload intensity-- Patient Turnover—	Index of admissions, discharges and transfers (ADT) per day, per unit	Number of patients admitted, discharged and transferred per unit, per day, divided by the number of patients in 12 midnight census.
Unit Level Staffing Variation	Measure of variation of staffing variables	Variation in hours per patient day, skill mix, percent contracted staff, ratio of required to actual hours and RN experience per unit, per day computed and analyzed.
Unit-level Pt. Turnover Variation.	Measure of variation of ADT Index variable	Variation in ADT Index per unit per day computed and analyzed.
Dependent Variables		
Hospital Acquired Pressure Ulcer Prevalence	Hospital acquired pressure related skin injury (NPUAP-AHCPR Ulcer Stages I-IV)--controlling for date of admission/discovery.	The percent of all patients on the day of prevalence study, with stage I, II, II, IV ulcers—other sources of skin injury are excluded.
Restraint Use Prevalence	Any method of physically restricting pt movement, physical activity or normal access to body.	Restraint use, type of restraint and clinical justification information is captured concurrently with pressure ulcer prevalence.
Falls	Patient's unplanned descent to the hospital floor.	Falls were analyzed as 7 day aggregate per unit; also actually number per unit.
Significant Clinical Event (SE)	Unexpected clinical event not related to the patient's illness or underlying condition resulting in unanticipated death or major permanent loss of function, or adversely affects the patient care quality or outcomes. Expanded from JCAHO Sentinel Event definition to capture added events hospitals consider "significant".	SE Events included all sentinel events plus other events reported to hospital's unusual occurrence database including delays, errors, or omissions of care, medication, treatments, procedures or tests; unexpected reactions or responses to care, medication, treatments, procedures or tests; patient injuries or accidents, regardless of cause; Non-compliance with prescribed plans of care or treatments; refusal of care; leaving against medical advise (AMA). Ultimately, The only data with sufficient numbers of events to calculate were Level III Events—Falls. Other SEs were so rare or so confounded as to not be useful for this analysis.
Demographic Variables—Hospital Level	Rural/Urban Designation; Ownership; No. Licensed acute care beds; Average daily census;	Rural/Urban Designation; Ownership; No. Licensed acute care beds were operationalized per the Calif. Hospital Assoc. definitions; Average daily census was based on 12MN census.

Sample

To reduce patient/unit heterogeneity and improve the generalizability of the findings, the study sample was limited to inpatient adult medical, surgical or combined medical/surgical units from a convenience sample of 25 acute care, not-for-profit California hospitals concurrently participating in the ongoing CalNOC Project. CalNOC uses a rolling site accrual process, open to all acute care hospitals in California, and a voluntary, convenience sampling method to enroll acute care hospitals with a strong strategic commitment to support the requisite data collection, annual data management site fee and participation over a sustained period. The demographics of CalNOC hospitals are observed, on face, to be typical of the population of hospitals statewide. Because CalNOC adds sites on a continuing basis, the representativeness of the hospital sample is constantly evolving. Figure 1 presents a graphic comparison of study hospital site size with CalNOC hospitals and hospitals statewide. Figure 2 compares study hospital sites by urban and rural designation with CalNOC hospitals and hospitals statewide.

Figure 1—Study Sites Compared with CalNOC and Statewide Acute Care Hospitals By

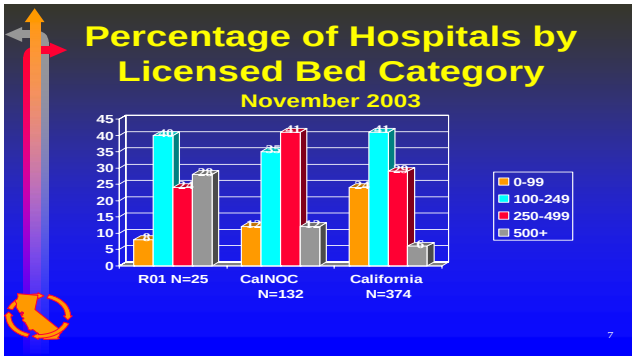
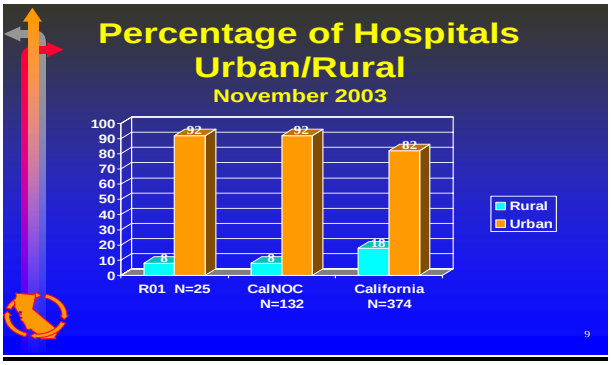


