UTILITY OF PATIENT SAFETY CASE FINDING METHODS AND ASSOCIATIONS AMONG ORGANIZATIONAL SAFETY CLIMATE, NURSE INJURIES, AND ERRORS

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Abstract

Background

Medical errors claim 44,000-98,000 lives annually. Understanding the role of organizational safety climate and nurse staffing are integral to successful patient safety interventions and may also pertain to nurse injury.

Methods

This study triangulated multiple data systems and case identification criteria to maximize patient safety event case-finding with the goal of conceptualizing a feasible and sustainable patient safety surveillance system. One hospital's inpatient discharge data and its error-reporting system were used. Unique identifiers were linked to find identical cases among data systems.

Using multilevel logistic regressions, two additional study components assessed nursing unit characteristics, nurse perceptions of organizational safety climate as measured by the Safety Attitudes Questionnaire (SAQ), and associations with patient and nurse injury.

Results

Data triangulation was necessary to detect patient safety events. The lack of overlap among the detection systems was significant.

Increasing Stress Recognition was associated with a 3-fold increase in the odds of nurse injury, and a 1.5 to 3-fold increase in the odds of patient falls, medication errors, and decubitus ulcers. Nurse injury odds decreased with increasing positive attitudes regarding Safety Climate and Morale/Job Satisfaction. A negative association was

observed between Safety Climate and the odds of decubitus ulcers.

A two-fold increase in the odds of nurse injury with increasing turnover was observed. No associations between nurse turnover and patient outcomes were found.

Nursing hours per patient day were negatively associated with patient falls and positively associated with medication errors.

Conclusions

The case-finding study found little overlap among case identification criteria as applied to administrative data and an error-reporting system. Available data systems should be triangulated to maximize the detection of patient safety events.

The study components linking organizational climate to injuries showed that: (1) nurse injury is associated with turnover while patient injury is not, (2) patient injuries are associated with nursing hours per patient day while nurse injuries are not, (3) increasingly positive perceptions of Safety Climate and Morale/Job Satisfaction are associated with decreased odds of nurse injury, while only Safety Climate is associated with decreased odds of decubitus ulcer, and (4) increased Stress Recognition is associated with increased odds of nurse and patient injury.

Thesis Readers:

Laura Morlock, Ph.D. – Advisor

Marlene Miller, MD, M.Sc. – Co-advisor

Jacqueline Agnew, Ph.D., MPH

Francesca Dominici, Ph.D.

Dedication

To The Great Ones…

I have asked

You have told

I have heard

I am still listening

Acknowledgments

Among students, I have been the most blessed to have not one, but two advisors. Dr. Laura Morlock welcomed me as her advisee during a time in my life when I really needed a true believer. Her faith has been unwavering and at times when my own has failed, hers has been the enabling force to carry on. When people speak about Laura, the first thing that they say is, “She’s the nicest person”. If at any point of my career that is said about me I will have achieved greatness. The incredible regard for Laura’s person is matched only by the great admiration of her as a scientist. To me, there are no greater indicators of self-actualization than the combination of attributes Laura brings to the simplest conversations or the most delicate negotiation.

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I am you and you are me, so you have never really died.

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Executive Summary and Synthesis

This dissertation is divided into three parts informed by two literature reviews. The first literature review summarizes patient safety event case finding methods and offers a conceptual framework for patient safety surveillance. A second, abbreviated literature review summarizes nursing unit, staffing, and organizational safety climate research related to patient safety.

Part I examines data systems and case identification criteria essential for the development of an ideal patient safety surveillance system. Part II uses the outcomes defined in Part I to examine correlations among nursing-sensitive patient injuries, organizational safety climate, and nursing unit characteristics. Part III uses the same methods in Part II to investigate if the factors associated with patient injury were associated with nurse injury. All study components used the Johns Hopkins Hospital's data for calendar year 2005.

Part I: Patient Safety Event Case Finding

In March, 2000, the Institute of Medicine released its seminal public report, "To err is human: building a safer health care system" citing an annual estimate of 44,000 to 98,000 deaths due to medical errors. This report elicited significant responses from the medical and public health communities in recognition of a growing problem reaching epidemic proportions. Evidence exists that these events contribute to poorer post-discharge prognosis, extended length of stay, extra costs, and attributable mortality.

Administrative data have proven a useful source of information for highlighting patient safety concerns in hospitals. The burden of patient safety events is currently unknown and depends ultimately on how patient safety events are defined and captured. Part I of this dissertation attempts to expand the current focus on medical errors embraced by much of the patient safety field to a greater conceptual framework that includes errors that do not result in injury and injuries that do not result from errors. This family of events is called "patient safety events." The expansion of scope is necessary to develop a patient safety surveillance system that will be comprehensive, feasible, adaptive, and uninterrupted as the patient safety field grows in its understanding of events, their causes, relationships, and their outcomes. A conceptual framework for visualizing these ideas is presented.

To investigate a subset of patient safety events, error-associated injuries (EAI), coded administrative hospital discharge data and a voluntary error reporting system were explored to determine which method or combination of methods maximized case finding. The four case identification criteria were: E-codes, N-codes, AHRQ Patient Safety Indicators (PSI), and University HealthSystems Consortium's Patient Safety Net (PSN). The first three case-inclusion criteria use administrative hospital discharge data while the last criteria uses an anonymous voluntary error reporting system. The number of identical cases was ascertained by data linkage using unique identifiers.

Part I determined that multiple data systems and case identification criteria were necessary to maximize the capture of patient safety events. This idea is called "triangulation." The degree of mutual exclusiveness among the detection systems was unexpected. Accidental laceration or puncture was the most revealing example: of the case identification criteria that found an identical event, only 100 of 476 unique events were detected by all methods. While Patient Safety Indicators (PSI) performed the best, there were still 148 unique events that it did not detect. Furthermore, the stark difference in detection between the error-reporting, Patient Safety Net (PSN), which detected only 2 events and the case identification criteria applied to the administrative data (PSI, E-code, N-code) was interesting.

This last finding might imply that PSN should be discarded. However, without PSN, falls and medication errors would not be detected. Therefore, the lesson is to continually train, monitor, and evaluate the reporting of these events. It is known that 476 unique accidental laceration or puncture events occurred, so it is possible to go back to the reporters to discern why events were not reported in PSN. Alternatively, if events like falls are very frequently detected by error-reporting systems like PSN, this may encourage the addition of new codes in administrative data systems to signify that a fall event occurred during the hospitalization.

Chart review has been hailed as the gold standard for detecting adverse events, but it is not the gold standard for errors. Errors that do not result in patient harm are not usually recorded in medical records. Only a voluntary error reporting system (such as PSN) that captures near misses would capture these events. The true gold standard for patient safety surveillance requires triangulation of multiple case finding methods if errors regardless of their effects on patients are included.

While the results of Part I showed very little overlap in patient safety events where overlap was anticipated, we do not wish to lose sight of the fact that, with regard to patient safety surveillance, there is little in common in the design of the systems. This further highlights the point that multiple data systems and case identification criteria need to be triangulated in order to conduct the surveillance of patient safety events as described by the "surveillance-focused approach to patient safety" conceptual framework. This last point is critical because what is counted forms the basis for policy development and research funding. For example, if the "injuries not resulting from error" domain of the conceptual framework is not included, the surveillance of adverse drug reactions could not be conducted. These events are very common, are of great concern to patients, and often require extra provider resources. We are not so bold as to think that research and development will not eventually discover methods to anticipate and reduce these types of events in the future. For this reason, it would be beneficial if the designers of a patient safety surveillance system would consider what is currently not known to be preventable as potentially preventable.

Parts II and III: Exploring Associations between Organizational Safety Climate, Patient Injury, and Nurse Injury

The nursing workforce has been challenged over the last two decades to adapt to an increasing workforce shortage. There are fewer registered nurses to take care of larger numbers of increasingly sicker and older patients. These changes have been confounded by decreasing healthcare reimbursements resulting in shorter lengths of stay. Nurses have reported increasing job dissatisfaction and burnout, and have raised concerns about the quality of care patients are receiving.

Poor organizational culture and low nurse staffing are associated with adverse patient outcomes and have been suggested as contributors to needle stick injuries and near-misses in the nursing workforce. While needle stick injuries to nurses are not a patient safety issue per se, they have been suggested as indicators of inadequate organizational commitment to safety that puts at risk not only nurses but patients. Part II examined unit-level organizational safety climate and nursing characteristics to determine if these were associated with nursing-sensitive patient outcomes. Part III examined these same organizational and nursing unit characteristics to determine if they were also associated with nurse injury.

There are numerous instruments available to assess organizational climate. The Safety Attitudes Questionnaire (SAQ) was used in Parts II and III because, of nine surveys measuring the patient safety climate of an organization, only the SAQ has been used to explore the relationship between safety climate scores and patient outcomes. The SAQ measures healthcare worker perceptions of organizational safety climate in six domains: Teamwork, Safety, Stress Recognition, Working Conditions, and Perceptions of Management. Favorable scores on the SAQ were associated with shorter lengths of stay and fewer medication errors. Favorable scores on four out of six domains of the SAQ were associated with lower nurse turnover. This instrument was the most obvious choice to explore if the same safety climate factors and nursing unit characteristics associated with nurse injury were associated with patient injury as well.

The SAQ traditionally uses responses from all respondents, but has also demonstrated acceptable psychometric properties for nurse respondents only. The SAQ data used in Parts II and III used were restricted to nurses to more precisely study nurse perceptions of safety climate and associations with nursing-sensitive patient outcomes and injuries to nurses.

Based on the literature, the Stress Recognition, Safety, and Morale SAQ domains were examined. The current nursing shortage creates opportunities for stress-induced mistakes, so the Stress Recognition SAQ domain was of great interest. In nursing, aviation safety interventions such as adaptation of the sterile cockpit protocol to medication administration have witnessed an 86% decrease in nurse-reported distractions induced by stressful working environments. Stress has long been associated with occupational injury. Moreover, stress has been found to be one of the leading causes of nursing job dissatisfaction along with workload and burnout.

In Part II, a 1.5 to 3-fold increase in the odds of patient falls, medication errors, and decubitus ulcers was observed with increasing nurse agreement on the questions in the Stress Recognition domain of the SAQ. Part III observed a three-fold increased in the odds of nurse injury with increasing Stress Recognition.

In discussions with the SAQ's developer, the Stress Recognition domain of the SAQ operates somewhat differently than the other domains. Stress Recognition represents the individual attitudes of the respondents rather than a consensus among people working on the unit. Since the nurse injuries in this study are voluntary reports to the Hospital's Occupational Health Department, the effect of increased stress recognition may represent an increased awareness of the importance of reporting injuries due either to heightened awareness of stress or because of a past stress-related experience.

Part II observed a decrease in the odds of decubitus ulcer with increasing agreement with the questions in the SAQ Safety domain. A negative association was observed between nurse injury and the SAQ Safety and Morale domains in Part III. Inclusion of safety climate as a domain in the SAQ was based on the initial recognition of the role of safety climate in both occupational injuries and injures in non-healthcare settings.

Based on a review of the literature, we believe the results described in Part III are among the first to show an association between nurse injury and nurse turnover. A two-fold increase in the odds of nurse injury with each 10% increase in the turnover rate was observed. While the literature offers evidence of associations between organizational climate and nurse turnover, little is known about a more direct relationship between turnover and patient or nurse injury. Interestingly, we did not find evidence of associations between nurse turnover and the patient outcomes examined in Part II.

In Part II, an interesting juxtaposition with nursing hours per patient day and nursing-sensitive patient outcomes was observed. Nursing hours per patient day were negatively associated with patient falls and positively associated with medication errors: for each additional hour of increased productive nursing hours per patient day, a 10% reduction in the odds of the patient falls was observed; conversely, an 8% increase in the odds of medication errors was observed with each additional hour of nursing per patient day. It is easier to see the advantage of increased nursing time with patients who are at risk for falls: more productive nursing time may lead to more direct observation and thus more opportunities for intervention prior to a fall. In the case of medication errors, increased nursing time may not necessarily be better depending on how that time is used. Medication administration is an opportune time for error because the process contains multiple steps where interruptions can cause distraction. For instance, during the course of medication administration a nurse may engage in other tasks such as administrative responsibilities, returning pages, or responding to emergencies. If protocols are not in place to ensure that nurses will not be distracted during medication administration, more nursing hours may unintentionally exacerbate the problem rather than ameliorate it.

Increased awareness of the effect of stress on job performance may be associated with increased awareness of injury risk, and may manifest itself in increased reporting of injuries by those sensitized to injury's root causes. It may also be plausible that the Stress Recognition domain serves as a parallel indictor of the stress level among nurses (e.g. "The more stressed I feel, the more likely I am to report that I understand how stress affects my performance"). Alternatively, past experience with a stressful event that caused a nurse or patient injury may also increase agreement with the effect of stress. We speculate that nurses who are more aware of the effect that stress has on their ability to perform may also be better reporters of nurse and patient injuries.

The literature has suggested that certain organizational climate constructs may be more related to certain nursing sensitive patient outcomes and not others. The results of these two study components show that:

- nurse injury is associated with turnover while patient injury is not,
- patient injuries (falls and medication errors) are associated with nursing hours per patient day while nurse injuries are not,
- increasing agreement with Safety and Morale score items is associated with decreased odds of nurse injury while only the Safety score is associated with decreased odds of decubitus ulcer, and
- increased Stress Recognition is associated with increased odds of nurse and patient injury.

The SAQ was developed to investigate associations between organizational safety climate and patient injuries. Part II affirms that the SAQ can detect associations with nursing-sensitive patient outcomes. The results of Part III extend the utility of the SAQ to nurse injury. The use of nurse respondents only demonstrates the value of the SAQ as an important nursing research survey instrument. The addition of unit characteristics previously described in the nursing literature further enriches our efforts to understand how organizational climate operates in the clinical setting.

Future investigations should continue to explore common factors between these two families of injuries to better understand the effect of organizational safety climate in its entirety. Organizational safety climate is a large construct that affects not only the final outcome of healthcare delivery (positive patient outcomes) but everything in between; including the safety of the healthcare workforce dedicated to ensuring the final product's outcome.

Policy Relevance

Unsafe conditions in high-risk settings such as aviation, oil/gas industry drilling and refining, and nuclear power have caused swift government responses in the form of legislative changes and the formation of new safety entities. Examples of such policies are the Aviation Safety Reporting System (ASRS), a comprehensive tracking system developed after a TWA airplane crash in 1974, and the Institute for Nuclear Power Operations (INPO) which was formed after the 1979 Three Mile Island incident to study and promulgate training regulations for plant employees and develop industrial standards. In these examples some kind of event reporting system or safety management system was required by legal action.

In contrast to these widely publicized events, when a patient experiences an error or injury in a healthcare setting, unless it is an egregious event, the general population may never hear about it. At the very least, news coverage would not be the same as that given to airline crashes or industrial accidents. Moreover, while the above examples represent unacceptable threats to public safety, healthcare errors have the potential to harm in far greater numbers and are therefore deserving of rapid response

One of the factors that may have caused increased dialog among healthcare providers is the growing media attention to medical errors and injuries in recent years. Examples of events that brought national attention to patient safety were the quadruple overdose of chemotherapy to Boston Globe columnist Betsy Lehman in 1992 and the administration of the wrong type blood transfusion error in a transplant case at Duke University in August of 2003. There seems to be a critical mass of consumers, providers, lawyers, and legislators that now realize the significance of the patient safety problem, that it matters personally to them and will affect people they know, that the problem only continues to grow, and that research must be done to understand the problem and to develop evidence-based models of addressing it.

Composition of a Patient Safety Surveillance System

The literature reveals limited discussion as to how the surveillance of patient safety events will be conducted. Triangulation of injury surveillance metrics (E-codes and N-codes), the Agency for Healthcare Research and Quality (AHRQ) PSI, and voluntary reporting systems (e.g., PSN) yields a robust method for the surveillance of patient safety events.

The ICD-9-CM codes used for E-codes, N-codes, and PSI are appealing because they are routinely collected, are relatively easy to acquire, and are used in other countries, creating the possibility of national and international comparisons.

The idea of a PSN-like system for error identification is enticing because it could capture a vast spectrum of patient safety events - the ideal of any surveillance system. If PSN were to be the launching pad for a national patient safety reporting system, it would need to be comprehensive, collecting errors that do not result in injury, errors that result in injury, and injuries that do not result from error in order to address all aspects of patient safety of interest to researchers, policymakers, and patients.

PSN-like systems have been strongly advocated by congressional testimony, patient safety legislation, and the IOM report To Err is Human, as well as subsequent IOM reports. It is unknown if or when a national system will be created, and whether it will be voluntary, mandatory, or anonymous.

While the system is as yet undetermined, interventions are already under way to ensure patient safety. It is incumbent on the public health system to devise methods and policies to track events so that these interventions can be evaluated not only in their institutional settings, but also so their dissemination and subsequent effects throughout the population may be measured. Such surveillance routinely is conducted in chronic disease (e.g. cancer morbidity and mortality) and injury (e.g. decrease in alcohol-related motor vehicle fatalities). Such measurement would provide researchers the evidence needed to demonstrate the return on investment in patient safety to funding agencies, Congress, and the private sector.

Since there was so little overlap in injury detection among the methods investigated in Part I of this dissertation, researchers, hospital administrators, and policy makers interested in tracking patient safety events should triangulate the data systems available to them in order to maximize the detection of patient safety events.

Opportunities for Injury Prevention and Control

Surveillance is a cornerstone of injury prevention and control. The Centers for Disease Control (CDC) has supported injury surveillance through state health department infrastructure development grants and the development of on-line data tools like Web-based Injury Statistics Query and Reporting System (WISQARS™) to support use of injury surveillance data. Moreover, CDC has been the government agency for chronic and communicable disease surveillance since 1946. It is logical that CDC should be considered as a potential "home" for patient safety surveillance. AHRQ has been the government agency charged with patient safety research, whether it is the correct "home" for a surveillance system needs to be determined. Precedent exists for placing responsibility for surveillance of patient safety at CDC. The Division of Healthcare Quality Promotion already has developed "7 Healthcare Safety Challenges" such as reducing catheter-related infections and surgical adverse events.

If patient safety were to be included within the domain of injury, efforts could be made to increase the operating budget of the CDC National Center for Injury Prevention and Control (NCIPC) as well as budgets of state and local injury prevention and surveillance programs, because the recognized burden of injury would increase in proportion to the chronic disease burden and require more resources for research and prevention. More importantly, if injury professionals embraced patient safety, they could bring their considerable expertise in designing, implementing, and evaluating effective injury prevention programs. Since the field of injury has a public health orientation, its efforts in patient safety would be delivered at the population-level, largely focusing on the dissemination of proven interventions and potentially contributing to a more rapid reduction in patient safety events than what would be accomplished by using a medical model (provider-to-patient focus, addressing symptoms of the patient as opposed to the larger healthcare system).

The End of Silos: Uniting Occupational and Patient Safety

Parts II and III of this dissertation build on previous work in the literature which demonstrated relationships between the organizational safety climates in which people work and their impact on patient and worker health. It is usual in this country for research funding to be distributed in very precise terms for specified programs. It is hoped that the findings in this dissertation will lend support for a broader perspective because many of the organizational safety climate factors that put patients at risk also put nurses at risk.

Modifications to the organizational climates to better serve patients may simultaneously protect the work force. This cannot be viewed as an unintended positive consequence spurred by concern for patients, but rather it should be an intentional desire to create safer systems that protect those who work in them as well as those who are served by them. Moreover, since most working-age patients are most likely to be in the workforce, the lost work time and potential increase in health care costs that a medical error causes the patient may have direct and indirect effects on his or her employer. This consideration could bring a new perspective to the conceptualization of occupational injury.

We are only just beginning to understand what organizational factors are most important for nurse injury versus patient injury, and which are important for both. In continuing this worthy effort, we must - in true public health fashion - turn to other industries that are more advanced in their understanding of how individual perceptions of an organization affect productivity. While healthcare is a very different setting than other industries, it should borrow what it can in order to make the largest strides in the shortest period of time in order to protect its workforce and its patients.

Literature Review: Patient Safety Event Case Finding

Introduction

In March 2000, the Institute of Medicine (IOM) released a report entitled "To Err is Human: Building a Safer Health Care System" citing an estimate of 44,000 to 98,000 deaths annually due to medical errors (Kohn, LT, Corrigan, JM, & Donaldson, MS, 2000). Debate about these figures has been ongoing and the argument has not been resolved to date (Dunn, J. D., 2001). This review describes the data systems and case identification criteria needed to maximize patient safety case finding with the goal of determining the critical components necessary to establish a national patient safety surveillance system.

A review of the literature has not revealed a study that compares various methods of capturing patient safety events that seek to establish the case identification criteria or combination of criteria and data systems that captures the largest number of cases – and that therefore provides the optimum schema for patient safety surveillance. "Triangulation" of such different methods has been suggested to be beneficial for case-finding (Miller, M. R., Elixhauser, A., & Zhan, C., 2003; Romano, P. S. et al., 2003).

To Err is Human drew from well-designed studies that conducted arduous chart reviews in several states' hospitals (Brennan, T. A. et al., 1991; Leape, L. L. et al., 1991), but a system to consistently capture these events has not been conceived. Consideration of such design and development is critical to the development of population-based prevention and policy methods. A strong epidemiological understanding of errors is essential for developing prevention strategies and for educating the public about their potential for errors. Examination of the magnitude of patient safety events in relation to other injuries and chronic diseases, expressing the burden to the health care system in terms of direct costs, avoidable length of stay, and lost productivity (patients and providers) is essential. Growing evidence suggests that these events contribute to poorer post-discharge prognosis, extended length of stay, extra costs, and attributable mortality (Classen DC, Pestotnik SL, & et al., 1997; Rigby K, Clark RB, & et al., 1999).

Medical errors are estimated at $38 billion annually; preventable errors constitute about 45% of this estimate (Agency for Healthcare Research and Quality, 2006). A comprehensive surveillance system that tracks both errors and injuries is essential to meet epidemiologic goals and to understand the resource burden on the healthcare system.

Landmark Patient Safety Studies

Harvard Medical Practice Study (I and II)

The Harvard Medical Practice Study (HMPS) sought to estimate the incidence of adverse events by examining medical injuries and a subset that resulted from negligence. This study defined adverse event as "an injury caused by medical management…that prolonged the hospitalization, produced a disability at the time of discharge, or both." This study further defined negligence as "care that fell below the standard expected of physicians in their community." (Brennan, T. A. et al., 1991; Leape, L. L. et al., 1991).

The HMPS reviewed 30,121 records from 51 acute-care nonpsychiatric hospitals in New York State in 1984. The methods included a random selection of charts screened by nurses and medical records analysts. If adverse events were found in the 7,743 cases selected as a result of the screening process, two physician reviewers assigned confidence scores on a scale from zero to six, with six indicating a case was most likely to be associated with an adverse event. This screening yielded 1,278 adverse events.

The results from this seminal patient safety study found that 3.7% of all hospitalizations demonstrated an adverse event. Twenty seven percent of all adverse events were determined to be due to negligence. Seventy percent of adverse events resulted in less than six months disability, 2.6% had permanent disability, and 13.6% resulted in death.

The study found a twofold increased risk of an adverse event in people aged 65 and older compared to those aged 16 to 44. Of all adverse events, drug complications were the most common (19%), followed by wound infections (14%) and technical complications (13%). Seventy-seven percent of the adverse events were classified as errors of omission, 75% were due to a diagnostic mishap, and 50% were associated with an operation. Significant differences in adverse event rates by medical specialty were also found, with vascular (16.1%) and cardiac and thoracic surgery (10.8%) having the highest percentages. Obstetrics and neurosurgery had lower adverse event rates at 1.5% and 9.9%, but when negligence was found, these specialties had the highest percentages of adverse events at 38.3% and 35.6% respectively.

One of the main limitations was that the study was only conducted in one state. State-to-state variations in record keeping, coding, and clinical opinions are well known (Iezzoni, L. I., 1997). As with most chart review studies, missing records are a persistent problem. While expert review of charts potentially may raise methodological issues, the HMPS demonstrated relatively high kappa statistics for agreement among physicians. Chart review is an onerous, time-consuming and expensive process and as a result, the HMPS employed only two physicians to review the records. Having an expanded reviewer team might have resulted in greater certainty in determining if an event constituted an error. Even considering these limitations, expert review of medical records is still considered to be the "gold standard" for medical error case finding (Murff, H. J., Patel, V. L., Hripcsak, G., & Bates, D. W., 2003). Subsequent chart abstractions studies found results similar to the HMPS (Bordeaux S., 1999; Edmonds, M., 2005; Forster, A. J. et al., 2004; Gawande, A. A., Thomas, E. J., Zinner, M. J., & Brennan, T. A., 1999; Thomas, E. J. et al., 2000).

Quality in Australian Health Care Study

The Quality in Australia Health Care Study (QAHCS) sought to repeat the HMPS in Australia. Medical records of over 14,000 admissions to 28 hospitals were reviewed in New South Wales and South Australia. The study found 16.6% of admissions were associated with an adverse drug or medical event; 2% resulted in major disability, 0.3% resulted in death, and more than 50% were preventable. The authors cited a previous government report estimating over $800 million dollars for extended hospital lengths of stay due to errors (Edmonds, M., 2005; Wilson, R. M., Harrison, B. T., Gibberd, R. W., & Hamilton, J. D., 1999). Furthermore, in investigating Australian mortality data, this study observed increases in adverse drug events (ADEs) during 1988-1997 from 1/100,000 population (501deaths) to 1.65/100,000 population (910 deaths)(Bordeaux S., 1999).

Reporting of Hospital Adverse Events in Australian Hospitals

In 1997, another Australian group sought to verify these findings through exploration of coded hospital discharge data in Victoria (O'Hara, D. A. & Carson, N. J., 1997). Using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), this study grouped adverse events according to the External Cause of Injury (E-codes) categories: "Misadventures to patient during surgical and medical care" (E870-E876), "Surgical and medical procedures as the cause of abnormal reaction of patients or later complication, without mention of misadventure at the time of procedure" (E878-E879), and "Drugs, medicinal and biological substances causing adverse effects in therapeutic use" (E930-E949).

Five percent of discharges from Victoria's hospitals had an adverse event E-code in 1994-1995; most of these were in the E878-E879 category. Using Diagnostic Related Groups (DRGs) to group diagnoses associated with an adverse event, surgery for injury had the highest rate of all discharges, followed by hip fracture and bowel excision. Comparing discharge disposition of patients with an adverse event to those without, patients with errors were more likely to be sent to other facilities such as nursing homes instead of being discharged directly to home. The in-hospital death rate was approximately twice as high for patients with an adverse event.

This study found adverse drug events to be identical to rates in the HMPS at 19% of all admissions and close to the QAHCS (16.6%); however, the in-hospital mortality rate (2.9%) was different from that found in the QAHCS (4.9%), and misadventures (E870-E876) were rarely reported, comprising only 2% of all adverse events. Overall, this study found that by using E-codes they were able to detect 65% of all adverse events identified by the chart review method in the QAHCS. This highlights a very serious limitation of administrative data - its sensitivity is less than that of chart review, the gold standard. Nonetheless, the authors argued, and others argue, that given the simplicity, feasibility, and low expense of using administrative data, the fact that it does not capture all adverse events may not necessarily preclude researchers from using this type of data to characterize the epidemiology of the problem. Given the undeniable feasibility of using administrative data, if the sensitivity compared to chart review is known, estimates of uncertainty can be calculated and applied to statistics using such data. Finally, administrative data are limited in that the severity of the adverse events and the long-term outcomes cannot be determined directly.

Patient Safety Indicators

Patient safety indicators (PSI) were developed by the Agency for Health Care Research and Quality (AHRQ) for the purpose of patient safety case finding and performance improvement at the provider and system level in hospitals (Agency for Healthcare Research and Quality, 2005). These indicators for complications and other iatrogenic events were selected based on their potential preventability; other patient safety concerns such as medication errors were excluded because of their low preventability (Leape, L. L., Lawthers, A. G., Brennan, T. A., & Johnson, W. G., 1993). Using 1997 hospital discharge data for New York, 2,400,000 discharge records were used to develop 29 indicators pertaining to 12 clinical conditions (Miller, M. R., Elixhauser, A., Zhan, C., & Meyer, G. S., 2001).

Romano: Patient Safety in US hospitals

Romano and colleagues used the PSI to estimate the incidence of patient safety events using the 1995-2000 AHRQ Healthcare Cost and Utilization Project (HCUP) data's National Inpatient Sample (NIS). This sample included data from more than 1000 hospitals in 28 states. Results from the analysis found increasing patient safety events with increasing age and with African-American ethnicity. This analysis identified 1.12 million potential safety related events out of 36,318,000 million hospitalizations in the year 2000: 35% of these events occurred in medical hospitalizations, 34% in surgical hospitalizations, 31% in obstetric hospitalizations, and 24% resulted in death (Romano,

P. S. et al., 2003).

The advantage of using the HCUP NIS is that the sample can be weighted to represent the United States and can provide a superior way to estimate the burden of patient safety events.

The study's greatest limitation is that it focused only on those events that were known to be preventable as determined by an expert review panel and that it excluded known complications of care, medication errors and adverse drug events, and those events for which current preventive strategies were not known. While PSIs identify improvement opportunities for hospital-based care, they were not conceptualized as a comprehensive surveillance tool and do not cover all potential patient safety events.

Patient Safety Events during Pediatric Hospitalizations

In continuing use of the PSI and HCUP data, Miller and colleagues studied the pediatric population. Pediatric discharges were labeled as either having a patient safety event (PSI event) or not. PSI events were highest during birth (birth trauma rate of 1.5 per 100 births). Comparing children with and without PSI events, the authors found a two to six fold increase in length of stay, two to 18 fold increase for in-hospital mortality, and a two to 20 fold increase in total charges for encounters. Patient safety events were found to be associated with greater illness severity and larger urban teaching hospitals. Furthermore, birth trauma was determined to be associated with African American and Hispanic ethnicity (Miller, M. R., Elixhauser, A., & Zhan, C., 2003).

The authors found a range of 0.2-154.0 events per 10,000 discharges for PSI and only 2.2 events per 10,000 discharges using codes E870-E876: "Misadventures to patient during surgical and medical care". The authors did not use E878-E879: "Surgical and medical procedures as the cause of abnormal reaction of patients or later complication, without mention of misadventure at the time of procedure" because while these have shown the highest incidence of adverse events (O'Hara, D. A. & Carson, N. J., 1997), Miller and colleagues excluded them because they were not considered preventable at a systems level. Moreover, the E-codes for adverse drug events (E930-E949) utilized in the Victoria study were excluded from the algorithm for PSI's for the same reason of non-preventability and therefore the contributions they could make to pediatric patient safety rates was unknown. Detailed references on the development of HCUP, PSI, and methods for using both are described elsewhere (Miller, M. R., Elixhauser, A., Zhan, C., & Meyer, G. S., 2001; Miller, M. R., Elixhauser, A., & Zhan, C., 2003; Miller, M. R. & Zhan, C., 2004; Romano, P. S. et al., 2003; Zhan, C. & Miller, M. R., 2003).

The principal difference between the PSI and traditional injury surveillance metrics (N-codes and E-codes) is that PSI try to tailor numerators and denominators to events that are solely preventable, whereas E-codes and N-codes include events for which preventability is difficult to ascertain or for which prevention strategies are unknown (Marlene Miller, personal communication).

The PSI do not rely heavily on the E-codes for adverse events. Discussion with one of the authors of the PSI indicates that these E-codes were evaluated for inclusion in the indicators, but ultimately E-codes were not included in the PSI predominantly because E-codes are intended to be used in conjunction with diagnosis or procedure ICD-9 codes and potentially could result in unwanted repeat identification of the same cases (Marlene Miller, personal communication).

However, in further investigating the decisions to include or exclude certain variables, one of the authors emphasized that the particular study used only one state's data to set the inclusion/exclusion criteria. The data were from New York State - a pioneer in inclusive data collection for hospital discharges - but it is possible that New York State's E-coding rates (defined as the percentage of N-codes with a supplemental E-code) may have been low and may have been the reason why the developers of the PSI did not include them in the algorithm. Furthermore, because medication errors and adverse drug events were not thought to be preventable, and did not seem to be reliably represented by ICD-9-CM codes, the PSI did not include them. However, medication events represent a significant subset of patient safety events and innovative interventions already suggest promise (Bates, D. W. et al., 1999; Carlson, R., 2004; Pape, T. M., 2003).

The Agency for Healthcare Research and Quality (AHRQ) has demonstrated the usefulness of administrative data for understanding adverse events especially as a vehicle for testing patient safety indicators (PSI) (Romano, P. S. et al., 2003). This method cannot replace the richness of data abstracted from medical records, but its results do assist public health entities in prioritizing patient safety efforts in a cost-effective manner. AHRQ has developed PSI for use with the HCUP administrative data (Miller, M. R., Elixhauser, A., Zhan, C., & Meyer, G. S., 2001; Romano, P. S. et al., 2003).

Triangulation of Data for Improved Surveillance of Patient Safety Events

In a review of the literature, only one peer-reviewed article has utilized all series of adverse event E-codes (E870-E876, E878-E879, E930-E949) to describe the burden of medical errors (O'Hara, D. A. & Carson, N. J., 1997). Other articles have utilized the diagnostic series of N-codes (Blanc, P. D., Jones, M. R., & Olson, K. R., 1993; Samore, M. H. et al., 2004; Slonim, A. D., LaFleur, B. J., Ahmed, W., & Joseph, J. G., 2003). extensive chart review (Brennan, T. A. et al., 1991; Leape, L. L. et al., 1991), incident report monitoring, voluntary reporting systems (Inoue K, Hirosawa I, Yatsuduka M, & et.al., 2002). One study used the E930-E949 series to describe medication errors (O'Hara, D. A. & Carson, N. J., 1997). Certain statistical reports and newsletters use all E-code adverse event ranges, but these have been limited to institutional publications from state governments and provincial authorities and have not been published in peer-reviewed journals (Center for Information Management and Evaluation, 2002; Helps, Y., Cripps, R., & Harrison, J., 2002; O'Hara, D. A. & Carson, N. J., 1997; Utah Health Data Committee, 2001).

No study has compared the different types of methods to capture patient safety events with the goal of determining which series of codes or combination of codes and data systems captures the largest number of patient safety events, hence providing the best case-inclusion criteria scheme for the surveillance of patient safety events. Some have suggested that such "triangulation" would be beneficial for case-finding (Miller, M. R., Elixhauser, A., & Zhan, C., 2003; Romano, P. S. et al., 2003) and may provide the foundation for a surveillance system.

The exploration of triangulation is an important research undertaking for three reasons:

(1) Existing detection systems for patient safety events may not capture the same events and a combination of systems may be necessary to accurately estimate the burden of patient safety events.

(2) Medical record expert chart review, the accepted gold standard, is not sustainable for continuous tracking of patient safety events due to the significant financial and time resources required; therefore, alternative data sources and methods are needed. Furthermore, if errors that do not result in injury are included in the definition of patient safety events, the gold standard of chart review would not be sufficiently comprehensive since these events are not recorded in the medical record.

(3) Coded administrative data currently exist and error reporting systems are becoming the norm in hospital patient safety. While these systems have their limitations, they consume fewer resources than chart review. Triangulation of existing systems may represent a realistic trade-off between an ideal, yet unsustainable system and the acceptance of imperfect, but readily available data.

Policy Relevance

Evolution of the Problem and Media Attention

Unsafe conditions in high-risk settings have engendered swift government responses in the form of legislative changes and the formation of new safety entities. Such high-risk settings have included aviation, oil/gas industry drilling and refining, and nuclear power, all of which have had damaging effects at the accident site and in the community. Government policy responses have included: the Aviation Safety Reporting System (ASRS), a comprehensive tracking system developed after a TWA airplane crash in 1974; and the Institute for Nuclear Power Operations (INPO), which was formed after the 1979 Three Mile Island incident to study and promulgate training regulations for plant employees and to develop industrial standards (Liang, B. A., 1999). In these examples, legal action required an event reporting system.

In contrast to these widely publicized events, the general population may never hear about any except the most egregious patient errors or injuries in a healthcare setting. At the very least, news coverage would not be the same as that given to airline crashes or industrial accidents. In addition to the relative invisibility of individual patient experiences to the general population, individual state coalitions or hospitals creating patient safety interventions need to improve the dissemination of lessons learned within their institution and throughout their greater clinical community.

The growing media attention to medical errors and injuries in recent years may have caused increased dialog among healthcare providers. Examples of events that brought national attention to patient safety were the quadruple overdose of chemotherapy to Boston Globe columnist Betsy Lehman in 1992 (Kong, D., 1995) and the transfusion of the wrong blood type in a transplant case at Duke University in August, 2003 (Kirkpatrick, C., 2003). A critical mass of consumers, providers, lawyers, and legislators now realize (1) the significance of the patient safety problem, (2) that patient safety shortfalls matter personally to them and will affect people they know, (3) that the problem only worsens over time, and (4) that research must be undertaken to understand the problem and to develop evidence-based models of addressing it.