Figure 2 – Study Sites Compared with CalNOC and Statewide Acute Care Hospitals By Urban and Rural Designation



Data Collection

Data Standardization. The CalNOC Codebook was revised to guide data collection for this study and codified all indicator definitions, coding specifications, and data documentation strategies. Designated "Site Coordinators", representatives from enrolled hospitals, participated in "orientation" conference call sessions in which they reviewed the Study Codebook and discussed readiness for daily data collection methods and new indicators for this study. Periodic conference calls with site representatives provided additional opportunities to ensure reliability of coding between sites. Data for this study were collected using scannable forms and electronic spreadsheets.

Scannable Forms. Scannable data submission forms were provided for the pressure ulcer/restraint indicators and RN Education/Experience Survey measure and were scanned into the Teleform software, interpreted by the software, and automatically exported to a designated file. The forms used a combination of numeric constrained print fields and choice fields where the selected response is "bubbled in." Existing CalNOC Teleforms were modified to support the data collection specifications of the Unit Level Nurse Workload Impacts on Patient Safety study. A data check examining 64% (121) of the 188 skill mix/patient days records for 3rd quarter 2000 submitted on scannable forms revealed only 4 errors in the 1331 data elements checked, for an error rate of 0.3%. In response to queries from hospital sites, we invested in programming and purchased five PDAs to enable interested sites to "pilot" PDA data entry of pressure ulcer prevalence study data. Data were entered at the bedside, hot-synced to the loaned laptop, uploaded into an Excel spreadsheet and then electronically transmitted to the CalNOC database.

Electronic submission. Study hospitals also had the option of submitting data using Excel files transmitted via e-mail to the CalNOC data manager. Coding specifications for each variable (e.g., 1=male, 2=female) are detailed in the column heading for the convenience of the sites. Using appropriate data safeguards, hospital representatives send the file to the CalNOC data manager

Data Collection Procedure. The first 30 days or calendar month of data collection were considered a "run in" period in which sites refined their data capture and submission strategies in consultation with the investigative team. Following the "run in" month, 2 calendar months or 60 consecutive days of data collection began. Sites collected data on a daily basis and transmitted it to CalNOC biweekly throughout the run-in and 60 day period of active data collection, with the exception of the pressure ulcer prevalence and restraint prevalence variables. Participating hospitals scheduled and conducted a pressure ulcer/ restraint use prevalence study of their medical surgical units participating in the study, at least 14 days after the onset of their data collection. Prevalence study data were then batched to the CalNOC data management center upon completion of the prevalence study.

The data were checked for reliability and face validity before processing proceeded. Site coordinators were asked to check the accuracy of data when values were out of expected ranges. Following error checking using Microsoft Excel and Access, all files are transferred to Statistical Analysis System (SAS) (SAS Institute, 1999). Additional data checks and selected recodes were performed on each file and summary data from the separate files (e.g., skill mix, falls, prevalence study data, RN education, hospital information such as average daily census, and unit characteristics such as type of unit) for each nursing unit in each hospital were used to create new unit-level and hospital-level files for statistical analyses and report production.

Because all CalNOC data management services are provided under a service contract and centralized at Cedars-Sinai Medical Center Nursing Research and Development Department, Burns & Allen Research Institute, under the supervision of Dr. Carolyn Aydin, this study benefited from the expertise of this team under the terms of a subcontract. Once the data were cleaned and uploaded, and computed variables calculated, the entire study dataset was transferred to the Senior Statistician Dr. Bruce Cooper at UCSF for statistical analyses.

Statistical Analyses and Results

Aim 1 examined the criterion variables: patient falls (scaled per 1000 patient days), the prevalence of hospital-acquired pressure ulcers, and restraint use in adult acute care medical and surgical units. We examined each of these variables with measures of daily unit-level staffing, including hours of care per patient day (total RN and total licensed hours), percent hours of care (RN, licensed, and contracted), and total hours of care per total treated patients (total and RN hours). In addition associations with type of unit, hospital size, and staff education levels, experience, and certification were examined.

Aim 1 Analyses: Patient Falls. We examined the number of falls/1000 patient days as our criterion with data from 76 hospital/unit combinations. Twenty-five hospitals were represented, with from one to 12 units per hospital. Data were collected daily by units for between 59 and 104 days, with 95% of the units reporting data for approximately 60 or 90 days. The distribution for the original reports at the daily level was extremely J-shaped. There were 4,848 daily records, but 4,465 reports were zero (92.1%), and only 383 were non-zero (7.9%). Non-zero values range from 10.2 to 166.7 falls/1000 patient days (M = 3.04, SD = 11.98), showing strong over-dispersion. The daily reports were therefore aggregated into weekly sums. Aggregated data were available for 768 weeks across all hospital/unit combinations.

The resulting variable, the weekly sum of the number falls/1000 patient days (hereinafter called "falls"), was also extremely J-shaped. There were 768 weekly sums; but 500 (65%) were zero, and 268 (35%) were non-zero. Non-zero values range from 10.2 to 166.7 falls/1000 patient days, showing strong over-dispersion (N.B. Overdispersion means that the standard deviation is greater than the mean; M = 3.04, SD = 11.98).

We examined three sets of predictors for falls: five context of care variables (or structure of care), two process of care variables, and hospital and unit characteristics. The context of care and process of care data were also reported daily, and they were therefore aggregated as weekly means. The variables representing these three categories of predictors are shown in Table 1.

Table 1. [a]Predictors of the number of falls/1000 patient days as weekly sums

Context or Structure of Care (aggregated as weekly means)
- Total RN hours of care per patient day (*TotRNmn*)
- Total licensed hours of care/patient day (*TotLicmn*)
- Percent RN hours of care (*RNHRpcmn*)
- Percent licensed hours of care (*LCHRpcmn*)
- Percent contracted hours of care (*ConHRpmn*)

Process of care (aggregated as weekly means)
- Total hours of care per total treated patients (*TotHRPmn*)
- Total RN hours of care per total treated patients (*TotRNPmn*)

Hospital & Unit Characteristics (measured once)
- Total staffed adult inpatient acute care beds as an index of complexity (<100, 100-199, 200-299, >=300; Bed Size)
- Type of unit: medical, surgical, mixed

[a]Predictor acronyms used in Tables 2 are italicized and in parentheses

Generalized estimating equations (GEE) analyses for fixed effects. We predicted the weekly sum of falls/1000 patient days with GEE (Intercooled Stata, Version 8, xtgee module; StataCorp, 2003). For these analyses, we specified the hospital/unit identifier as the clustering variable, with week number as the repeated measures index. We specified the negative binomial family with a log link function for the error distribution, and we modeled the correlation matrix across weeks as autoregressive with a lag of one [AR(1)]. We used robust estimation for the standard errors in case AR(1) was not correct, to reduce bias in the estimates of the standard errors for the tests of our predictors.

A "naive" analysis of the correlations among the staffing and unit activity index variables revealed strong colinearity, as one would expect. Most of these variables either subsume others in the set, or are different representations of similar constructs (various representations of hours of care by registered nurses, for example). Therefore, we examined the predictive utility of the context and process of care variables with separate analyses. Four of these seven analyses resulted in significance for the individual predictors (See Table 2).

Individual analyses of falls predicted by hospital complexity (number of beds in four categories) and by type of unit (medical, surgical, and mixed) were each significant (Table 2). Falls were predicted to decrease as hospital complexity increased. The effect due to type of unit was weak, and post hoc analysis (protecting against an inflated type 1 error with the Bonferroni inequality) did not identify significant pairwise comparisons among the three types of units. Neither of these two predictors provided significant unique contributions when both were in the model.

The next step in the analyses was to check the predictive utility of the context of care and process of care predictors combined with hospital complexity (bed size) and/or type of unit. For each of the context of care and process of care predictors – one model at a time – we first added hospital complexity alone, then unit type alone, and then both variables in the same model. All of the process of care and context of care predictors that were significant alone remained significant in models that included one or both of hospital complexity and type of unit. It is interesting that one of the context of care and process of care predictors that was not significant alone – percent licensed hours of care – became significant in the model with hospital complexity. Also, percent licensed hours of care was a significant predictor when both of the hospital/unit predictors in the same model, although it was not significant alone.

Hospital complexity continued to be a significant predictor for each model in which it was included with one of the context of care and process of care predictors, even when the latter predictors were not themselves significant. The effect due to type of unit was weak. Although the omnibus test for type of unit was significant, post hoc analysis (protecting against an inflated type 1 error with the Bonferroni inequality) did not identify any significant pairwise comparisons among the three types of units.(Table 2).

TABLE 2. Predictions of patient falls/1000 patient days for predictors in three categories – context of care, process of care, and hospital/unit – via generalized estimating equations regression analyses (negative binomial error distribution with a log link).