Patient Safety Surveillance: Structure and Opportunities

Composition of a Patient Safety Surveillance System

The literature contains limited discussion as to how the surveillance of patient safety events will be conducted. Injury surveillance (E-codes and N-codes), AHRQ intramural investigators (PSI), and voluntary reporting systems (PSN) offer parts of the solution. Triangulation of these may yield a robust method for the surveillance of patient safety events. The ICD-9-CM codes used for E-codes, N-codes, and PSI are appealing because they routinely are collected, relatively easily acquired, and are used in other countries - creating the possibility of national and international comparisons.

The idea of a PSN-like system for error identification is enticing because it could capture a vast spectrum of patient safety events - the ideal of any surveillance system. In order for PSN to be the launching pad for a national patient safety reporting system, and simultaneously to address all aspects of patient safety of interest to researchers, policymakers, and patients, it would need to be comprehensive and capable of collecting errors that do not result in injury, errors that result in injury, and injuries that do not result from error. PSN-like systems have been strongly advocated by congressional testimony (108th Congress, 2003; United States Senate 106 Congress, 2000; United States Senate 107 Congress first session, 2001), and patient safety legislation (Senate Health, Education Labor and Pensions & House Energy and Commerce, 2005), and the IOM report To Err is Human (Kohn, LT, Corrigan, JM, & Donaldson, MS, 2000). It is unknown if or when a national system will be created, and whether it will be voluntary, or mandatory, or anonymous.

While the characteristics of a national reporting system are undetermined, interventions are already under way to ensure patient safety. The public health system must devise methods and policies to track events so as to ensure that these interventions can be evaluated in their institutional settings, and so as to ensure that their dissemination and subsequent effects throughout the population may be measured. Such surveillance is routinely conducted in chronic disease (e.g. cancer morbidity and mortality) and injury (e.g. decrease in alcohol-related motor vehicle fatalities). Such measurement provides researchers with the evidence needed to demonstrate the return on investment in patient safety to funding agencies, Congress, and the private sector.

Build on Existing Systems

The patient safety literature and congressional testimony to support federal patient safety legislation frequently cites the field of aviation safety research as the evidence-based discipline that informs error reduction in the aviation industry and that is proposed to be the model for error reduction in medicine. The literature does not set forth a blueprint for exactly how this would work. Nonetheless, if legislation passes, the patient safety community should stand ready with a model for what a patient safety event reporting system should look like. Similar to PSN, the Aviation Safety Reporting System (ASRS) captures voluntarily reported errors and near misses (events when an error occurred, but damage was averted through human or technological interaction). The United States Congress has considered such a system in medicine, but such a system does not currently exist. Over the past several years Congress has entertained multiple House and Senate bills to create patient safety legislation; several bills have included versions of a reporting system. The final version of a Senate bill included a voluntary anonymous medical error reporting system (similar to PSN at Johns Hopkins Hospital) (Senate Health, Education Labor and Pensions & House Energy and Commerce, 2005).

While many respectable agencies testified at these hearings regarding the importance of the bills (which would create a national medical error reporting system that protected the data and reporting providers from legal discovery) available data on a national level that illustrated the size of the patient safety problem was absent. Moreover, Congress maintained a strong interest in creating incentives for the reporting of patient safety events by increasing reimbursements to hospitals and other patient care organizations under the Medicare program in exchange for error reporting. Some healthcare purchasers' alliances have proposed penalizing hospitals by not permitting reimbursements to hospitals for extended lengths of stay caused by errors (The Leapfrog Group). The literature contains no evaluation of the efficacy of power-coercive strategies such as attaching financial disincentives to reported errors.

Before approving a policy of cutting funding to already under-compensated healthcare providers, scientists must understand what causes errors and what methods work to prevent errors. Since patient safety events disproportionately affect the oldest and youngest members of society, strong epidemiological evidence would help support policy decisions such as reimbursement levels and generalized proposals to improve care.

Conceptual Framework

Injury-Focused Approach to Patient Safety

In 2002, Layde and colleagues offered a conceptual approach to medical error reduction by using an injury prevention and control framework. The authors suggested that it was more practical to focus on medical injuries as opposed to medical errors since not all errors resulted in harm. The authors recognized the Harvard Medical Practice Study's (HMPS) finding that 27% of cases involved negligence. Given that more than

70% of injuries detected in the HMPS did not involve negligence, the authors concluded that focusing on errors would be looking at a very small part of the patient safety problem. The authors also argued that medical injuries were more easily detected than errors, citing the HMPS in which very good interrater reliability existed with respect to the determination of injuries by physician reviewers, but poor agreement existed with respect to whether an adverse event was due to negligence (Layde, P. M. et al., 2002). In this paper, the authors seemed to equate an error with medical negligence. This is not consistent with the Institute of Medicine report, To Err Is Human, which more broadly defined an error as "the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim" (Kohn, LT, Corrigan, JM, & Donaldson, MS, 2000). Using the IOM definition, errors could - or could not - lead to patient injury, rather than errors just being injuries that are caused by negligence. The authors cited limitations inherent in expert chart review, such as labor intensiveness and low specificity, to justify the opinion that identification of medical errors was not reliable. However, a retrospective review of error and injury judgments might never accurately describe either category; rather, the use of prospective systems that look at factors upstream of the error or injury may have better predictive power (Marx, D. A. & Slonim, A. D., 2003; McNutt, R. A., Abrams, R., & Arons, D. C., 2002).

Error-Focused Approach to Patient Safety

McNutt and colleagues offer a dissenting opinion regarding the direction that patient safety efforts should take. They posit that efforts should focus on errors and not injuries. This perception is based on two ideas - the definition of error itself and the idea that the epidemiological model is insufficiently complex to handle the constant change present in the medical care delivery system. As with the Layde article, these authors use a different definition of error than the IOM report. These authors adopt a "root or core causes at the system of medical care" orientation as opposed to “failed decision-making” or “failed processes” (McNutt, R. A., Abrams, R., & Arons, D. C., 2002). They reason that the IOM definition represents relatively low-hanging fruit and does not focus on the root causes of these processes. They argue that not focusing on these root causes will make it very difficult if not impossible to change systems of care. Furthermore, they suggest that focusing on human beings and their role in the process should not be the focus of improvement efforts. Finally, they offer that the IOM report’s focus on processes of care is too broad in that if the flawed individual parts of the chain are not fixed and instead the entire process is changed, the most likely result will be more error. These concerns are interesting in that, while the authors argue that the injury epidemiological framework is inadequate for the study of ever-changing factors promoting errors, they argue for a root cause orientation which has been embraced by the field of injury prevention and control. The field predominantly has focused on passive interventions directed at weak links in an injury scenario (as ascertained by application of the Haddon matrix) as opposed to alterations of human behavior. The Haddon matrix is the seminal framework which examines injury prevention opportunities from the perspectives of the person injured (or creating the injury), the injurious agent, and the physical, social, and biological environment in which the injury occurs. It is based on the traditional epidemiological model of disease and offers a tremendous opportunity to explore multiple patient safety interventions (Baker, S. P., O'Neill B., Ginsburg M.J., & Li G., 1992; Layde, P. M. et al., 2002).

Surveillance-Focused Approach to Patient Safety

Both the Layde and McNutt papers use different definitions of error than are used in the IOM report and argue that due to limited resources it is critical to focus on only injuries (Layde) or errors (McNutt). However, choosing either of these orientations creates a framework too narrow given the growing evidence that both are important in the patient safety problem. The most opportune framework for addressing and eventually ameliorating the problem would be to embrace the study of both errors and injuries in what can be called a *surveillance* perspective. The Centers for Disease Control and Prevention (CDC) define surveillance as:

> the ongoing, systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know. The final link of the surveillance chain is the application of these data to prevention and control (Halperin, W and Baker E. L., 1992).

Surveillance is an activity done in order to develop priorities for research, programmatic planning, and policy. Surveillance therefore, by definition, casts a very broad net with respect to what it will capture. This accomplishes the collection of data that may be used for prevention immediately, while at once capturing data that may assist in predicting not only events of concern in the future but also events for which no known prevention mechanisms exist.

> Surveillance data should be used to identify areas needed in research and service, that, in turn, help to define training needs. Unless these data are provided to those who set policy and implement programs, their use is limited to archival and academic pursuits, and are appropriately considered to be health information rather than surveillance data. Though both may be based on surveillance, they are independent public health activities. Hence, the boundary of surveillance practice is drawn before the actual conduct of research and the implementation of delivery programs.

> The uses of surveillance include detecting new health problems,...detecting epidemics, documenting the spread of disease, providing quantitative estimates of the magnitude of morbidity and mortality, describing the clinical course of disease, identifying potential factors involved in disease occurrence, facilitating epidemiological research, targeting resources for program intervention, and assessing control of prevention activities (Halperin, W and Baker E. L., 1992).

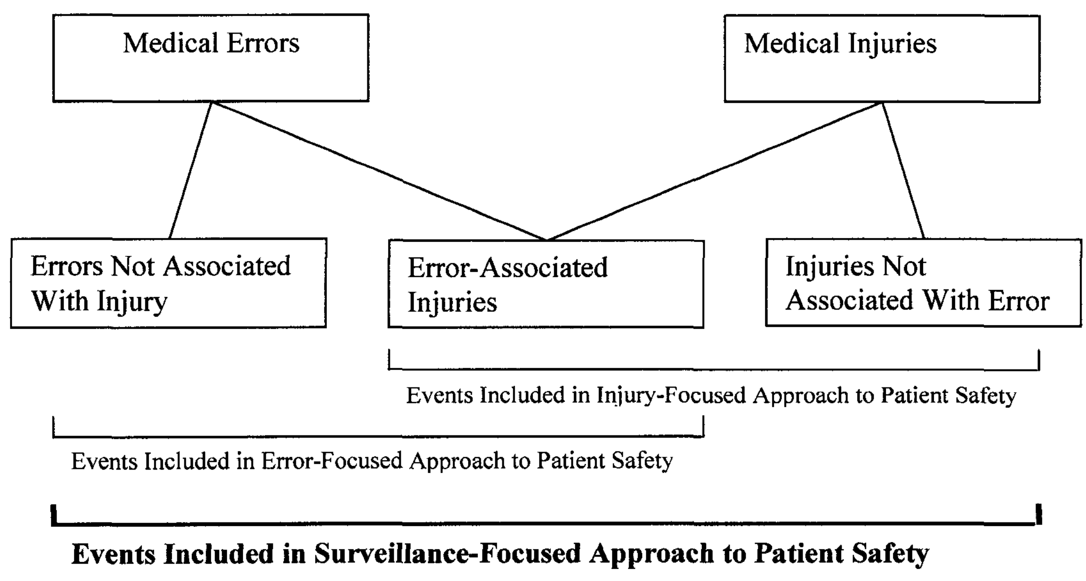
The surveillance-focused approach to patient safety is visualized in **Figure 1**. The concept of focusing on medical injuries alone (Layde, P. M. et al., 2002) is extended to include ideas about focusing on errors (McNutt, R. A., Abrams, R., & Arons, D. C., 2002) and unites them under the umbrella of surveillance to illustrate what is necessary to fully understand the burden of the current patient safety problem.

Three domains inform the conceptual framework: (1) errors that do not lead to injury (near misses), (2) errors that lead to injury (adverse events, preventable adverse events), and (3) injuries that do not result from error (potentially preventable adverse events). The literature currently does not offer consistent epidemiological descriptions of these categories. The amount of overlap among these categories is unknown. A patient safety clinician suggested the possibility that an error that does not result in harm one day may result in harm the next (Marlene Miller, personal communication). For example, one patient may be given a 10% extra medication dose and have no adverse reaction, while another patient given the same overdose may have an adverse reaction. A bidirectional arrow may be present between the boxes containing "errors that do not lead to injury" and "errors that do lead to injury" in the conceptual framework. This however, remains to be determined.

Maintaining a broad and inclusive framework is important because this will allow for the evaluation of interventions. Using the "errors that do lead to injury" category as an example, it is possible to develop an intervention focused on preventing the error or the injury. An error-based approach would be more upstream while an injury approach would be more downstream. However, if the only known effective intervention were a downstream approach, and these injuries were successfully prevented, then some events detected from a surveillance system could move from the "errors that do lead to injury" category to the "errors that do not lead to injury" category.

If an upstream approach is used, the intervention may reduce events in both categories and focus research upon the remaining category "injuries that do not result from error". This framework lays the foundation for capturing as many patient safety events as possible and studying the effect of interventions across categories.

Figure 1. Conceptual Framework: A Surveillance-Focused Approach to Patient Safety



Adapted from Layde, P. M. Maas L. A. Teret S. P. Brasel K. J. Kuhn E. M. Mercy J. A. Hargarten S. A. "Patient Safety Efforts Should Focus on Medical Injuries." JAMA 287 (2002): 1993-97.

Methods to Detect Patient Safety Events

Various methods are employed to find patient safety events: "stimulated" or "non-stimulated" self-report through occurrence or reporting systems, computer monitoring of medical records coded by trained nosologists for the purpose of preparing records for billing, medical record (chart) review by expert clinicians, direct observation, clinical experts participating in clinical rounds, or a combination of methods (von Laue, N. C., Schwappach, D. L. B., & Koeck, C. M., 2003). For purposes of this review, only the first two methods will be explored. Medical record review by expert clinicians, while arguably the gold standard in medical error detection, is not feasible because of the tremendous time and personnel resources required and because it does not capture errors that do not result in injury (near misses).

Four case identification criteria are discussed further: E-codes, N-codes, AHRQ Patient Safety Indicators (PSI), and University HealthSystems Consortium's Patient Safety Net (PSN). The first three case-inclusion criteria use administrative hospital discharge data while the last criteria uses an anonymous voluntary error reporting system.

N-codes and E-codes

While the literature to date on patient safety and patient safety events comes largely from quality improvement and clinical communities, the opportunity is present for the injury prevention and control research community to contribute to understanding the epidemiology of this problem. Traditional injury surveillance relies on well known sources of data: mortality data (from state vital statistics departments), hospital discharge data including inpatient and outpatient visits, emergency department data, and sometimes - although rarer - physician office visit data, clinic data, or insurance claims data.

In 1997, the National Center for Health Statistics (NCHS), issued an E-code matrix for use in injury surveillance (Centers for Disease Control, 1997). E-codes are part of the International Classification of Disease (ICD-9-CM) codes used to describe morbidity and mortality. An initial set of codes is applied to a death or a hospital visit to describe the diagnosis of the injury: laceration, contusion, burn, poisoning, etc. These 'N-codes' signify the *nature* of the injury. When an injury occurs and receives one of these diagnostic codes, it is to be followed by a supplemental code called an 'E-code', which describes the *external* mechanism of the injury: motor vehicle crash, surgical misadventure, assault by an intimate partner, etc.(Centers for Disease Control and Prevention, 2005). In the ICD-9-CM, a series of E-codes describes adverse events in medical and surgical care and the administration of medications, E870-E876, E878-E879, E930-E949 (International Classification of Diseases, 9th Revision, Clinical Modification). Moreover, another series of N-codes is found in the 960-979 range and appears rarely to be used for patient safety events because this series of codes is listed as "poisonings" - a determination that is confusing to nosologists and clinicians alike when an event occurs with no sequelae (Marlene Miller, personal communication).

Patient Safety Indicators (PSI)

The Agency for Health Care Research and Quality (AHRQ) developed Patient Safety Indicators using 1997 hospital discharge data for New York: 2,400,000 discharge records were used to develop 29 indicators pertaining to 12 clinical conditions (Miller, M. R., Elixhauser, A., Zhan, C., & Meyer, G. S., 2001).

Patient safety indicators were intended to be used for case finding and performance measurement, consistent with previous priorities identified by national organizations such as the American Medical Association (AMA), the Joint Commission on Accreditation in Healthcare Organizations (JCAHO), and the National Committee for Quality Assurance (NCQA). The qualifications of measurements favored by these organizations included indicators that would be well-measured in terms of valid and reliable indicators and availability of data, would be preventable in terms of focusing on errors for which there are known interventions, and would bear significant cost savings for hospitals.

At the time of PSI development it was understood that these indicators merely would be a "patch" to the system until comprehensive error reporting systems were created. These metrics were intended to serve as indicators of opportunities amenable to error reduction. Given both the great political interest at the time and the money given to AHRQ by Congress, AHRQ acted quickly to offer indicators that at once would be immediately available and would meet the growing need for patient safety information.

The patient safety indicators were developed in four stages and are described in greater detail by Miller (Miller, M. R., Elixhauser, A., Zhan, C., & Meyer, G. S., 2001). Analyses that investigated patient characteristics among records with a PSI event compared to records without found the following differences:

- Two- to three-fold increase in length of stay,
- Two- to twenty-fold increase in in-hospital mortality,
- Two- to eight-fold increase in total charges, and
- Increasing age, increasing volume of inpatient surgical procedures, and increasing percentage of ICU hospital beds.

During stage 4 of PSI development, one group was created with E-codes only. This group was kept separate from a PSI summary measure for two reasons: (1) it was noted that E-codes were not consistently recorded in hospital discharge records and therefore needed to be separated to avoid bias in PSI reporting, and (2) E-codes can duplicate N-codes (e.g. foreign body) and were segregated in order to prevent duplicate case counts (Marlene Miller, personal communication). In a review of current PSI, E-codes seem to have been incorporated marginally into the indicators: 8 out of 29 use E-codes in their case inclusion criteria (**Table 1).** The event rate for the original PSI ranged from 0.8 – 84.1 per 10,000 discharges. E-codes had a rate of 8.9 per 10,000.

Table 1. Indicators and Use of External Cause of Injury Codes

Indicator Number (used in software)	Indicator Name	Use of External Cause-of-Injury Codes
15 & 25	Accidental puncture or laceration	Required. Used in both the numerator and denominator definitions.
17	Birth trauma	Not used.
1	Complications of anesthesia	Required. Used in the numerator definition
2	Death in low mortality DRGs	Not used.
3	Decubitus ulcer	Not used.
4	Failure to rescue	Not used.
5 & 21	Foreign body left during procedure	Required. Used in the numerator definition although the other ICD-9 CM codes may capture the same information.
6 & 22	Iatrogenic pneumothorax	Not used.
20 & 29	Obstetric trauma – cesarean section	Not used.
18 & 27	Obstetric trauma – vaginal with instrument	Not used.
19 & 28	Obstetric trauma – vaginal without instrument	Not used.
9	Postoperative hemorrhage or hematoma	Not used.
8	Postoperative hip fracture	Used as exclusion criteria in denominator population.
10	Postoperative physiologic and metabolic derangements	Not used.
12	Postoperative pulmonary embolism or deep vein thrombosis	Not used.
11	Postoperative respiratory failure	Not used.
13	Postoperative sepsis	Not used.
14 & 24	Postoperative wound dehiscence	Not used.
7 & 23	Selected infections due to medical care	Not used.
16 & 26	Transfusion reaction	Required. Used in the numerator definition although the other ICD-9 CM codes may capture the same information.