Criterion: Falls/1000 patient days[a]			
Predictor[b]	**Coefficient[c]**	**Semi-Robust S.E.**	**Autocorrelation Estimate**
Context/Structure of Care			
TotRNmn	-.18**	.069	.27
TotLicmn	-.18*	.073	.26
RNHRpcmn	-.02***	.006	.24
LCHRpcmn	-.01	.008	.28
ConHRpmn	-.01	.012	.30
Process of Care			
TotHRPmn	-.12	.097	.30
TotRNPmn	-.31**	.098	.23
Hospital/Unit Predictors			
Complexity (Bed Size)	-.31**	.105	.21
Type of Unit[d]			.27
Constant	3.13	.129	
Medical	-.48	.226	
Surgical	-.66	.318	

[a]Weekly sums of daily reports
[b]See Table 1 for definitions of predictor acronyms. Tabled results are for *bivariate* GEE models.
[c]Significance levels: *p < .05, **p < .01, ***p < .001
[d]Medical and surgical units compared to mixed medical/surgical: omnibus Wald $Chi^2 = 7.15$, 2 df, $p < .05$; tests of individual coefficients not significant unless p < alpha per comparison = .05/3 = .0167. Additional analysis for medical/surgical coefficient not significant.

In summary, four of the context of care and process of care measures of daily unit-level staffing predicted falls, as well as hospital complexity (measured as the total number of beds in the hospital). *These predictions were as expected: as staffing increased, falls/1000 patient days decreased; as the number of patients increased, falls also increased.* Given the constant sample size across analyses, we can see from Table 2 that the strongest predictor was "mean percent RN hours of care." We may infer from this analysis that for a 5% increase in RN hours of care (averaged over a week), the incident rate ratio would predict a .89 decrease in falls/1000 patient days (summed over a week) or a decrease of about 10%. There were significant differences among types of units (medical, surgical, and mixed), but the differences were weak, appearing in some analyses with other predictors, but not others – depending on the association of type of unit with the other predictors. Type of unit was never significant when hospital complexity was in the same model.

Associations between falls/1000 patient days and RN experience, education, and staffing. Spearman correlations were computed to assess the strength of association between falls and nurses' experience, education, and training. *Only "percent of RNs with a BSN (or higher degree)," correlated with falls* (*rho* = -.26, *p* = .03, two-tailed), thus a unit level composite of staff in which a greater number of direct care nurses have a BSN or higher degree was associated with fewer falls/1000 patient days.

Aim 1 Analyses: Hospital Acquired Pressure Ulcers and Restraint Use. We examined several factors to learn whether they related to the percent of patients with hospital-acquired pressure ulcers and the percent of patients in restraints. The distributions of these two criterion variables were highly skewed, so nonparametric analyses on ranks were performed.

Factors of interest included type of unit and hospital size; staffing ratios; and staff education levels, experience, and certification. Of 76 hospital/unit combinations surveyed, we obtained data from 65 regarding pressure ulcers, and 60 regarding use of restraints. Information related to staff education, experience, and certification was collected by survey once for each unit. For the purposes of these analyses, staffing ratios were computed as means for the seven days prior to the survey.

Type of unit and hospital size. We conducted Kruskal-Wallis one-way analyses of variance to determine whether the mean ranks of the criterion variables differed by type of unit or hospital size. Cell sizes were too small for some combinations to test interactions. Type of unit was classified as Medical, Surgical, or Mixed. There were no differences among types of units on the mean ranks for either criterion.

Hospital size was classified as a categorical variable with the following categories: under 100 Beds, 100-199 Beds, 200-299 Beds, and 300 Plus Beds. The mean ranks for the percent of patients with hospital-acquired pressure ulcers differed by hospital size (Chi-squared = 10.95, 3 df, p = .01). Post hoc pairwise comparisons with t-tests on the mean ranks (cf. Conover, 1980, p. 231), controlling the Type 1 error rate with the Bonferroni correction, were calculated. (Each of the six post hoc pairwise comparisons was conducted at alpha' = .0083). At this level, the mean rank for the percent of patients with hospital-acquired pressure ulcers was higher for hospitals with 100-199 beds, compared to hospitals with 200-299 beds (t = 3.51, p < .001). The differences in mean ranks for the percent of patients in restraint was not significant.

Staffing ratios. In an effort to measure unit specific staffing effectiveness, we examined the ratio of "actual" to "required" hours of care, noting that, as required by law in California, each unit/facility computed the required hours of caring using an institutional specific acuity-based staffing system. It should also be noted that the validity and reliability of these systems was unknown. We computed Spearman rank correlations (Rs) to examine the associations between the two criterion variables and RN Ratios and HR Ratios, both operationalized as means and as percent days with the ratios less than 100% for the 7 days prior to the prevalence study. *The percent of patients with hospital-acquired pressure ulcers was significantly associated with the mean HR ratio for the prior seven days (Rs = -.25, 63 df, p < .05), and with the percent days with the HR Ratio <100% for the prior seven days (Rs = .25, 63 df, p < .05).* Larger HR Ratios and HR Ratios closer to 100% were associated with a lower percent of patients with hospital-acquired pressure ulcers. The percent of patients in restraint was not associated with these staffing variables.

Staff education levels, experience, and certification. Spearman correlations were used to examine the associations between the two criteria and education, experience, and certification. *The percent of patients in restraint was significantly associated with the percent of RNs currently certified (Rs = -.41, 54 df, p = .002),* indicating that a greater percent of certified RNs was associated with a lower percent of patients in restraint. There were no other significant associations.

In conclusion, hospitals with an ADC of 300-399 reported greater variation in staffing during the 7 days prior to the prevalence study with 60% reporting the ratio of actual to required RN hours under 100%. *Small but significant Spearman correlations were observed between the percent of HAPU and ratio of actual to required hours, total hours of care per patient day and total RN hours of care per patient day.*

Aim 2 examined the criterion variable, patient falls (scaled per 1000 patient days), in relation to measures of unit level workload intensity, including number of patients per RN, number of patients per all licensed staff, and a unit activity index (ratio of ADT categories to the number of total treated patients). In addition associations with type of unit, hospital size, and staff education levels, experience, and certification were examined.

Just as for Aim 1, we examined two sets of workload intensity predictors for falls: two context of care variables (or structure of care), and one process of care variable. The context of care and process of care data were also reported

daily, and they were therefore aggregated as weekly means. The variables representing these two categories of predictors are shown in Table 3.

Table 3. [a]Predictors of the number of falls/1000 patient days as weekly sums

Context or Structure of Care *(aggregated as weekly means)*	***Process of care*** *(aggregated as weekly means)*
Total number of patients per RN (*Tot24rmn*)	Unit activity index -- Ratio of ADT categories to total treated patients (*UNIndxmn*)
Total number of patients per licensed staff (*Tot24lmn*)	

[a]Predictor acronyms used in Table 4 are italicized and in parentheses

Generalized estimating equations (GEE) analyses for fixed effects. We predicted the weekly sum of falls/1000 patient days with GEE, as for Aim 1. As can be seen in Table 4, *only the unit activity index predicted falls*. The next step in the analyses was again to check the predictive utility of the context of care and process of care predictors combined with hospital complexity (bed size) and/or type of unit. For each of the context of care and process of care predictors – one model at a time – we first added hospital complexity alone, then unit type alone, and then both variables in the same model. *The unit activity index remained significant in models that included one or both of hospital complexity and type of unit*. Also, *the number of patients per RN was a significant predictor when both of the hospital/unit predictors in the same model*, although it was not significant alone.

TABLE 4. Predictions of patient falls/1000 patient days for predictors in three categories – context of care, process of care, and hospital/unit – via generalized estimating equations regression analyses (negative binomial error distribution with a log link).

Criterion: Falls/1000 patient days[a]			
Predictor[b]	**Coefficient[c]**	**Semi-Robust S.E.**	**Autocorrelation Estimate**
Context/Structure of Care			
Tot24rmn	.16*	.064	.27
Tot24lmn	.19	.123	.27
Process of Care			
UNIndxmn	.02*	.010	.30

[a]Weekly sums of daily reports
[b]See Table 3 for definitions of predictor acronyms. Tabled results are for *bivariate* GEE models.
[c]Significance levels: *p < .05

Analyses for Aim 3 provided a preliminary examination of variation in patient falls across hospital units. For this aim, we examined the variance component for random intercepts with multilevel regression, specifying a Poisson distribution with over-dispersion. Analyses were conducted with MLwiN (version 2.01; Rasbash, J., Steele, F., Browne, W., & Prosser, B., 2004). We found that the variance for intercepts was .42 (SE = .105), indicating that it was significantly greater than zero ($Z = 4.01$, $p < .001$). This model included information available to us at the unit level (level 2, or the context level) – hospital size and unit type – so we conclude that there is more variation among units to explain than we were able to explore with the available data (cf., Kreft & de Leeuw, 1998). Further research is needed with a greater number of context variables (hospital/unit descriptors) to explore other sources of variation in patient falls.