Source: PSI guide. Version 2.1, Revision 3 (January 17, 2005) pg 25.

The principal difference between the PSI and traditional injury surveillance metrics (N-codes and E-codes) is that PSI attempt to tailor numerators and denominators to events that are solely *preventable*, whereas E-codes and N-codes include events for which preventability is difficult to ascertain or for which prevention strategies are unknown (Marlene Miller, personal communication).

The PSI do not rely heavily on the E-codes for adverse events. Discussion with one of the authors of the PSI indicates that these E-codes were evaluated for inclusion in the indicators, but ultimately the entire set of E-codes were not included in the PSI. This occurred predominantly since E-codes are meant to be used in conjunction with diagnosis or procedure ICD-9 codes and could potentially result in unwanted repeat identification of the same cases (Marlene Miller, personal communication).

Error Reporting Systems

An ideal system to capture patient safety events is as elusive as the definition of patient safety itself (Dovey, S. M. & Phillips, R. L., 2004; Johnson, C. W., 2003; Tamuz, M., Thomas, E. J., & Franchois, K. E., 2004). However, the current political frontrunner capitalizes on the success of the Aviation Safety Reporting System (ASRS), a voluntary reporting system of errors and near-misses similar to the University HealthSystems Consortium's PSN in use at Johns Hopkins. Such a national reporting system for medical errors and near misses has been discussed in the IOM report, To Err is Human, and in testimony before Congress (108th Congress, 2003; Senate Health, Education Labor and Pensions & House Energy and Commerce, 2005; United States Senate 106 Congress, 2000; United States Senate 107 Congress first session, 2001). The structure of the system could include various components such as mandatory reporting of deaths and serious adverse events, and voluntary reporting of near misses and minor adverse events. In order to ensure that providers make reports to the system, it has been suggested that reports be anonymous - de-identifying the patient as well as the provider. However, this requirement impedes patient safety research because the lack of identifying information makes follow-up and in-depth research impossible. The alternative to anonymity would be confidential reporting with reports being exempt from use in lawsuits (Kohn, LT, Corrigan, JM, & Donaldson, MS, 2000; Liang, B. A., 1999). Over the past several years, Congress has offered many proposals to create patient safety reporting systems, with the latest versions (H.R. 3205, S.544, S. 720) espousing a voluntary error reporting system with some protection of the data from legal discovery (Senate Health, Education Labor and Pensions & House Energy and Commerce, 2005).

Many hospitals nationwide, as well as governments and private groups around the world, have started to develop reporting systems. While the initial analysis from these systems is forthcoming, a *national* patient safety reporting system presently does not exist in the United States. PSN, the error reporting system adopted by Johns Hopkins Hospital, is one of many systems available in the marketplace. **Table 2** provides a sample of various reporting systems.

Table 2. Examples of Patient Safety Reporting Systems

Mandatory External Reporting

State Adverse Event Tracking

Food and Drug Administration (medical products and devices)

Voluntary External Reporting

Joint Commission on Accreditation of Healthcare Organizations (JCAHO) - sentinel events

Medication Errors Reporting Program (MER)

MedMARx (U.S. Pharmacopoeia)

Aviation Safety Reporting System (ASRS)

CDC Nosocomial Infection Surveillance system (NNIS)

Neonatal Intensive Care Quality collaborative, 2000, 2002, (Vermont Oxford Network)

Intensive Care Unit Safety Reporting System (ICUSRS), Johns Hopkins Hospital

Mandatory Internal Reporting with Audit

Occupational Safety and Health Administration

Other
PHICO's Event Reporting Trending System (PERTS) - insurance claims of adverse drug reactions and medication errors

Patient Safety Reporting System (Department of Veterans Affairs)

Australian Incident Monitoring Study (AIMS-ICU)

Sources: To err is human: building a safer health system. 2000. National Academy Press, Washington, DC. pp 86-106.
Benjamin, D. and Pendrak, R. Journal of Clinical Pharmacology, 2003;43:754-759.
Suresh, G. et. al. Pediatrics, 2004;113:1609-1618.
Beckman, U. et al. Anaesthesia Intensive Care, 1998;26(4):396-400.

Administrative data have proven a useful source of data for highlighting patient safety concerns in hospitals. The burden of patient safety events is currently unknown and depends ultimately on how patient safety events are defined and captured. This study attempts to expand the current focus on injurious, preventable medical errors embraced by much of the patient safety field to a greater conceptual framework that includes errors that do not result in injury and injuries that do not result from errors. This family of events is called "patient safety events". The expansion of scope is necessary to develop a patient safety surveillance system that will be comprehensive, feasible, adaptive, and uninterrupted as the patient safety field grows in its understanding of events, their causes, and their outcomes.

The next section recalls the "Surveillance-focused Approach to Patient Safety" conceptual framework, investigating the middle domain of the conceptual framework, error-associated injuries. This domain was chosen because it had the most potential overlap upon preliminary inspection. Because of the strength of evidence in the literature, administrative discharge data and an error-reporting system were evaluated to identify the degree of overlap among them in detecting patient safety events.

Reference List

108th Congress. U.S. Senate Governmental Affairs Committee: Permanent Subcommittee On Investigations Holds A Hearing On Patient Safety. Copyright 2003 FDCH E-Media, Inc. (F/K/A Federal Document Clearing House, Inc.) FDCH Political Transcripts. 6-11-2003. U.S. Senate Governmental Affairs Committee: Permanent Subcommittee On Investigations.
Ref Type: Hearing

Agency for Healthcare Research and Quality (2005). *AHRQ Quality Indicators - Guide to The Patient Safety Indicators* (Rep. No. 03-R203). Rockville, MD: Agency for Healthcare Research and Quality.

Agency for Healthcare Research and Quality (2006). *Medical Errors: The Scope of the Problem*. Fact sheet, Publication No. AHRQ 00-P037. *http://www.ahrq.gov/qual/errback.htm* [Announcement posted on the World Wide Web]. 2005, from the World Wide Web: http://www.ahrq.gov/qual/errback.htm

Baker, S. P., O'Neill B., Ginsburg M.J., & Li G. (1992). Introduction. In *The Injury Fact Book* (2 ed., pp. 4). New York: Oxford University Press Inc.

Bates, D. W., Teich, J. M., Lee, J., Seger, D., Kuperman, G. J., Ma'Luf, N., Boyle, D., & Leape, L. (1999). The impact of computerized physician order entry on medication error prevention. *J.Am.Med.Inform.Assoc., 6,* 313-321.

Blanc, P. D., Jones, M. R., & Olson, K. R. (1993). Surveillance of poisoning and drug overdose through hospital discharge coding, poison control center reporting, and the Drug Abuse Warning Network. *Am.J.Emerg.Med., 11,* 14-19.

Bordeaux S. (1999). *Injury Mortality Australia, 1997* (Rep. No. 20). Adelaide, Australia: Australian Institute of Health and Welfare National Injury Surveillance Unit.

Brennan, T. A., Leape, L. L., Laird, N. M., Hebert, L., Localio, A. R., Lawthers, A. G., Newhouse, J. P., Weiler, P. C., & Hiatt, H. H. (1991). Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N.Engl.J.Med., 324,* 370-376.

Carlson, R. (2004). Setting safe standards. Homegrown bar coding medication administration system helps VA hospitals minimize mistakes at the point of care. *Health Manag.Technol., 25,* 30-33.

Center for Information Management and Evaluation (2002). *Missouri Patient Safety Report Guide* Jefferson City, Missouri: Missouri Department of Health and Senior Services.

Centers for Disease Control (1997). Recommended framework for presenting injury mortality data. *MMWR Recomm.Rep., 46,* 1-30.

Centers for Disease Control and Prevention (2005). ICD-9-CM Official Guidelines For Coding and Reporting. *Google* [Announcement posted on the World Wide Web]. 6-29-2005, from the World Wide Web: http://www.cdc.gov/nchs/data/icd9/icdguide.pdf.

Classen DC, Pestotnik SL, & et al. (1997). Adverse Drug events in Hospitalized Patients. *JAMA, 277,* 301-306.

Dovey, S. M. & Phillips, R. L. (2004). What should we report to medical error reporting systems? *Qual.Saf Health Care, 13,* 322-323.

Dunn, J. D. (2001). Error in medicine. *Ann.Intern.Med., 134,* 342.

Edmonds, M. (2005). Hot Topics in Patient Safety. *Australian Patient Safety Foundation* [Announcement posted on the World Wide Web]. 2005, from the World Wide Web: http://www.informatics.adelaide.edu.au/research/Preop/ME-DSPreOpPres.html

Forster, A. J., Clark, H. D., Menard, A., Dupuis, N., Chernish, R., Chandok, N., Khan, A., & van, W. C. (2004). Adverse events among medical patients after discharge from hospital. *CMAJ., 170,* 345-349.

Gawande, A. A., Thomas, E. J., Zinner, M. J., & Brennan, T. A. (1999). The incidence and nature of surgical adverse events in Colorado and Utah in 1992. *Surgery, 126,* 66-75.

Halperin, W. a. B. E. L. (1992). *Public Health Surveillance*. New York: Van Rostrand Reinhold.

Helps, Y., Cripps, R., & Harrison, J. (2002). *Hospital Seperations due to injury and poisoning, Australia 1999-2000.* Adelaide, Australia: Australia Insititute of Health and Welfare.

Iezzoni, L. I. (1997). Assessing quality using administrative data. *Ann.Intern.Med., 127,* 666-674.

Inoue K, Hirosawa I, Yatsuduka M, & et.al. (2002). Utilization of a Voluntary Reporting System in Quantitative Risk Assessment for Medical Tasks in a Hospital Setting-with Special Reference to Tasks Done by Nurses. *Journal of Occupational Health (Japan), 44,* 360-372.

Johnson, C. W. (2003). How will we get the data and what will we do with it then? Issues in the reporting of adverse healthcare events. *Qual.Saf Health Care, 12 Suppl 2:ii64-7.,* ii64-ii67.

Kirkpatrick, C. (2003, August 2). Hospital heals long list of flaws. *The Herald-Sun*

(Durham, N.C.).

Kohn, L., Corrigan, J., & Donaldson, M. To err is human: building a safer health system. Linda T.Kohn, Janet M.Corrigan, and Molla S.Donaldson. 2000. Washington, DC, National Academy Press.
Ref Type: Serial (Book,Monograph)

Kong, D. (1995, March 24). State Faults Dana-Farber Says Center Failed to Tell Promptly of Two Overdoses of Cancer Drug. *The Boston Globe*.

Layde, P. M., Maas, L. A., Teret, S. P., Brasel, K. J., Kuhn, E. M., Mercy, J. A., & Hargarten, S. A. (2002). Patient Safety Efforts Should Focus on Medical Injuries. *JAMA, 287,* 1993-1997.

Leape, L. L., Brennan, T. A., Laird, N., Lawthers, A. G., Localio, A. R., Barnes, B. A., Hebert, L., Newhouse, J. P., Weiler, P. C., & Hiatt, H. (1991). The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. *N.Engl.J.Med., 324,* 377-384.

Leape, L. L., Lawthers, A. G., Brennan, T. A., & Johnson, W. G. (1993). Preventing medical injury. *Qual.Rev.Bull., 19,* 144-149.

Liang, B. A. (1999). Error in Medicine: Legal Impediments to U.S. Reform. *Journal of Health Politics, Policy, and Law, 199,* 26-57.

Marx, D. A. & Slonim, A. D. (2003). Assessing patient safety risk before the injury occurs: an introduction to sociotechnical probabilistic risk modelling in health care. *Qual.Saf Health Care, 12 Suppl 2:ii33-8.,* ii33-ii38.

McNutt, R. A., Abrams, R., & Arons, D. C. (2002). Patient safety efforts should focus on medical errors. *JAMA, 287,* 1997-2001.

Miller, M. R., Elixhauser, A., & Zhan, C. (2003). Patient safety events during pediatric hospitalizations. *Pediatrics, 111,* 1358-1366.

Miller, M. R., Elixhauser, A., Zhan, C., & Meyer, G. S. (2001). Patient Safety Indicators: using administrative data to identify potential patient safety concerns. *Health Serv.Res., 36,* 110-132.

Miller, M. R. & Zhan, C. (2004). Pediatric patient safety in hospitals: a national picture in 2000. *Pediatrics, 113,* 1741-1746.

Murff, H. J., Patel, V. L., Hripcsak, G., & Bates, D. W. (2003). Detecting adverse events for patient safety research: a review of current methodologies. *J.Biomed.Inform., 36,* 131-143.

O'Hara, D. A. & Carson, N. J. (1997). Reporting of adverse events in hospitals in Victoria, 1994-1995. *Med.J.Aust., 166,* 460-463.

Pape, T. M. (2003). Applying airline safety practices to medication administration. *Medsurg.Nurs., 12,* 77-93.

Rigby K, Clark RB, & et al. (1999). Adverse events in health care: Setting priorities based on economic evaluation. *Journal of Quality Clinical Practice, 19,* 7-12.

Romano, P. S., Geppert, J. J., Davies, S., Miller, M. R., Elixhauser, A., & McDonald, K. M. (2003). A national profile of patient safety in U.S. hospitals. *Health Aff.(Millwood.), 22,* 154-166.

Samore, M. H., Evans, R. S., Lassen, A., Gould, P., Lloyd, J., Gardner, R. M., Abouzelof, R., Taylor, C., Woodbury, D. A., Willy, M., & Bright, R. A. (2004). Surveillance of medical device-related hazards and adverse events in hospitalized patients. *JAMA, 291,* 325-334.

Senate Health, E. L. a. P. & House Energy and Commerce. Patient Safety and Quality Improvement Act of 2005. S. 544. 2005.
Ref Type: Bill/Resolution

Slonim, A. D., LaFleur, B. J., Ahmed, W., & Joseph, J. G. (2003). Hospital-reported medical errors in children. *Pediatrics, 111,* 617-621.

Tamuz, M., Thomas, E. J., & Franchois, K. E. (2004). Defining and classifying medical error: lessons for patient safety reporting systems. *Qual.Saf Health Care, 13,* 13-20.

Thomas, E. J., Studdert, D. M., Burstin, H. R., Orav, E. J., Zeena, T., Williams, E. J., Howard, K. M., Weiler, P. C., & Brennan, T. A. (2000). Incidence and types of adverse events and negligent care in Utah and Colorado. *Med.Care, 38,* 261-271.

United States Senate 106 Congress. Medical errors: administration response and other perspectives. 2-22-2000. Health, Education, Labor, and Pensions, Labor, Health and Human Services, and Education (of the Committee on Appropriation).
Ref Type: Hearing

United States Senate 107 Congress first session. Patient safety: what is the role for Congress. 5-24-2001. Health, Education, Labor and Pensions.
Ref Type: Hearing

Utah Health Data Committee (2001). *Adverse Events Related to Medical Care, Utah 1995-1999* Salt Lake City, Utah: Utah Department of Health.

von Laue, N. C., Schwappach, D. L. B., & Koeck, C. M. (2003). The epidemiology of preventable adverse drug events: A review of the literature. *Wien Klin Wochenschr (The Middle European Journal of Medicine), 115,* 407-415.

Wilson, R. M., Harrison, B. T., Gibberd, R. W., & Hamilton, J. D. (1999). An analysis of the causes of adverse events from the Quality in Australian Health Care Study. *Med.J.Aust., 170,* 411-415.

Zhan, C. & Miller, M. R. (2003). Excess length of stay, charges, and mortality attributable to medical injuries during hospitalization. *JAMA, 290,* 1868-1874.

PART I: Utility of Patient Safety Case Finding Methods in an Inpatient Hospital Setting

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Abstract

Administrative data have proven a useful source for highlighting patient safety concerns in hospitals. The burden of patient safety events is currently unknown and depends ultimately on how patient safety events are defined and captured. This study expands the current focus on medical errors embraced by much of the patient safety field to a greater conceptual framework that includes both errors that do not result in injury and injuries that do not result from errors. This family of events is called "patient safety events." The expansion of scope is necessary to develop a patient safety surveillance system that will be comprehensive, feasible, adaptive, and uninterrupted as the patient safety field increases its understanding of events, their causes, and their outcomes.

This study examined methods to determine which method or combination of methods maximizes patient safety event case finding. The first three methods used inpatient hospital administrative discharge data from the Johns Hopkins Hospital. The last method used a voluntary reporting system for errors and near-misses in use at Johns

Hopkins Hospital.

This study investigated four methods of detecting patient safety events, identified the overlap among them, and ascertained that multiple data systems and case identification criteria are necessary to maximize the capture of patient safety events.

The mutual exclusiveness of the detection systems was unexpected. Accidental laceration or puncture is the most revealing example: of the case identification criteria that found an identical event, only 100 of 476 unique events were detected. While PSI performed the best, there were still 148 unique events that it did not detect. Furthermore, the stark difference in detection between the error-reporting system (PSN) which detected only 2 events and the case identification criteria applied to the administrative data (PSI, E-code, N-code) was concerning.

Introduction

In March, 2000, the Institute of Medicine (IOM) released its seminal public health report, To Err is Human: Building a Safer Health Care System citing an annual estimate of 44,000 to 98,000 deaths due to medical errors (Kohn, LT, Corrigan, JM, & Donaldson, MS, 2000). Debate ensued about these estimates and the argument as to how many events occur annually has yet to be resolved (Dunn, J. D., 2001).

To Err is Human drew from well-designed studies that conducted arduous chart reviews in several states' hospitals (Brennan, T. A. et al., 1991; Leape, L. L. et al., 1991), but a system to consistently capture these events has not been conceived. Consideration of such design and development is critical to the development of population-based prevention and policy methods. Examination of the magnitude of patient safety events in relation to other injuries and chronic diseases, expressing the burden to the health care system in terms of direct costs, avoidable length of stay, and lost productivity (patients and providers) is essential. Growing evidence suggests that these events contribute to poorer post-discharge prognosis, extended length of stay, extra costs, and attributable mortality (Classen DC, Pestotnik SL, & et al., 1997; Rigby K, Clark RB, & et al., 1999). Medical errors are estimated at $38 billion annually; preventable errors constitute about 45% of this estimate (Agency for Healthcare Research and Quality, 2006). A comprehensive surveillance system that tracks both errors and injuries is essential to meet epidemiologic goals and to understand the resource burden on the healthcare system.

This study describes the data systems and case identification criteria needed to maximize patient safety case finding with the goal of determining the components necessary to establish an ideal patient safety surveillance system.

A review of the literature has not revealed a study that compares various methods of case finding with the express goal of discovering which case-finding criteria provide the optimum schema for patient safety surveillance. "Triangulation" of such different methods has been suggested to be beneficial for case-finding (Miller, M. R., Elixhauser, A., & Zhan, C., 2003; Romano, P. S. et al., 2003).

Landmark Patient Safety Studies

Harvard Medical Practice Study

The Harvard Medical Practice Study (HMPS) sought to estimate the incidence of adverse events by examining medical injuries and a subset that resulted from negligence in an extensive chart review study.

The results from this seminal patient safety study found adverse events in 3.7% of hospitalizations, 27% of which were determined to be due to negligence (Brennan, T. A. et al., 1991; Leape, L. L. et al., 1991).

The study found a twofold increased risk of an adverse event in people aged 65 and older compared to those aged 16 to 44. Of all adverse events, drug complications were the most common (19%), followed by wound infections (14%) and technical complications (13%). Subsequent chart abstractions studies had findings similar to the HMPS (Bordeaux S., 1999; Edmonds, M., 2005; Forster, A. J. et al., 2004; Gawande, A. A., Thomas, E. J., Zinner, M. J., & Brennan, T. A., 1999; Thomas, E. J. et al., 2000).

Reporting of Hospital Adverse Events in Australian Hospitals

An exploration of coded hospital discharge data was conducted in Victoria (O'Hara, D. A. & Carson, N. J., 1997). Using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), this study grouped adverse events according to the External Cause of Injury (E-codes) categories: "Misadventures to patient during surgical and medical care" (E870-E876), "Surgical and medical procedures as the cause of abnormal reaction of patients or later complication, without mention of misadventure at the time of procedure" (E878-E879), and "Drugs, medicinal and biological substances causing adverse effects in therapeutic use" (E930-E949). Five percent of discharges from Victoria's hospitals had an adverse event E-code in 1994-1995. The E-codes from the ICD-9-CM used in this study are traditional injury surveillance metrics used in conjunction with nature of injury codes (N-codes).

Patient Safety Indicators

Patient Safety Indicators (PSI) were developed by the Agency for Health Care Research and Quality (AHRQ) for the purpose of patient safety case finding and performance improvement at the provider and system level in hospitals (Agency for Healthcare Research and Quality, 2005). These indicators for complications and other iatrogenic events were selected based on their potential preventability; other patient safety concerns such as medication errors were excluded because of perceived low preventability (Leape, L. L., Lawthers, A. G., Brennan, T. A., & Johnson, W. G., 1993).

Romano and colleagues used the PSI to estimate the incidence of patient safety events using the 1995-2000 AHRQ Healthcare Cost and Utilization Project (HCUP) data's National Inpatient Sample (NIS). Results from the analysis found increasing patient safety events with increasing patient age and with African-American ethnicity. This analysis identified 1.12 million potential safety related events out of 38,316,000 hospitalizations in the year 2000 (Romano, P. S. et al., 2003).

In continuing use of the PSI and HCUP data, Miller and colleagues studied the pediatric population (Miller, M. R., Elixhauser, A., & Zhan, C., 2003).Comparing children with and without PSI events, the authors found a two to six fold increase in length of stay, two to 18 fold increase for in-hospital mortality, and a two to 20 fold increase in total charges for encounters.

The greatest limitation of the PSI is that they focus only on those events that are known to be preventable. Complications of care, medication errors, adverse drug events, and those events for which current preventive strategies were not known are excluded from the PSI. While the PSI identify improvement opportunities for hospital-based care, they were not conceptualized as a comprehensive surveillance tool and did not cover all potential patient safety events. PSI are described in more detail elsewhere (Miller, M. R., Elixhauser, A., Zhan, C., & Meyer, G. S., 2001; Miller, M. R., Elixhauser, A., & Zhan, C., 2003; Miller, M. R. & Zhan, C., 2004; Romano, P. S. et al., 2003; Zhan, C. & Miller, M. R., 2003).

Error Reporting Systems

An ideal system of capturing patient safety events is as elusive as the definition of patient safety itself (Dovey, S. M. & Phillips, R. L., 2004; Johnson, C. W., 2003; Tamuz, M., Thomas, E. J., & Franchois, K. E., 2004). To Err is Human, and testimony before Congress discuss such a national reporting system for medical errors and near misses similar to the Aviation Safety Reporting System (ASRS) (108th Congress, 2003; Senate Health, Education Labor and Pensions & House Energy and Commerce, 2005; United States Senate 106 Congress, 2000; United States Senate 107 Congress first session, 2001). The structure of the system could include various components, such as mandatory reporting of deaths and serious adverse events as well as voluntary reporting of near misses and minor adverse events. In order to ensure that providers make reports to the system, it has been suggested that reports be anonymous, de-identifying the patient as well as the provider. However, this requirement impedes patient safety research since the lack of identifying information makes follow-up and in-depth research impossible. The alternative to anonymity would be confidential reporting with reports being exempt from use in lawsuits (Kohn, LT, Corrigan, JM, & Donaldson, MS, 2000; Liang, B. A., 1999). Over the past several years, numerous proposals before Congress have sought to create patient safety reporting systems with the latest versions (H.R. 3205, S. 544, S. 720) espousing a voluntary error reporting system with some protection of the data from legal discovery (Senate Health, Education Labor and Pensions & House Energy and Commerce, 2005).

Conceptual Framework: Surveillance-Focused Approach to Patient Safety

In 2002, Layde and colleagues offered a conceptual approach to medical error reduction by using an injury prevention and control framework. The authors suggested that it was more practical to focus on medical injuries as opposed to medical errors since not all errors resulted in harm (Layde, P. M. et al., 2002).

McNutt and colleagues offer a dissenting opinion regarding the direction that patient safety efforts should take. They proposed that efforts should focus on errors and not injuries. This perception is based on two ideas - the definition of error itself and the idea that the epidemiological model is insufficiently complex to handle the constant change present in the medical care delivery system (McNutt, R. A., Abrams, R., & Arons, D. C., 2002).

Both the Layde and McNutt papers use different definitions of error than are used in the IOM report and argue that, due to limited resources, it is critical to focus on only injuries or errors. However, choosing either of these orientations creates a framework too narrow given the growing evidence that both are important in the patient safety problem. The most opportune framework for addressing and eventually ameliorating the problem would be to embrace the study of both errors and injuries in what can be called a *surveillance* perspective. The Centers for Disease Control and Prevention (CDC) define surveillance as "the ongoing, systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know" (Halperin, W and Baker E. L., 1992).

Surveillance is an activity conducted to develop priorities for research, programmatic planning, and policy. For this reason, surveillance need not be exact and its definitions may be amorphous or overly broad by design. This accomplishes the collection of data that may be used for prevention immediately, while simultaneously capturing data that may assist in predicting not only events of concern in the future, but also events for which no known prevention mechanisms currently exist.

The surveillance-focused approach to patient safety is visualized in **Figure 1**. The concept of focusing on medical injuries alone (Layde, P. M. et al., 2002) is extended to include ideas about focusing on errors (McNutt, R. A., Abrams, R., & Arons, D. C., 2002). and unites them under the umbrella of surveillance to illustrate what is necessary to fully understand the burden of the current patient safety problem. Of the three different categories of patient safety events described in the conceptual framework, **Table 1** lists the expected overlap of the three types of patient safety events among the four case-finding methods.

Three domains inform the conceptual framework: (1) errors that do not lead to injury (near misses), (2) errors that lead to injury (adverse events, preventable adverse events), and (3) injuries that do not result from error (potentially preventable adverse events). The literature currently does not offer consistent epidemiological descriptions of these categories. The amount of overlap among these categories is unknown. An error that does not result in harm one day may result in harm the next. For example, one patient may be given a 10% extra medication dose and have no adverse reaction, while another patient given the same overdose may have an adverse reaction. A bidirectional arrow may be present between the boxes containing "errors that do not lead to injury" and “errors that do lead to injury” in the conceptual framework. This however remains to be determined.

Maintaining a broad and inclusive framework is important because this will allow for the evaluation of interventions. Using the “errors that do lead to injury” category as an example, it is possible to develop an intervention focused on preventing the error or the injury. An error-based approach would be more upstream while an injury approach would be more downstream. However, if the only known effective intervention were a downstream approach, and these injuries were successfully prevented, then some events detected from a surveillance system could move from the “errors that do lead to injury" category to the “errors that do not lead to injury" category.

If an upstream approach is used, the intervention may reduce events in both categories and focus research upon the remaining category “injuries that do not result from error.” This framework lays the foundation for capturing as many patient safety events as possible and studying the effect of interventions across categories.

Study Goal

To address these ideas, we investigated the middle domain of the conceptual framework, error-associated injuries. We chose this domain because it had the most potential overlap upon preliminary inspection. Because of the strength of evidence in the literature, administrative discharge data and an error-reporting system were evaluated to identify the degree of overlap among them in detecting patient safety events.

Materials and Methods

Study Design

The study design was cross-sectional and used retrospective data. The setting was the Johns Hopkins Hospital, a level-one trauma center. This study used the hospital's inpatient discharge data and error-reporting system (Patient Safety Net) for calendar year 2005. Only one year of data were used in order to facilitate case finding of identical encounters across databases and case identification criteria.

Data Sources

The Department of Risk Management provided inpatient discharge and PSN data. Unique identifiers were collected for all events (name, medical record number, hospital stay encounter number). Demographic, diagnostic, admission and discharge dates were used to distinguish discharges detected by more than one method. All study activities were approved by the institutional review board at the Johns Hopkins Bloomberg School of Public Health. HIPAA approval was given by the Johns Hopkins Hospital.

Four case identification criteria were examined to determine which criteria or combination of criteria maximized patient safety event case finding: (1) AHRQ's Patient Safety Indicators (PSI), (2) ICD-9-CM Nature of Injury codes (N-codes), (3) ICD-9-CM

External Cause of Injury codes (E-codes), and (4) the UHC Patient Safety Net error reporting system (PSN). The first three methods used inpatient hospital administrative discharge data from the Johns Hopkins Hospital. The last method used a voluntary reporting system for errors and near-misses at the Johns Hopkins Hospital (PSN).

Patient Safety Indicators (PSI)

We applied AHRQ's publicly available Windows QI software was applied to the hospital's administrative discharge data (Agency for Healthcare Research and Quality, 2005). The Patient Safety Indicators use the principal and secondary diagnosis fields to indicate potentially preventable events. These indicators are intended to designate an event that occurred either during or after a single hospital encounter (readmission). PSI detected 1,463 events in the hospital's 2005 discharge data. **Table 2** lists the PSI categories.

Patient Safety Net (PSN)

In July 2004, the Johns Hopkins Hospital implemented a voluntary, electronic occurrence reporting system for errors and near-misses. Patient Safety Net (PSN) v. 3.0© was developed by the University HealthSystems Consortium. It contains ten domains that nurses and physicians use to describe errors, near misses and their circumstances (**Table 2**). Each error was given an event type to identify the mechanism and a score (A-I; A=unsafe conditions, I=death) to indicate the extent of harm to the patient. In 2005, PSN had 9,013 events. We selected cases that had a harm score of "C" or higher (n=5,668), indicating that an event had reached the patient. Our rationale to include these events regardless of harm was that, for these cases, there was an potential opportunity to prevent the event from reaching the patient.

E-codes and N-codes

The hospital's discharge data contained 15 diagnosis fields, including the principal diagnosis. A patient safety event was indicated by the presence of an ICD-9-CM External Cause of Injury (E-code) from the ranges E870-E879 and E930-E949 or a Nature of Injury (N-code) code from the injury diagnosis range (800-999) in the principal and/or associated ICD-9-CM diagnosis fields of the discharge data. The first field encountered in the diagnostics string was used to categorize the event. E-codes detected 13,407 patient safety events and N-codes detected 13,263. The E-code and N-code case identification criteria are found in **Table 3**.

Statistical Analysis

In order to generate summary statistics, a dichotomous variable was made for each of the four case identification criteria (PSN, PSI, E-code, N-code) within a patient encounter: any discharge identified as having a patient safety event was assigned a numeric value of "1". Non-events were given a "0" value. Data were managed in Microsoft Access©. The study employed the STATA software package (Stata 8, StataCorp LP, College Station, TX) to perform all analyses.

Differences between events and non-events were summarized by age, length of stay, charges, discharge disposition, gender, and complexity. Complexity was assessed through the APRDRG Patient Complexity Level in the hospital's discharge database. It was calculated using ICD9 diagnoses, ICD9 procedures, and patient age by the 3M APRDRG grouping software, Ver 12. Each patient was assigned a value: 1 (Low) to 4 (High). For the analysis, complexity was dichotomized into high (3 or 4) and low (1 or 2) categories.

Statistical significance was determined through Chi-square and t-tests. All analyses used a two-sided *P* value of less than .05 to indicate a statistically significant difference.

Crosswalk among Case Identification Criteria

Each case identification criterion had some categories that on initial inspection seem to be similar. Prior to other analyses, each system's categories were reviewed and a crosswalk showing agreement of categories was created. The crosswalk was verified by a physician (Marlene Miller) from the hospital.

Comparison of Different Case Identification Criteria to Detect Overlap of Patient Safety Events

The initial analysis was conducted to determine how many events each method captured. A subsequent analysis was performed to ascertain the number of identical cases simultaneously captured by each criterion. While systems may capture a similar number of cases, this does not mean they are identical. If some cases are captured by only one method, the design of an ideal surveillance system may have to incorporate each method.

Results

Summary Statistics

48,418 discharges were recorded for the calendar year 2005. Of these, 19,169 (40%) had at least one patient safety event detected by one or more of the case identification criteria (**Table 4**). As expected from previous findings in the literature, encounters (hospital stay) with a patient safety event were more likely to have higher average total charges ($29,518.90 versus $11,268.06, p=0.000) and higher average length of stay (8.46 versus 3.71, p=0.000). Patients that had events were older (46 years versus 40 years, p=0.000) and had higher levels of complexity as measured by the APRDRG complexity score (57.97% High complexity versus 26.76% High complexity).

Crosswalk

Initially we developed a crosswalk to discern which events were present in each case identification criteria. However, only three types of patient safety events were found to be detected by all four case identification criteria: foreign body, accidental puncture or laceration, and transfusion reactions. Because of so little overlap, the crosswalk was modified to compare each of the case identification criteria to those events detected by Patient Safety Net (PSN). PSN was selected as the benchmark for comparison due to its use in two companion studies using these data to explore the role of organizational culture in patient and nurse injury. Moreover, events reported to PSN are entered by frontline staff (physicians and nurses), therefore PSN more precisely captures event location and the observations of the health care providers about the event. This are in contrast to administrative data which are coded by highly trained nosologists, but is based on documentation in the medical record, and not an actual observation by the coder.

Upon completion of the PSN crosswalks, more events were found to be in common comparing PSN with each of the other three criteria (**Table 5**).

Finding of Events in the Same Event Type

Table 6 shows the number of events detected by each of the case identification criteria, showing overlap where it exists. It was surprising how little overlap there was among the different case identification criteria; most of the events can be considered to be mutually exclusive. For example, in the case of decubitus ulcers, Patient Safety Indicators detected 165 events and Patient Safety Net detected 7 events. The ICD-9-CM injury diagnosis ranges (E-codes and N-codes) do not contain codes for decubitus ulcer.

Another example of the surprising degree of exclusiveness was unintended lacerations or punctures. Patient Safety Indicators (PSI) detected 328 events, nature of injury (N-code) codes detected 321 events, and external cause of injury (E-code) detected 205. Only two of these events were detected by Patient Safety Net (PSN).

Finding of Identical Events

The next analysis was conducted to discern how many of the events detected by overlapping case identification criteria were identical. Of the 19,169 events detected as having at least one patient safety event, PSN detected 5,668, PSI detected 1,463, E-codes detected 13,407, and N-codes captured 13,263. Of note is that only 272 unique identifiers were found in all four case identification criteria. The highest degree of identical case finding was between nature of injury codes and external cause of injury codes (10,377 identical events, 78% and 77% respectively). This was not an unexpected result as the ICD-9-CM Coding Rules and Guidelines state that an N-code should be accompanied by an E-code to fully describe the injury episode (ICD-9-CM Official

Guidelines For Coding and Reporting).

However, these cases were not necessarily the same type of event or the same encounter. To address this, we linked cases on their unique identifier to discern identical encounters within the same event category. As displayed in the last column in **Table 6**, the amount of overlap was surprisingly small. Returning to the overlap between PSN and PSI with regard to decubitus ulcers, none of the unique identifiers were the same (n=0).

Figure 2 illustrates in a Venn diagram the overlap in all permutations examined for accidental laceration and punctures. When linking unintended lacerations or punctures on their unique identifier, out of 476 events, 188 were identical between PSI and E-code, 172 were identical between N-code and E-code, 118 were identical between PSI and N-code. Only 100 events were identical among all three. The two events detected by PSN were not found in any of the other case identification criteria.

Discussion

This study investigated four methods of detecting patient safety events, identified the overlap among them, and ascertained that multiple data systems and case identification criteria are necessary to maximize the capture of patient safety events.

The mutual exclusiveness of the detection systems was unexpected. Accidental laceration or puncture is the most revealing example: all four case identification criteria had codes for these events but, only 100 of 476 identical events were detected by E-codes, N-codes, and PSI. While PSI performed the best, there were still 148 unique events that it did not detect. Furthermore, the stark difference in detection between the error-reporting system (PSN) which detected only 2 events and the case identification criteria applied to the administrative data (PSI, E-code, N-code) was concerning. In discussion with the PSN data stewards, this particular type of event may have reporting issues. PSN events are largely reported by nurses, but accidental puncture/lacerations are usually the result of a surgical activity. It is possible that surgeons are not reporting these events either because they do not perceive them to be errors, or because they are not well-trained in the use of PSN.

This is not to say that PSN should be discarded. Falls and medication errors would not be detected if it were not for PSN. Therefore, the lesson is to continually train, monitor and evaluate the reporting of these events. It is known from PSI that 328 events occurred, so it is possible to consult the reporters to discern why events were not reported in PSN. Alternatively, if events such as falls are highly detected by PSN, this may encourage the addition of new codes in administrative data systems to signify that a fall event occurred during the hospitalization. While the E-codes capture fall events, the place of occurrence cannot be distinguished and these codes are useless for fall surveillance.