Comparing the sensitivity of daily versus monthly nurse staffing and outcomes. A key question this study provided an opportunity to explore was the relative representativeness of monthly nurse staffing and patient falls data, compared to a daily measure. For the purposes of this analysis CalNOC's customary unit-level monthly data for staffing (hours of nursing care), skill mix, nurse to patient ratios, and patient falls was compared with unit-level daily data for the same measures collected as part of the *Impact of Unit Level Nurse Workload Study* (R01) for a two month period from 2002-2003. To compare the daily and monthly data, the sample was defined as any unit with complete data in both datasets for the same two-month period. Units were eliminated from the comparison if they did not have a record in the monthly CalNOC dataset and a record for each day in the month in the daily (R01) dataset. A total of 55 units in 21 hospitals (n=115 unit/month records) had staffing and patient days data. 56 units in 22 hospitals (117 unit/month records) had patient falls data. Findings revealed all correlations were equal to r=0.90 or above, and that all

were statistically significant (p<.0001) as would be expected since we were correlating two measures of the same variable. We did note evidence that suggested some falls were reported in the daily dataset that were not recorded in the monthly dataset and vice versa, affirming our suspicion that falls data may continue to be confounded by reporting error. For total nursing care hours, most of the units show close agreement between the datasets. The largest difference in care hours submitted was seen for total contracted care hours. Several units reported no contracted hours in the daily dataset, but did report contracted hours to the monthly dataset. It is possible that the contracted hours were included in the total hours reported to the daily dataset, but that the data source (e.g., staffing acuity system) did not provide enough information to distinguish which hours were provided by contract staff and which by staff employed by the facility. Thus there is close agreement in total hours submitted, but not for the subset of contracted hours.

Conclusion

Limitations of the Study Design and Measures

This study used a convenience sample of self selecting hospitals that were willing and able to capture and report required daily data. These hospitals may have differed significantly from hospitals that, despite their participation in CalNOC, were unable or unwilling to submit daily staffing, workload intensity (patient admissions, discharges, & transfers), or significant clinical events data. These hospitals clearly had a strategic commitment to CalNOC goals and the resources to participate. It may be that those hospitals not participating in the CalNOC project, in fact, differed significantly from the overall CalNOC sample and thus from the sub-sample of hospitals that participated in this study. Further, hospital sites were recruited from California only, and while recent findings suggest that California data with regard to staffing may be representative of a larger multi state sample and thus generalizable, findings may be limited to states with similar marketplace characteristics and workforce imperatives.

In addition, this study did not measure or control for differences in patient mix, risk or acuity—factors that may exert an effect on the associations between variables that are the focus of this study. We did stratify findings based on type of unit and hospital size increasing the likelihood of meaningful comparisons.

It is important to note that this study relied on hospitals to report actual versus required hours of care gleaned from their patient complexity/acuity systems as a result, error may have been introduced as it is known that these systems vary widely in their inherent reliability and validity, and may be further compromised by unknown inter-clinician reliability in coding and computing patient status. Despite this, we included these potentially imperfect measures directly from units, because this is how the units define “short” staffing and because these data provided a window into the realities of working conditions through the lens of the direct care setting.

Our measure of significant clinical events did not provide us with sufficient data for a meaningful analysis with the exception of patient falls. This was a new measure for participating hospitals and relied on incident reporting systems which varied widely. When our own observations of the data were informed by feedback from our sites suggesting the majority of the significant clinical events could not be reliably captured across hospitals and units, we made the difficult decision to simply use the falls data, which was not new to sites and offered strong reliability. Future studies need to consider a method of significant clinical event data extraction electronic reporting systems and work with sites to ensure these data are valid and reliable.

Methodologic Challenges

Finally, as we have noted, these data presented a number of methodological challenges inherent in their very essence as relatively rare events, which include missing data, zero values and skewness. While we took the unusual step of engaging in a national meeting to discuss analyses of these data with other nursing quality database investigative teams (National Database of Nursing Quality Indicators; Military Nursing Outcomes Database; Veteran Affairs Nursing Outcomes Database) and a cadre of consultants, we became especially aware of the limits of methods in this regard. Because literature is now emerging to guide analyses of this type including nested data, collected over time, we may discover alternative approaches to these analyses in the near future. Clearly we have generated more questions for further methodological study that were beyond the scope of this effort. For example, can we explicate and test a theoretic model for nursing staffing and patient outcomes; how do these data compare to similar data from CalNOC’s informal partners in nursing quality measurement enterprise?