Chart review has been hailed as the gold standard for detecting adverse events, but it is not the gold standard for errors. Errors that do not result in patient harm are not usually recorded in medical records. Only a voluntary error reporting system that captures near misses would capture these events. The true gold standard for patient safety surveillance requires triangulation of multiple case finding methods if events like errors regardless of their effect to patients are included.

E-codes, N-codes, and PSI are captured in a different way than PSN: trained nosologists (medical records coders) review charts to assign codes largely for the purpose of reimbursement. Nosologists are rigorously trained for this task, usually having taken coursework and graduated from a medical records education program.

The sensitivity and predictive value for many of the PSI is either poor or has not been evaluated in the literature (Agency for Healthcare Research and Quality, 2005). Specifically, two of the indicators (failure to rescue, death in low-mortality DRGs) for pediatric patients have been described as "inaccurate" and not representing preventable errors (Sedman, A. et al., 2005). Furthermore, PSI do not include medication errors and adverse drug events and consequently do not capture a significant portion of patient safety events.

In contrast, PSN does not rely on trained nosologists, rather nurses and physicians enter information into a system for which they receive minimal training. While it may be possible that events entered into PSN eventually make their way to medical records (and thus to the coders), these systems are so new that it is not known what percentage of PSN events will be found in charts. It may be that only injuries would be documented; errors that do not result in harm would not be noted in the chart because they have no meaning for reimbursement purposes. The validity of PSN is not known, e.g., there has not been a survey to assess among hospital staff how often events are subsequently entered into PSN. It is not known if every error, injury, and near-miss that occurs is captured. It is also possible that there may be reporting bias in PSN in that events are more likely to be entered for some patients (e.g. children), or that a certain nursing service has a stronger commitment to reporting compared to other services.

In a review of the literature, only one peer-reviewed article has utilized all series of adverse event E-codes (E870-E876, E878-E879, E930-E949) to describe the burden of medical errors (O'Hara, D. A. & Carson, N. J., 1997). Other articles have utilized the diagnostic series of N-codes (Blanc, P. D., Jones, M. R., & Olson, K. R., 1993; Samore, M. H. et al., 2004; Slonim, A. D., LaFleur, B. J., Ahmed, W., & Joseph, J. G., 2003), extensive chart review (Brennan, T. A. et al., 1991; Leape, L. L. et al., 1991), incident report monitoring, and voluntary reporting systems systems (Inoue K, Hirosawa I, Yatsuduka M, & et.al., 2002). One study used the E930-E949 series to describe medication errors (O'Hara, D. A. & Carson, N. J., 1997). Certain statistical reports and newsletters use all adverse event ranges, but these have been limited to institutional publications from state governments and provincial authorities and have not been published in peer-reviewed journals (Center for Information Management and Evaluation, 2002; Helps, Y., Cripps, R., & Harrison, J., 2002; O'Hara, D. A. & Carson,

N. J., 1997; Utah Health Data Committee, 2001).

This study has demonstrated that only through triangulation would the ideal case-inclusion criteria for the surveillance of all patient safety events be created. The exploration of triangulation is an important undertaking for three reasons:

(1) Existing detection systems for patient safety events do not capture the same events and a combination of systems is necessary to accurately estimate the burden of patient safety events.

(2) Medical record expert chart review, the accepted gold standard, is not sustainable for continuous tracking of patient safety events due to the significant financial and time resources required; therefore, alternative data sources and methods are needed. Furthermore, if errors that do not result in injury are included in the definition of patient safety events, the gold standard of chart review would not be sufficiently comprehensive since these events are not recorded in the medical record.

(3) Coded administrative data currently exists and error reporting systems are becoming the norm in hospital patient safety. While these systems have their limitations, they consume fewer resources than chart review. Triangulation of existing systems represents a realistic trade-off between an ideal, yet unsustainable system and the acceptance of imperfect, but readily available data.

The main strength of this study is that it attempted to develop a mechanism to combine the four methods of detecting patient safety events to maximize case finding. However, the method of triangulation used in this study was applied at only one hospital.

Previous patient safety research has examined incidence of adverse events across hospitals, an undertaking which requires case-mix adjustment to account for the fact that patients are not the same across hospitals with regard to risk factors like age or severity. The results gathered from this study are representative only of patients seen at the Johns Hopkins Hospital. Future studies should consider the application of the methodologies employed in this study to a larger sample of hospitals. Such a study would require participating hospitals to have an error-reporting system like PSN in operation.

While administrative data are readily available to apply the PSI, E-codes, and N-codes, fewer hospitals have taken the initiative to institute a voluntary error reporting system like PSN. PSN has proven to be valuable for error and injury case finding especially with regard to falls and medication errors which are difficult to detect through administrative data. We hope that the results of this study will help provide the evidence that hospitals seek to justify the resources required to establish this type of error reporting system. However, as with administrative data, it is clear that continued training is required to encourage appropriate use and accurate data entry in systems like PSN.

Since this study found so little overlap among the methods investigated, researchers, hospital administrators, and policy makers interested in tracking patient safety events should triangulate the data systems available to them in order to maximize the detection of patient safety events.

The literature contains limited discussion as to how the surveillance of patient safety events will be conducted. Injury surveillance (E-codes and N-codes), AHRQ's PSI, and voluntary reporting systems (PSN) offer parts of the solution. Triangulation of case identification criteria yields a method for the surveillance of patient safety events.

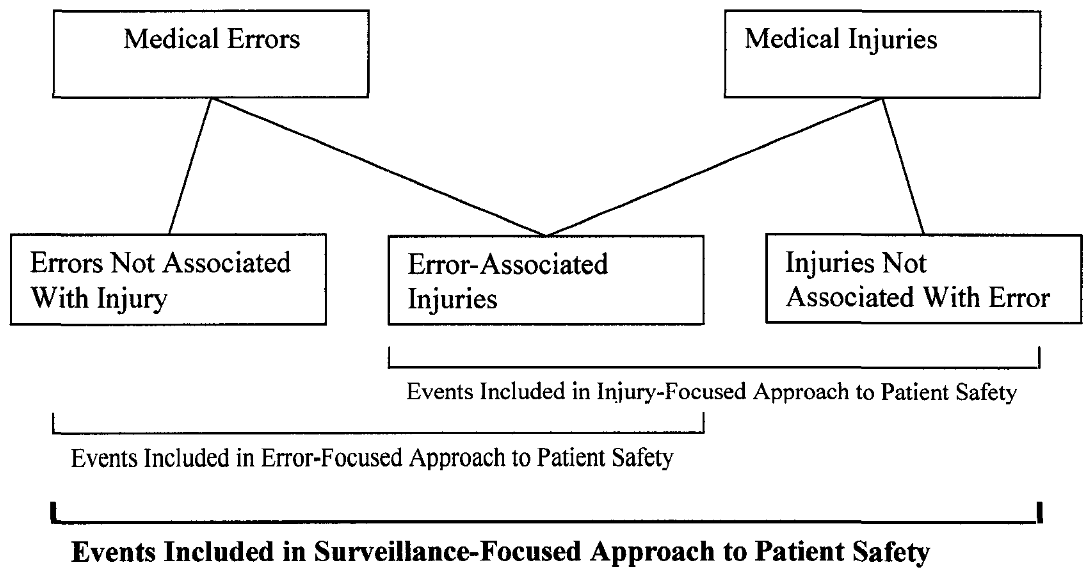
The ICD-9-CM codes used for E-codes, N-codes, and PSI are appealing because they routinely are collected, are relatively easily acquired, and are used in other countries - creating the possibility of national and international comparisons. The idea of a PSN-like system for error identification is enticing because it could capture a vast spectrum of patient safety events - the ideal of any surveillance system. In order for PSN to be the launching pad for a national patient safety reporting system, and simultaneously to address all aspects of patient safety of interest to researchers, policymakers, and patients, it would need to be comprehensive and capable of collecting errors that do not result in injury, errors that result in injury, and injuries that do not result from error. PSN-like systems have been strongly advocated by congressional testimony (108th Congress, 2003; Senate Health, Education Labor and Pensions & House Energy and Commerce, 2005; United States Senate 106 Congress, 2000; United States Senate 107 Congress first session, 2001). It is unknown if or when a national system will be created, and whether it will be voluntary, or mandatory, or anonymous.

While the system is undetermined, interventions are already under way to ensure patient safety. The public health system must devise methods and policies to track events so as to ensure that these interventions can be evaluated in their institutional settings, and to ensure that their dissemination and subsequent effects throughout the population may be measured. Such surveillance is routinely conducted in chronic disease (e.g. cancer morbidity and mortality) and injury (e.g. motor vehicle crashes and fatalities). Such measurement provides evidence, both to the agencies that fund patient safety research and the public that pays for those efforts, that their investment has returned its benefit in the form of measurable reductions in the incidence of patient safety events.

Conclusion

While the results of this study showed very little overlap in patient safety events where overlap was anticipated, we do not wish to lose sight of the fact that, with regard to patient safety surveillance, there is little in common in the design of the systems. This further highlights the point that multiple data systems and case identification criteria need to be triangulated in order to conduct the surveillance of patient safety events as described by the "surveillance-focused approach to patient safety" conceptual framework. This last point is critical because what is counted forms the basis for policy development and research funding. For example, if the "injuries not resulting from error" domain of the conceptual framework is not included, the surveillance of adverse drug reactions would not be conducted. These events are very common, are of great concern to patients, and often require extra provider resources. We are not so bold as to think that research and development will not eventually discover methods to anticipate and reduce these types of events in the future. For this reason, it would be beneficial if the designers of a patient safety surveillance system would consider what is currently not known to be preventable as potentially preventable and cast as wide a net as possible.

Figure 1. Conceptual Framework: A Surveillance-Focused Approach to Patient Safety



Adapted from Layde, P. M. Maas L. A. Teret S. P. Brasel K. J. Kuhn E. M. Mercy J. A. Hargarten S. A. "Patient Safety Efforts Should Focus on Medical Injuries." JAMA 287 (2002): 1993-97.

Table 1. Expected Types of Patient Safety Events Captured by each Detection Method

	ENI	EAI	INE
PSN	+	+	-
PSI	-	+	-
E-code	-	+	+
N-code	-	+	+

ENI = error, no injury (near-miss)
EAI = error-associated injury (medical error)
INE = injury, no error (adverse event, complication)

Table 2. PSN and PSI Categories

Patient Safety Net (PSN)	
Score	**Event Type**
A	Medication Error
B	Adverse Drug Reaction
C	Equipment/Supplies/Devices
D	Fall
E	Error related to Procedure/Treatment/Test
F	Complication of Procedure/treatment/Test
G	Transfusion
H	Behavioral
I	Skin Integrity
J	Care Coordination/Records
K	Other/Miscellaneous
Harm Score	**Description**
No Actual Harm	
A	Unsafe Conditions
Event, No Harm	
B1	The event did not reach the individual because of chance alone ("near-miss")
B2	The event did not reach the individual because of active recovery efforts by caregivers ("near-miss")
C	The event reached the individual but did not cause harm
D	The event reached the individual and required additional monitoring or treatment to prevent harm
Event, Harm	
E	The individual experienced temporary harm and required treatment or intervention
F	The individual experienced temporary harm and required initial or prolonged hospitalization
G	The individual experienced permanent harm
H	The individual experienced harm and required intervention necessary to sustain life (e.g. transfer to ICU)
Event, Death	
I	The individual died
	Source: University HealthSystem Consortium. Patient safety Net: Guide to Event Types, 7/05

Patient Safety Indicators (PSI)	
PSI	**Description**
1	Complications of Anesthesia
2	Death in Low-Mortality DRGs
3	Decubitus Ulcer
4	Failure to Rescue
5	Foreign Body Left During Procedure
6	Iatrogenic Pneumothorax
7	Selected Infections Due to Medical Care
8	Postoperative Hip Fracture
9	Postoperative Hemorrhage or Hematoma
10	Postoperative Physiologic and Metabolic Derangements
11	Postoperative Respiratory Failure
12	Postoperative Pulmonary Embolism or Deep Vein Thrombosis
13	Postoperative Sepsis
14	Postoperative Wound Dehiscence
15	Accidental Puncture or Laceration
16	Transfusion Reaction
17	Birth Trauma – Injury to Neonate
18	Obstetric Trauma – Vaginal with Instrument
19	Obstetric Trauma – Vaginal without Instrument
20	Obstetric Trauma – Cesarean Delivery
	Source: Guide to Patient Safety Indicators, v 3.0, AHRQ, 2005

Table 3. ICD-9-CM External Cause of Injury and Nature of Injury Codes

N-codes	
960-979	**Poisoning by drugs, medicinal and biological substances**
960	poisoning by antibiotics
961	poisoning by other infectives
962	poisoning by hormones and synthetic substitutes
963	poisoning by primarily systemic agents
964	poisoning by agents primarily affecting blood constituents
965	poisoning by analgesics, antipyretics, and antirheumatics
966	poisoning by a anticonvulsants and anti-parkinsonism drugs
967	poisoning by sedatives and hypnotics
968	poisoning by other central nervous system depressants and anesthetics
969	poisoning by psychotropic in each ends
970	poisoning by central nervous system stimulants
971	*poisoning by drugs primarily affecting the autonomic nervous system*
972	poisoning by agents primarily affecting the cardiovascular system
973	poisoning by agents primarily affecting the gastrointestinal system
974	poisoning by water, mineral, and uric acid metabolism drugs
975	poisoning by agents primarily acting on the smooth and skeletal muscles and respiratory system
976	poisoning by agents primarily affecting skin and mucous membrane, ophthalmological,otorhinolaryngological, and dental drugs
977	poisoning by other an unspecified drugs and medicinal substances
978	poisoning by bacterial vaccines
979	poisoning by other vaccines and biological substances
996-999	**Complications of Surgical and Medical Care NEC**
996	Complications Peculiar to Certain Specified Procedures (Ex. mechanical and graft complications)
997	Complications Affecting Body Systems NEC (Ex. cardiac, respiratory, digestive)
998	Other complications of procedures NEC (Ex. post-operative shock, accidental puncture)
999	Complications of Medical Care NEC (Ex. air embolism, serum reaction)
E-codes	
E850-E858	**Accidental Poisoning by Drugs, Medicinal Substances, and Biologicals**
E850	accidental poisoning by analgesics, antipyretics, and antirheumatics
E851	*accidental poisoning by barbiturates*
E852	accidental poisoning by other sedatives and hypnotics
E853	accidental poisoning by tranquilizers
E854	accidental poisoning by other psychotropic agents
E855	accidental poisoning by other drugs acting on Central and autonomic nervous system
E856	accidental poisoning by antibiotics
E857	accidental poisoning by other anti-ineffectiveness
E858	accidental poisoning by other drugs acting on Central and autonomic nervous system
E870-E876	**Misadventures to patients during surgical and medical care**
E870	accidental cut, puncture, perforation, or hemorrhage during medical care
E871	foreign object left in body during procedure
E872	failure of sterile precautions during procedure
E873	failure in dosage
E874	mechanical failure and instrument or apparatus during procedure
E875	contaminated or infected blood, other fluid, drug, or biological substance
E876	other an unspecified misadventures during medical care
E878-E879	***Surgical and Medical Procedures as the cause of abnormal reaction of patient or later complication, without mention of misadventure at the time of procedure***
E878	surgical operation and other surgical procedures as the cause of abnormal reaction of patients, or of later complication, without mention of misadventure at the time of operation
E879	other procedures, without mention of misadventure at the time of procedure, as the cause of abnormal reaction of patient, or of
E930-E949	**Drugs, Medicinal and Biological substances causing adverse effects in therapeutic use ("correct drug properly administered in therapeutic or prophylactic dosage, as the cause of adverse effect")**
E930	antibiotics
E931	other anti-infectives
E932	hormones and synthetic substitutes
E933	primarily systemic agents
E934	agents primarily affecting blood constituents
E935	analgesics, antipyretics, and antirheumatics
E936	anticonvulsants and anti-parkinsonism drugs
E937	sedatives and hypnotics
E938	other central nervous system depressants and anesthetics
E939	psychotropic agents
E940	central nervous system stimulants
E941	drugs primarily affecting the autonomic nervous system
E942	agents primarily affecting the cardiovascular system
E943	agents primarily affecting gastrointestinal system
E944	water, mineral, and uric acid metabolism drugs
E945	agents primarily acting on the smooth and skeletal muscles and respiratory system
E946	agents primarily affecting skin and mucous membrane, ophthalmological,otorhinolaryngological, and dental drugs
E947	other an unspecified drugs and medicinal substances
E948	bacterial vaccines
E949	other vaccines and biological substances

= not elsewhere classified

Table 4. Summary Statistics of Patients

Patient Characteristics		Total	No PSE	PSE	pvalue*
Count of Patient Safety Events		48,418	29,249	19,169	---
			60%	40%	---
Patient Characteristics					
Average Total Charges (dollars)		18493.36	11268.06	29518.90	0.000
	se	153.13	74.18	355.39	
Average Length of Stay (days)		5.59	3.71	8.46	0.000
	se	0.04	0.27	0.10	
Mean Age		42.61	40.12	46.40	0.000
	se	0.11	0.14	0.17	
Complexity (scale= 1-4)		%	%	%	
0 (levels 1 and 2)		60.88	73.24	42.03	0.000
1(levels 3 and 4)		39.12	26.76	57.97	
Sex		%	%	%	
male		49.23	49.17	49.32	0.685
female		50.76	50.82	50.68	
Race		%	%	%	
Caucasian		54.54	50.44	60.81	0.000
African-American		40.04	44	33.99	
Other		5.41	5.56	5.2	

***P-values calculated using t-test for continuous variables or chi square test for categorical variables**
PSE=Patient Safety Event