Discussion

Key significant findings gleaned from this study included:

- The strongest predictor of patient falls was "mean percent RN hours of care."
- "Percent of RNs with a BSN (or higher degree)" was associated with fewer falls.
- Individual analyses of falls were predicted by hospital complexity (number of beds in four categories).
- The percent of patients with hospital-acquired pressure ulcers differed by hospital size for hospitals with 100-199 beds.
- The percent of patients with hospital-acquired pressure ulcers was significantly associated with the mean actual required staffing ratio for the week PRIOR to the prevalence study and with the percent days with the staffing <100% for the prior seven days.
- A greater percent of certified RNs was associated with a lower percent of patients in restraint.
- Unit activity index was a significant predictor of falls and remained significant in models that included one or both of the following: hospital complexity and type of unit.
- The number of patients per RN was a significant predictor of falls when both of the hospital/unit predictors were in the same model, although it was not significant alone.

These findings consistently reaffirm the unique contribution of the RN to the incidence of patient falls and the prevalence of pressure ulcers and restraint use. Noting the thread of significance associated with hospital size, a proxy variable for hospital complexity, we explored the empirical observation that California's smallest hospitals served a special population of community-based elderly and validated this hunch. CalNOC data reveals statistically significantly differences in patient age by hospital size. The percent of patients age 65 and over in hospitals with an average daily census less than 100 is 60%, compared to 55% for hospitals with a census of 100-199, and 48% for a census of 200 or more. Because descriptive data also reveals that both falls and hospital acquired pressure ulcers increase with age (Donaldson et al, 2005), this may explain findings in which hospital size is a predictive variable.

Our findings linking RN attainment of BSN or higher education to fewer falls may on-face affirm the report by Aiken et al, linking higher proportions of BSN or higher RNs with lower mortality and failure to rescue rates. While our unit level data on the education status on staff directly caring for the patient population adds temporal contiguity, we used a unit level staff survey, with response rates that varied from 24% to 100%, and with a mean response rate across all 72 units of 75.5%, as the "composite" education for direct care staff on the unit. Clearly, actually surveying individual nurses who directly cared for a particular patient would be ideal. Further, our finding linking RN certification with lower restraint use prevalence is intriguing. One explanation may be that certification is associated with greater experience in a specialty area which has enabled the nurse to acquire expertise in predicting patient responses and managing care using alternatives to restraint. This is an area of further study in subsequent analyses of this dataset.

Capturing the impact of unit level patient turnover (admissions, discharges and transfers) on patient falls was an important finding as it provides evidence of how the pace of patient care may compromise prevention of adverse events, in this instance falls. Prevention of patient falls requires skilled initial screening of patient risk and further assessment combined with individualized intervention of patients found to be "at risk" (Perell, Nelson, Goldman, et al, 2001; Rubenstein, L., 2005) It may be posited that the capacity of direct care staff to individualize interventions to prevent falls or recognize emerging risk factors during treatment may be compromised when unit level patient turnover exceeds unit level safe production thresholds. Another glimpse of this phenomenon may be found in our findings associating the prevalence of hospital acquired pressure ulcers with suboptimal staffing or days when actual staffing hours of care are less than the required hours computed using the patient care resource/acuity system. Known colloquially as "short staffing", it may be that attention to the patient's skin integrity and implementation of early interventions to prevent pressure ulcers may be deferred when direct care staff provide care with fewer staff than patient needs require. In light of the Lang et al conclusion that based on five key studies using this HAPU as the outcome "the evidence does not support a relationship between nurse staffing and the incidence of pressure ulcers" (p. 329), these data may be particularly timely, as they clearly reveal this missing link as well as demonstrate a novel methodological approach to the study of this key outcome.

Finally, leveraging this dataset with CalNOC's ongoing nursing quality measurement study provided a unique opportunity to consider how the aggregation of these measures might impact analyses. Our findings revealed robust correlations between daily and monthly measures and reassured us that the increased feasibility and reduced burden of data collection associated with CalNOC's current monthly aggregation of staffing and falls is an acceptable alternative to the greater burden of daily data collection.

Implications

Because this study was one of several funded by Congress to assist policy makers to understand the impact of working conditions on patient safety, we attempted to the extent possible, to convert these data into information for

decision support. As an example, it may inferred from this analysis that a 5% increase in RN hours of care (averaged over a week), would predict a .89 decrease in falls/1000 patient days (summed over a week) or a decrease of about 10%. However, we also have evidence that staffing may be confounded by characteristics of the patient population or setting, noting findings in which a falls process of care predictor that was not significant alone – percent licensed hours of care – became significant in the model with hospital complexity. While there were significant differences among types of units (medical, surgical, and mixed), the differences were weak, appearing in some analyses with other predictors, but not others – depending, of course, on the association of type of unit with the other predictors. Type of unit was never significant when hospital complexity was in the same model. Yet, repeatedly hospital size, which may be a proxy for a significantly older, community-based patient population not requiring tertiary care provided in larger hospitals, was a factor in falls predictive models. One implication of this finding is to reconsider the definition of "high risk" as patient population and setting related. Our data suggests older patients found in smaller hospitals may be at increased risk for falls and pressure ulcers, not because of suboptimal care, but because they are perhaps frail elderly in a less acute hospital setting.

We believe our measure of process of care in which "suboptimal" staffing was tapped one week prior to the pressure ulcer prevalence survey breaks new ground in linking the enduring effects of a process of care measure, in this instance RN hours of care, with a future adverse event, such as hospital acquired pressure ulcers (HAPU). As evidence of the robustness of this finding, small but significant Spearman correlations were observed between the % of HAPU and ratio of actual to required hours, total hours of care per patient day and total RN hours of care per patient day.

Significance

This study adds substantively to the body of prospective studies conducted in acute care, using robust measures of nurse staffing and key outcomes at the unit level. While many of the context of care and process of care variables predicted falls, as well as hospital complexity (measured as the total number of beds in the hospital), the strongest predictor was "mean percent RN hours of care." These findings add to a growing body of evidence affirming the relationship between the "dose" of direct care nurse staffing and patient care outcomes, in this example, patient falls and hospital acquired pressure ulcers. Further, this study reveals robust, multifaceted associations between measures of staffing and outcomes that have been recently adopted for public reporting by the National Quality Forum (NQF, 2004). Medical, surgical and mixed medical-surgical units were selected as the setting for this study because they represented then and now the "trenches" of contemporary nursing care of patients in hospitals. Prior to the introduction of mandated nurse-to-patient ratios in hospital medical surgical units in California in 2004, the CalNOC pre-ratio baseline demonstrated widely varied staffing. Since ratios, our data reveals convergence of hospitals toward staffing patterns in compliance with the ratios. However ratios alone cannot account for the variance in staffing and outcomes observed in this study. The education and expertise of staff, beyond the "head count" in a ratio, may be a key factor in determining patient outcomes, and the uniqueness of each unit/hospital/patient population combination is clearly a yet to be fully revealed and powerful outcome. Despite our best effort, we note in this report that a great deal of variance is not accounted for in our models and these random sources of variance must be further examined, explicated and explained.

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Publications, Presentations and Products

2002 "CalNOC RO1" with Diane Storer Brown, PhD, RN, Networking Breakfast. Association of California Nurse Leaders 2002 Annual Program, *Discovering the Oasis,* February 5, 2002

2002 "The California Outcomes Project (CalNOC) and its Role in Guiding the Development of Staffing Guidelines", American Nurses Association/California General Assembly, March 16, 2002, San Diego, CA

2003 "Hot off the Press: Early Findings from Unit Level Nurse Workload Impacts on Patient Safety", Fifth Annual California Nursing Outcomes Coalition Conference, Strategic Leveraging for Safe Patient Care: Quality and Staffing Measurement, Sacramento, CA November 17, and 18, 2003.

2004 "Stars and Stripes: Leveraging for Safe Patient Care: Quality and Staffing Measurement." CalNOC Panel with Diane Storer Brown and Nancy Carlson, 26th Annual ACNL Conference: Mission Possible at Mission Bay, San Diego, CA, February 11, 2004

2004 "Impact of Unit Level Nurse Staffing on Hospital Patient Falls—Preliminary Findings" Nursing Science: Working Toward a Healthier Nation, 2004 National Congress on the State of the Science in Nursing Research, Washington, DC, October 7, 2004

2004 "Impact of Unit-Level Nurse Staffing on Hospital Acquired Pressure Ulcers" UCSF Stanford LPCH Center for Research & Innovation in Patient Care, Research Day 2004 *"Research In Action"* October 28, 2004, South San Francisco, CA

2005 "Driving Results" , CalNOC Panel with Diane Storer Brown and Linda Burnes Bolton, 27th Annual ACNL Annual Conference, Destination Monterey: Jazz Up Your Drive, Monterey, CA February 9, 2005

2004 Donaldson, Brown, Aydin, Burnes Bolton**.** "Updating Unit Level Nurse Workload Impacts on Patient Safety," American Nurses Association 2004 Biennial Convention & Education Program. Specialty Nursing Organization Lecture Series, Minneapolis, MN, June 27, 2004

2005 AHRQ Patient Safety/Health Information Technology Conference: Making the Health Care System Safer Through Implementation and Innovation, Panel: Impact of Working conditions on Patient Safety, June 6, 2005, Washington, D.C.

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