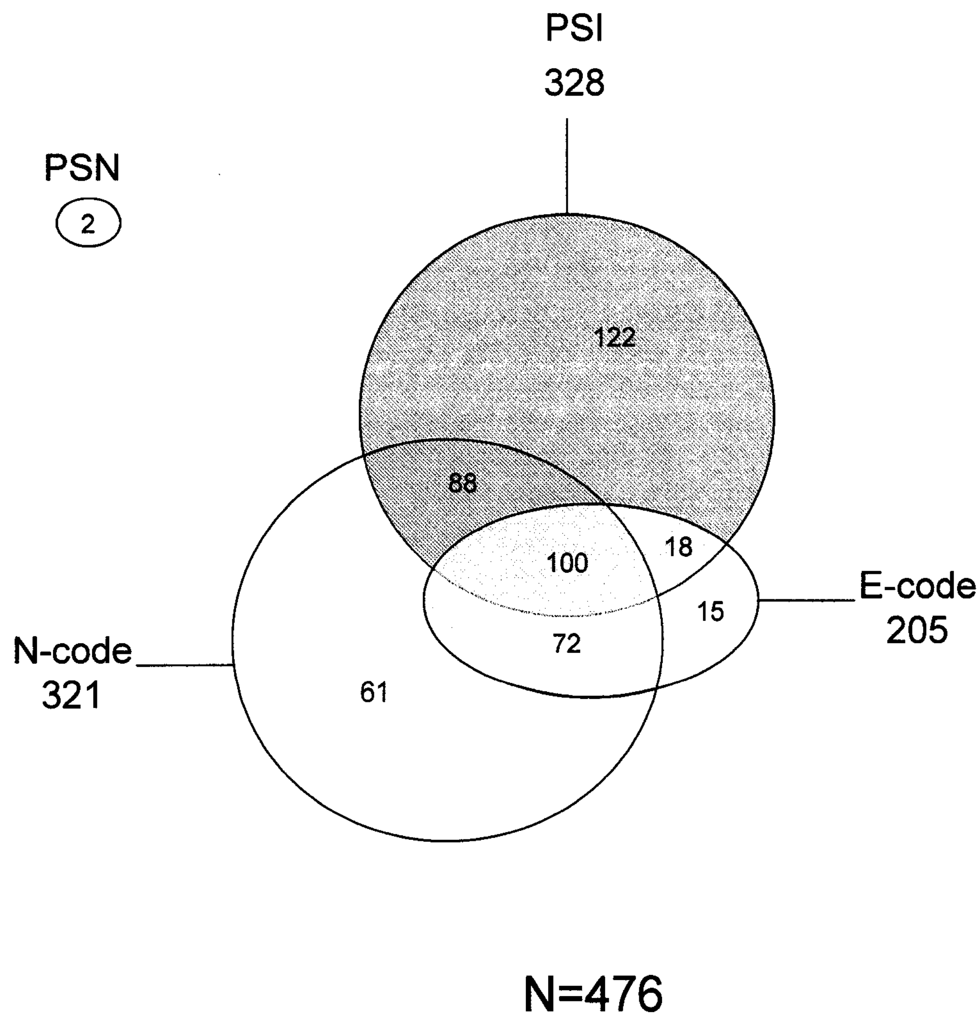
Table 5. Revised Crosswalk: PSN with each Case Identification Criteria

Events Common among all 4 Case Identifying Criteria
Accidental Puncture or laceration
Transfusion Reaction
Foreign Body
Events Common between PSN_PSI
Fall
Unintended laceration or puncture
Death
Wound dehiscence
Pulmonary embolism
Anesthesia/Sedation Event
Birth injury or trauma
Transfusion Reaction
Decubitus ulcer
Foreign Body
Events Common between PSN_E-code
Medication Error
Adverse drug reactions
Equipment/supplies/devices
Error related to procedure/treatment/test
Complication of procedure/treatment/test
Transfusion Reaction
Foreign Body
Events Common between PSN_N-code
Adverse drug reactions
Equipment/supplies/devices
Error related to procedure/treatment/test
Complication of procedure/treatment/test
Transfusion Reaction
Foreign Body

Table 6. Crosswalk of All Case Identification Criteria Showing Overlap and Identical Case Finding

Event Type			PSN	PSI	E-code	N-code	Identical Events
From PSN Taxonomy			# events detected	# events detected	# events detected	# events detected	# events detected
A. Medication Error			1691		35		3
B. Adverse drug reactions			14		3415	768	0
C. Equipment/supplies/devices			194		1	5021	0
D. Fall			417	3			2
E. Error related to Procedure/Treatment/Test							
	1. Surgery/invasive procedure problem						
		g. Foreign body in patient	0	3	8	2	0
		m. Unintended laceration or puncture	2	328	205	321	0
F. Complication of Procedure/Treatment/Test							
	1. Complication following surgery or invasive procedure						
		g. Wound dehiscence	1	1			0
		k. Pulmonary embolism	1	298			0
	2. Anesthesia/Sedation Event		2	16			0
	5. Neonatal complication						
		d. Birth injury or trauma	1	18			0
G. Transfusion Reaction			3	4	0	8	0
I. Skin Integrity							
	1. Pressure ulcer		7	165			0
Crosswalk Totals			**2333**	**836**	**3664**	**6120**	**5**
Original Totals			5668	1463	13,407	13,263	
Events not in Crosswalk			3335	627	9743	7143	

Figure 2. Overlap of Unique Identifier: Accidental Laceration or Puncture



Reference List

108th Congress. U.S. Senate Governmental Affairs Committee: Permanent Subcommittee On Investigations Holds A Hearing On Patient Safety. Copyright 2003 FDCH E-Media, Inc. (F/K/A Federal Document Clearing House, Inc.) FDCH Political Transcripts. 6-11-2003. U.S. Senate Governmental Affairs Committee: Permanent Subcommittee On Investigations.
Ref Type: Hearing

Agency for Healthcare Research and Quality (2005). *AHRQ Quality Indicators - Guide to The Patient Safety Indicators* (Rep. No. 03-R203). Rockville, MD: Agency for Healthcare Research and Quality.

Agency for Healthcare Research and Quality (2006). *Medical Errors: The Scope of the Problem.* Fact sheet, Publication No. AHRQ 00-P037. *http://www.ahrq.gov/qual/errback.htm* [Announcement posted on the World Wide Web]. 2005, from the World Wide Web: http://www.ahrq.gov/qual/errback.htm

Blanc, P. D., Jones, M. R., & Olson, K. R. (1993). Surveillance of poisoning and drug overdose through hospital discharge coding, poison control center reporting, and the Drug Abuse Warning Network. *Am.J.Emerg.Med., 11,* 14-19.

Bordeaux S. (1999). *Injury Mortality Australia, 1997* (Rep. No. 20). Adelaide, Australia: Australian Institute of Health and Welfare National Injury Surveillance Unit.

Brennan, T. A., Leape, L. L., Laird, N. M., Hebert, L., Localio, A. R., Lawthers, A. G., Newhouse, J. P., Weiler, P. C., & Hiatt, H. H. (1991). Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N.Engl.J.Med., 324,* 370-376.

Center for Information Management and Evaluation (2002). *Missouri Patient Safety Report Guide* Jefferson City, Missouri: Missouri Department of Health and Senior Services.

Classen DC, Pestotnik SL, & et al. (1997). Adverse Drug events in Hospitalized Patients. *JAMA, 277,* 301-306.

Dovey, S. M. & Phillips, R. L. (2004). What should we report to medical error reporting systems? *Qual.Saf Health Care, 13,* 322-323.

Dunn, J. D. (2001). Error in medicine. *Ann.Intern.Med., 134,* 342.

Edmonds, M. (2005). Hot Topics in Patient Safety. *Australian Patient Safety Foundation* [Announcement posted on the World Wide Web]. 2005, from the World Wide Web: http://www.informatics.adelaide.edu.au/research/Preop/ME-DSPreOpPres.html

Forster, A. J., Clark, H. D., Menard, A., Dupuis, N., Chernish, R., Chandok, N., Khan, A., & van, W. C. (2004). Adverse events among medical patients after discharge from hospital. *CMAJ., 170,* 345-349.

Gawande, A. A., Thomas, E. J., Zinner, M. J., & Brennan, T. A. (1999). The incidence and nature of surgical adverse events in Colorado and Utah in 1992. *Surgery, 126,* 66-75.

Halperin, W. a. B. E. L. (1992). *Public Health Surveillance*. New York: Van Rostrand Reinhold.

Helps, Y., Cripps, R., & Harrison, J. (2002). *Hospital Seperations due to injury and poisoning, Australia 1999-2000.* Adelaide, Australia: Australia Insititute of Health and Welfare.

Inoue K, Hirosawa I, Yatsuduka M, & et.al. (2002). Utilization of a Voluntary Reporting System in Quantitative Risk Assessment for Medical Tasks in a Hospital Setting-with Special Reference to Tasks Done by Nurses. *Journal of Occupational Health (Japan), 44,* 360-372.

Johnson, C. W. (2003). How will we get the data and what will we do with it then? Issues in the reporting of adverse healthcare events. *Qual.Saf Health Care, 12 Suppl 2:ii64-7.,* ii64-ii67.

Kohn, L., Corrigan, J., & Donaldson, M. To err is human: building a safer health system. Linda T.Kohn, Janet M.Corrigan, and Molla S.Donaldson. 2000. Washington, DC, National Academy Press.
Ref Type: Serial (Book,Monograph)

Layde, P. M., Maas, L. A., Teret, S. P., Brasel, K. J., Kuhn, E. M., Mercy, J. A., & Hargarten, S. A. (2002). Patient Safety Efforts Should Focus on Medical Injuries. *JAMA, 287,* 1993-1997.

Leape, L. L., Brennan, T. A., Laird, N., Lawthers, A. G., Localio, A. R., Barnes, B. A., Hebert, L., Newhouse, J. P., Weiler, P. C., & Hiatt, H. (1991). The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. *N.Engl.J.Med., 324,* 377-384.

Leape, L. L., Lawthers, A. G., Brennan, T. A., & Johnson, W. G. (1993). Preventing medical injury. *Qual.Rev.Bull., 19,* 144-149.

Liang, B. A. (1999). Error in Medicine: Legal Impediments to U.S. Reform. *Journal of Health Politics, Policy, and Law, 199,* 26-57.

McNutt, R. A., Abrams, R., & Arons, D. C. (2002). Patient safety efforts should focus on medical errors. *JAMA, 287,* 1997-2001.

Miller, M. R., Elixhauser, A., & Zhan, C. (2003). Patient safety events during pediatric hospitalizations. *Pediatrics, 111,* 1358-1366.

Miller, M. R., Elixhauser, A., Zhan, C., & Meyer, G. S. (2001). Patient Safety Indicators: using administrative data to identify potential patient safety concerns. *Health Serv.Res., 36,* 110-132.

Miller, M. R. & Zhan, C. (2004). Pediatric patient safety in hospitals: a national picture in 2000. *Pediatrics, 113,* 1741-1746.

O'Hara, D. A. & Carson, N. J. (1997). Reporting of adverse events in hospitals in Victoria, 1994-1995. *Med.J.Aust., 166,* 460-463.

Rigby K, Clark RB, & et al. (1999). Adverse events in health care: Setting priorities based on economic evaluation. *Journal of Quality Clinical Practice, 19,* 7-12.

Romano, P. S., Geppert, J. J., Davies, S., Miller, M. R., Elixhauser, A., & McDonald, K. M. (2003). A national profile of patient safety in U.S. hospitals. *Health Aff.(Millwood.), 22,* 154-166.

Samore, M. H., Evans, R. S., Lassen, A., Gould, P., Lloyd, J., Gardner, R. M., Abouzelof, R., Taylor, C., Woodbury, D. A., Willy, M., & Bright, R. A. (2004). Surveillance of medical device-related hazards and adverse events in hospitalized patients. *JAMA, 291,* 325-334.

Sedman, A., Harris, J. M., Schulz, K., Schwalenstocker, E., Remus, D., Scanlon, M., & Bahl, V. (2005). Relevance of the Agency for Healthcare Research and Quality Patient Safety Indicators for children's hospitals. *Pediatrics, 115,* 135-145.

Senate Health, E. L. a. P. & House Energy and Commerce. Patient Safety and Quality Improvement Act of 2005. S. 544. 2005.
Ref Type: Bill/Resolution

Slonim, A. D., LaFleur, B. J., Ahmed, W., & Joseph, J. G. (2003). Hospital-reported medical errors in children. *Pediatrics, 111,* 617-621.

Tamuz, M., Thomas, E. J., & Franchois, K. E. (2004). Defining and classifying medical error: lessons for patient safety reporting systems. *Qual.Saf Health Care, 13,* 13-20.

Thomas, E. J., Studdert, D. M., Burstin, H. R., Orav, E. J., Zeena, T., Williams, E. J., Howard, K. M., Weiler, P. C., & Brennan, T. A. (2000). Incidence and types of adverse events and negligent care in Utah and Colorado. *Med.Care, 38,* 261-271.

United States Senate 106 Congress. Medical errors: administration response and other perspectives. 2-22-2000. Health, Education, Labor, and Pensions, Labor, Health and Human Services, and Education (of the Committee on Appropriation).
Ref Type: Hearing

United States Senate 107 Congress first session. Patient safety: what is the role for

Congress. 5-24-2001. Health, Education, Labor and Pensions.
Ref Type: Hearing

Utah Health Data Committee (2001). *Adverse Events Related to Medical Care, Utah 1995-1999* Salt Lake City, Utah: Utah Department of Health.

Zhan, C. & Miller, M. R. (2003). Excess length of stay, charges, and mortality attributable to medical injuries during hospitalization. *JAMA, 290,* 1868-1874.

Literature Review: Organizational Culture, Nurse Staffing, and Patient Outcomes

Introduction

In March, 2000, the Institute of Medicine (IOM) released a report entitled, To err is human: building a safer health care system citing an annual estimate of 44,000 to 98,000 deaths due to medical errors (Kohn, LT, Corrigan, JM, & Donaldson, MS, 2000). This report elicited significant responses from the medical and public health communities in recognition of a growing problem. Increasing evidence suggests that these events contribute to poorer post-discharge prognosis, extended length of stay, extra costs, and attributable mortality (Classen DC, Pestotnik SL, & et al., 1997; Rigby K, Clark RB, & et al., 1999).

Aiken and colleagues, in studying the nursing shortage, found that for each additional patient assigned to a nurse, 30-day patient mortality increased by 7% and failure-to rescue rates increased by 7%. They also found that for each additional patient assigned, the odds of nursing job dissatisfaction increased by 15% and the odds of nurse burnout increased by 23% (Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H., 2002). Poor organizational culture and low nurse staffing have been suggested as contributors to needle stick injuries and near-misses in the nursing workforce. Clarke and colleagues posited that, while needle stick injuries to nurses are not a patient safety issue per se, they might be indicators of inadequate organizational commitment to safety that puts at risk not only nurses but also patients (Clarke, S. P., Sloane, D. M., & Aiken, L. H., 2002). Risk factors known to be associated with occupational injuries that should be investigated in patient safety include fatigue, hours on shift, time of day worked, shortage of appropriate staff, communication between providers (particularly investigating hierarchical flow), equipment failure, and training (specifically nonadherence to clinical pathways).

The purpose of this review was two-fold. First, identify evidence in the literature that addresses the relationship between patient injury, organizational safety climate, and nursing unit characteristics. Second, discern if these same factors were related to nurse injury. Because of the breadth of articles available, this summary focuses almost exclusively on review articles.

"An Integrated Analysis of Nurse Staffing and Related Variables: Effects on Patient Outcomes" (Curtin, L. L., 2003).

Curtin investigated the role of nurse staffing and its association with patient length of stay, patient mortality, and nurse turnover. She noted that patient outcomes traditionally have been investigated by disease type (AIDS) or setting (ICU).

Effect of Nurse Staffing on Patient Mortality and Length of Stay

Citing studies by Pronovost, this review concluded that low nurse to patient ratios of 1:1 or 1:3, while not associated with patient mortality, were associated with reduced length of stay (Pronovost, P. J. et al., 1999). Subsequent studies, found that patient complications increased in hospitals that had fewer ICU nurses (O'Brien-Pallas, L., Thomson, D., Alksnis, C., & Bruce, S., 2001; Pronovost, P. J. et al., 2001). Fewer nurses increased the risk for reintubation and resulted in a 14% increase in hospital costs (Dimick, J. B., Swoboda, S. M., Pronovost, P. J., & Lipsett, P. A., 2001).

Effect of the Organizational Characteristics on Patients and Staffing Outcomes

Both nurse-to-patient ratios and nursing hours have been described as having a significant relationship to mortality. Unruh elucidated that nursing hours of care impacted patient outcomes more so than skill mix (Unruh, L, 2003). Aiken found that one additional nurse per patient day reduced the odds of dying by 50%. Hospitals that had optimal staffing ratios had shorter overall length of stay and shorter ICU days. (Aiken, L. H., Sloane, D. M., Lake, E. T., Sochalski, J., & Weber, A. L., 1999). It was posited that increased nurse autonomy vis-à-vis the ability to control staffing arrangements would protect patients (Aiken, L. H., Sochalski, J., & Lake, E. T., 1997). In a later study, Aiken investigated nurse to patient ratios, mortality, and failure to rescue for orthopedic, general, and vascular surgery patients. Patient mortality and failure to rescue increased by 7% for every additional patient, in excess of four patients, that was assigned to a particular nurse (Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H., 2002).

Strengthening these ideas about organizational culture, collaboration between physicians and nurses was observed to have a positive impact on patient outcomes in the ICU setting after adjusting for patient case mix and severity. Subsequent studies discussed the benefit of collaboration as having significant influence on weaning from mechanical ventilation, reducing ventilator-associated pneumonia rates, and decreasing admissions to the ICU (Kaye, J. et al., 2000; Malila, F. M. & Von Reuden, K. T, 2002; Young, M. P. et al., 1998). The overall assessment was that in a toxic hospital environment, patient outcomes would be poor (Knaus, W., Draper, E., Wagner, D., & Zimmerman, J., 1987).

Nurse Turnover

In a study that surveyed 235 veterans' hospitals (Gelinas, L & Bohlen, C, 2002), hospitals with low nurse turnover had shorter overall lengths of stay. This study defined low turnover as 4% to 12% and defined high turnover as 21.6% to 43.8%. Because length of stay was increased with increasing nurse turnover, charges were also higher: 36% more on high turnover units compared to low turnover units.

The overall suggestions from this review are summarized in five points:

- Employ sufficient nursing staff to meet the needs of patients without the use of overtime or excessive capacity expectations that may affect nurse health and patient outcomes.
- Ensure strong, cohesive, and knowledgeable teams to provide continuity of patient care and to create supportive work environments for nurses.
- Reinvest in appropriately prepared managers and nurse clinical leadership.
- Examine the rules and activities of frontline nurses to determine ways to increase the time available for patient care. (Curtin, L. L., 2003)

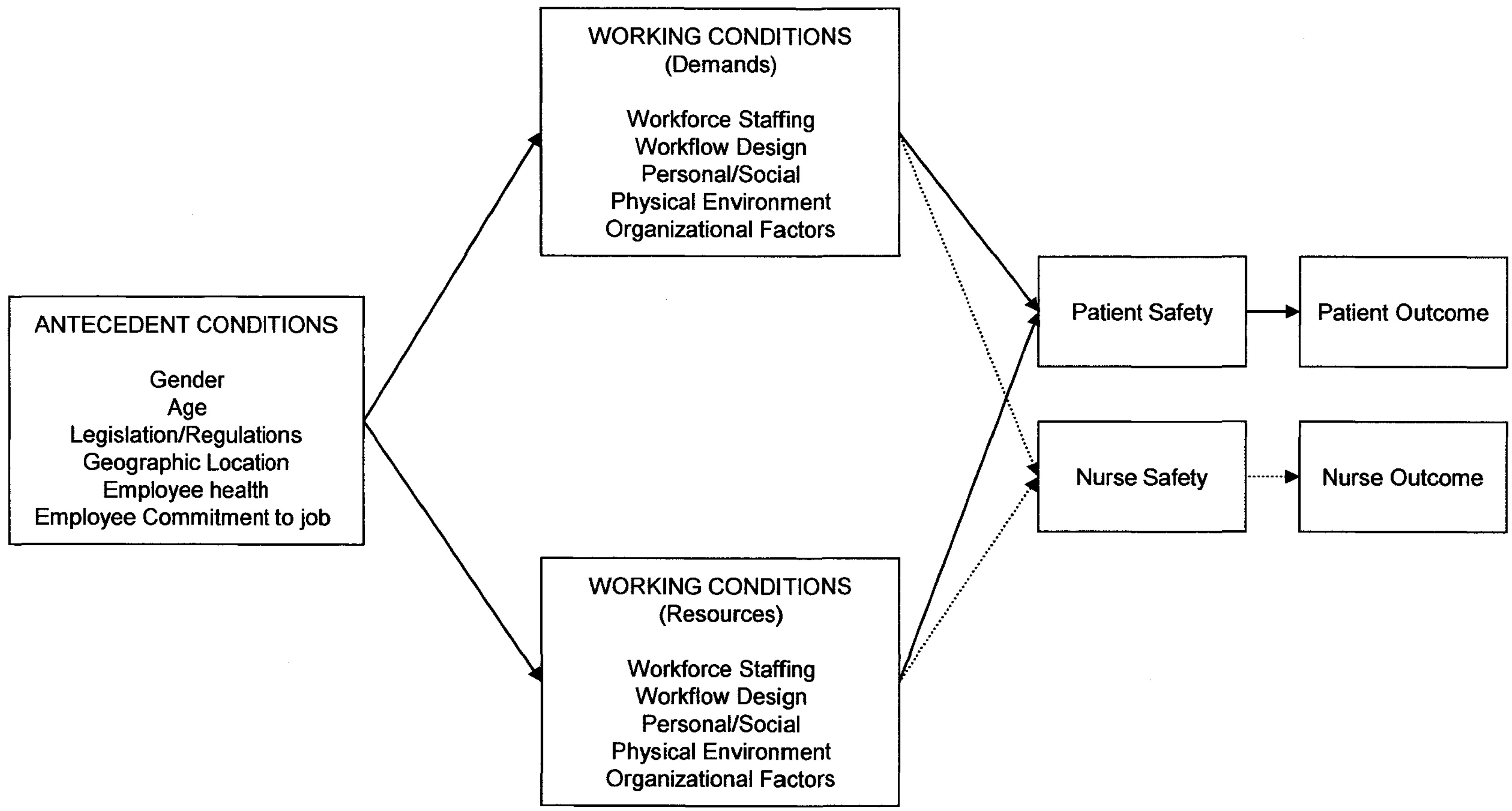
The articles synthesized in this review suggest that nurse-to-patient ratios or nursing hours per patient day need to be considered along with modifiers such as nurses' experience, patient acuity and case mix, and the interaction among the providers in the hospital setting.

Conceptual Framework

The Effect of Healthcare Working Conditions on Patient Safety (Hickam DH, Severance S, & Feldstein A, et al., 2003).

This evidence report prepared by the Oregon Health and Science University evidence based practice center developed a conceptual framework for working conditions in healthcare. The domains of this framework were workforce staffing, workflow design, personal/social factors, physical environments, and organizational factors. When these factors improve work quality they are referred to as "Resources." When they interfere with work quality, they are called "Demands." **Figure 1** shows an adaptation of this framework, originally developed for patient safety, to include nurse injury.

Figure 1. Conceptual Framework for Working Conditions in Healthcare



Adapted from: Hickam DH, Severance S, and Feldstein A. The Effect of Health Care Working Conditions on Patient Safety. Agency for Healthcare Research and Quality. Evidence Report/Technology Assessment Number 74, 2003.

The domains most relevant to the studies addressed by this literature are workforce staffing, personal/social, and organizational.

Workforce staffing describes the volume of work, required job skills, duration of the experience, and work schedules. Personal/social factors encompass job satisfaction, burnout, motivation, stress, autonomy, and professionalism. Organizational factors describe the perception of workers toward their workplace culture.

Of note in this report is that the researchers developed a model of patient safety by using the Haddon matrix from injury prevention and control (Haddon, W., 1972) and James Reason's principles of a human factors and accident causation (Reason, J., 1990). The researchers used these two models together to develop a conceptual model of patient safety that encompassed medical errors regardless of the outcome, and patient injuries regardless of whether they were the result of an error. Also of note is that this report neither attempted to address the impact of working conditions on nurse injury nor did it consider nurse staffing issues such as turnover or absenteeism except where related to patient safety concerns.

This comprehensive literature review of publications from 1980 through 2002 found that valid evidence supported several hypotheses about the effect of working conditions on patient outcomes. The recommendations suggested the following: (1) increased staffing levels of licensed and unlicensed nurses will lead to improved patient outcomes, (2) high volume physicians have lower incidence of preventable complications during technical procedures, (3) duration of experience is associated with better patient outcomes for some types of clinical care, (4) reductions in interruptions and distractions will reduce medical errors, (5) increased information exchange including continuity of care and an understanding of who is in charge during patient handoffs decreases medication errors and possibly hospital readmissions (Hickam DH, Severance S, & Feldstein A, et al., 2003).

"A Review of the Literature Examining Linkages between Organizational Factors, Medical Errors, and Patient Safety" (Hoff, T., Jameson, L., Hannan, E., & Flink, E., 2004).

This review was published one year after the AHRQ report and presented a far more dismal picture than the report on working conditions (Hoff, T., Jameson, L., Hannan, E., & Flink, E., 2004). This review found little evidence of associations between organizational factors and patient safety. The reviewed literature encompassed from 1990-2002, a similar time frame to the AHRQ report. This review consisted for the most part of a critique of the literature.

The first complaint concerned study design, in that none of the studies were longitudinal. Most studies were descriptive and cross sectional; a few had pre and post designs and some were case control. The critique regarding the organizational variables cited a lack of standardized definitions to measure or describe these factors. A similar criticism addressed the dependent variables examined in the 42 studies reviewed. The authors claimed a bias in that the majority of the studies examined medication errors - leaving the process errors, treatment errors and diagnostic errors disproportionally underrepresented. The authors further stated that no two studies used the same dependent variable. Finally, only a few of the studies used theoretical frameworks like continuous quality improvement or breakthrough series collaboratives. The authors stated that this deficiency compromised the integrity of the findings because the researchers did not describe how the organizational variables they examined were defined and how they potentially related to the dependent variable under analysis.

As with the dependent variables argument, most of the studies only examined one organizational variable at a time, therefore causing the authors to argue that the studies did not accurately represent the dynamic interrelatedness of organizational variables.

While the review and tone were somewhat disparaging, the authors remarked on the nascent nature of the understanding of organizational climates and patient safety. The authors offered suggestions for future research efforts such as standardizing the definition of an error, using more stringent study designs to deal with errors that are not instantaneously observable (longitudinal), and measuring errors regardless of the outcome to patients so that the bias of studying what is only a "seen" is abrogated.

"Nurse Sensitive Patient Outcomes" (Haberfelde, M., Bedecarre, D., & Buffum, M., 2005).

This review summarized the literature on nurse staffing and patient outcomes in acute care settings (Haberfelde, M., Bedecarre, D., & Buffum, M., 2005). It emanated from the review necessary to establish the Veterans Affairs Nursing Outcomes Database (VANOD), the goal of which was to create a database of acute care nursing sensitive quality indicators. The initiative to develop nursing sensitive quality indicators started with the 1995 American Nurses Association Safety and Quality Initiative. This effort ultimately produced the National Database of Nursing Quality Indicators (NDNQI).

The indicators explored in this review included patient falls, pressure ulcers, medication errors, failure to rescue, gastrointestinal bleeding, deep vein thrombosis/pulmonary embolism, central line infections, pneumonia, urinary tract infections, length of stay, nurse satisfaction, patient satisfaction, skill mix, and nursing hours per patient day.

This review examined articles from 1998 through 2004. It generally found that patient adverse events decreased with increasing nursing hours per patient day and an increased proportion of registered nurses in the skill mix. The literature suggested possible thresholds over which patient adverse events may increase as nursing hours and registered nurse ratios increase (Blegen, M. A., Goode, C. J., & Reed, L., 1998). The authors believed this phenomenon was observed because the reporting of errors may be better when more registered nurses were on the job. Certain patient outcomes have been suggested to be specialty-specific and suggestions have been made that investigations of nurse staffing issues should focus on homogeneous patient populations within those specialties only (Whitman, GR, Kim Y, Davidson LJ, Wolf GA, & Wang S, 2002).

In addition to the benefits of nursing hours and a high rate of registered nurses in the skill mix, lower adverse events were associated with lower length of stay, decreased mortality, and decreased costs (Cho, S. H., Ketefian, S., Barkauskas, V. H., & Smith, D. G., 2003).

However, this review concluded that not all patient outcomes benefit from a high rate of registered nurses in the skill mix. Unruh and colleagues found that patient falls decreased when the proportion of unlicensed assistive personnel increased (Unruh, L, 2003), further supporting the hypothesis that certain patient outcomes may be more sensitive to nursing skill mix and staffing than other types of outcomes (Whitman, GR, Kim Y, Davidson LJ, Wolf GA, & Wang S, 2002). Only one study reviewed controlled for patient acuity, yet it still found a decrease in patient adverse events with increased nurse staffing. The consensus emerged that nurse staffing can be defined as nursing hours per patient day and skill mix.

Assessment of Nursing-Sensitive Care

The National Quality Forum (NQF) developed a set of voluntary consensus measures for the evaluation of nursing care by introducing a set of 15 Performance Measures for Nursing-Sensitive Care in 2004 (**Table 1**). Working with the American Nurses Association and others, the NQF adopted several of the National Database of Nursing Quality Indicators (NDNQI) metrics, creating a framework to assess the interaction of nurses as teams and to highlight process issues that might arise in the course of nursing but remain outside of nurses' immediate control.

These indictors include nursing unit characteristics i.e. "System-centered" and patient injuries, i.e. "Patient-Centered Outcome Measures."

Table 1. NQF Performance Measures for Nursing-Sensitive Care

Framework Category	Measure
Patient-Centered Outcome Measures	Death among surgical inpatients with treatable serious complications (failure to rescue)
	Pressure Ulcer prevalence
	Falls prevalence
	Falls with Injury
	Urinary catheter-associated urinary tract infection (UTI) for intensive care unit (ICU) patients
	Central line catheter-associated blood stream infection rate for ICU and high-risk nursery (HRN) patients
	Ventilator-associated pneumonia for ICU and HRN patients
Nurse-Centered Outcome Measures	Smoking Cessation Counseling for AMI
	Smoking Cessation Counseling for HF
	Smoking Cessation counseling for pneumonia
System-Centered Measures	Nursing Skill Mix
	Nursing Care Hours per patient day
	Practice Environment

Source: www.qualityforum.org/txNCFINALpublic.pdf

"Nurse Staffing and Healthcare Outcomes: A Systematic Review of the International Research Evidence"(Lankshear, A. J., Sheldon, T. A., & Maynard, A., 2005).

This review examined international research from 1990 through 2004 for multi-site and case-mix adjusted studies. This review identified twenty-two studies. The authors combined nursing hours per patient day and nurse-to-patient ratio into one metric called "converted hours per patient day" so that all of the studies would be comparable with respect to this variable. As with the other reviews, increase in nursing staffing levels was associated with reduced adverse patient outcomes.

A principal criticism of the studies summarized in this review was that many of the studies aggregated nurse staffing at the hospital level rather than at the individual nursing unit level. Use of such aggregated data may reduce the estimated effect under investigation and result in measurement error. Only one study that met the reviewers' criteria used hierarchical modeling and unit level data for patients and staff. That study found decreased numbers of adverse patient outcomes with increased proportions of registered nurses on a unit (Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H., 2002). The authors of this review stressed the importance of hierarchical models to address confounding caused by the structure of these data (interdependence of nurses who work on the same units). Ultimately, the authors recommended hierarchical models in such studies and longitudinal studies as the more robust design of choice.

Two of the studies reviewed show curvilinear relationships between nurse staffing and improved patient outcomes, thereby suggesting marginal returns when registered nurse levels reached a certain threshold (Blegen, M. A. & Vaughn, T., 1998; Mark, B. A., Harless, D. W., McCue, M., & Xu, Y., 2004). This suggests that a certain point exists where it is appropriate to add less qualified staff to the registered nursing staff already at optimal levels. The authors suggested that this curvilinear effect may be of concern for future cost-effectiveness interventions because of this threshold effect. Therefore, nursing hours per patient day may be a better variable.

The last point was further elaborated in that cross sectional studies may be reflecting nurse preferences for certain hospitals over other hospitals based on reports of better patient outcomes or better reports of nurse satisfaction rather than a true effect (i.e., selection bias).

Nurse Turnover

The nursing workforce has been challenged over the last two decades to adapt to an increasing workforce shortage. There are fewer registered nurses to care for larger numbers of increasingly sicker and older patients. These changes have been confounded by deceasing healthcare reimbursements resulting in shorter lengths of stay. Moreover, with hospital cost cutting measures, many nurses are assuming other tasks such as housekeeping or other types of therapy customarily performed by different professionals who possess more appropriate training (Haberfelde, M., Bedecarre, D., & Buffum, M., 2005). Nurses have reported increasing job dissatisfaction and burnout, and have raised concerns about the quality of care that patients receive.

With regard to nurse turnover, most of the literature has focused on reasons for leaving and retention strategies. Increased nurse turnover has been associated with longer patient stays and higher costs per discharge (Gelinas, L & Bohlen, C, 2002), but little is known about the effect of nurse turnover on patient or provider outcomes (Jones, C. B., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002).

Economic studies have placed the annual cost of turnover to be approximately $1 million per hospital and have posited adverse effects to nurses and patients due to lost productivity and workforce instability (Jones, C. B., 2004; Jones, C. B., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002). Because of difficulty obtaining internal hospital data, these studies defined turnover as termination from hospitals without including internal transfers to other units (Jones, C. B., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002).

Emerging evidence links organizational climate and nurse turnover (Hart, S. E., 2005; Stone, P. W. et al., 2006; Stordeur, S. & D'Hoore, W., 2007). Stone and colleagues have conducted two important studies measuring the effect of organizational climate with nurse burnout and a variety of nurse injuries in a multi-hospital study (Stone, P. W., Du, Y., & Gershon, R. R., 2007) and have examined organizational climate and its positive association with reduced body fluid and blood exposures in ICU settings. Decreased nurse turnover correlated with increased agreement on certain domains of the Safety Attitudes Questionnaire, a survey instrument for inpatient settings that also has been used to detect associations with patient outcomes (Sexton, J. B., 2002).

Hayes and colleagues, for the years 1991 – 2004, provided the most recent comprehensive review of the literature on nurse turnover (Hayes, L. J. et al., 2006). A prior literature review from 1998 defined turnover predictors as job satisfaction, age, tenure, perceived job responsibilities, supervisor's behavior, and organizational commitment (Tai, T. W. & Robinson, C. D., 1998). Not surprisingly, nurse turnover affects those who remain on the unit: high turnover increases their workload and stress levels while new nurses are being trained.

The relationship between job satisfaction and nurse turnover is well-established

(Mueller, C. W. & McCloskey, J. C., 1990). Stress has been found to be one of the leading causes of job dissatisfaction (Bratt, M. M., Broome, M., Kelber, S., & Lostocco, L., 2000) along with workload and burnout (Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H., 2002; Strachota, E., Normandin, P., O'Brien, N., Clary, M., & Krukow, B., 2003).

Very few studies have addressed the impact that turnover might have on health effects in nurses. O'Brien-Pallas found that as hours of patient care increased, nurse overtime increased along with missed shifts due to illness (O'Brien-Pallas, L., Thomson, D., Alksnis, C., & Bruce, S., 2001). Shamian and O'Brien-Pallas, in reviewing work-related compensation claims, found that musculo-skeletal claims comprised the majority of nurse reports (Shamian, J. & Villeneuve, M., 2000). Poor organizational culture and low staffing have been suggested as contributors to needle stick injuries and near-misses in the nursing workforce (Clarke, S. P., Sloane, D. M., & Aiken, L. H., 2002). None of these studies expressly examined nurse turnover along with known turnover factors.

In the next two sections, two papers attempt to further explore the relationship between workforce organizational factors and injuries. The overarching research question is, "Are the same safety climate perceptions and nursing unit characteristics that are associated with nurse injury found to be associated with patient injury as well?" This consideration could bring a new perspective to the conceptualization of occupational injury as part of the safety continuum.

Reference List

Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H. (2002). Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA, 288,* 1987-1993.

Aiken, L. H., Sloane, D. M., Lake, E. T., Sochalski, J., & Weber, A. L. (1999). Organization and outcomes of inpatient AIDS care. *LDI.Issue.Brief., 5,* 1-4.

Aiken, L. H., Sochalski, J., & Lake, E. T. (1997). Studying outcomes of organizational change in health services. *Med.Care, 35,* NS6-18.

Blegen, M. A., Goode, C. J., & Reed, L. (1998). Nurse staffing and patient outcomes. *Nurs.Res., 47,* 43-50.

Blegen, M. A. & Vaughn, T. (1998). A multisite study of nurse staffing and patient occurrences. *Nurs.Econ., 16,* 196-203.

Bratt, M. M., Broome, M., Kelber, S., & Lostocco, L. (2000). Influence of stress and nursing leadership on job satisfaction of pediatric intensive care unit nurses. *Am.J.Crit Care, 9,* 307-317.

Cho, S. H., Ketefian, S., Barkauskas, V. H., & Smith, D. G. (2003). The effects of nurse staffing on adverse events, morbidity, mortality, and medical costs. *Nurs.Res., 52,* 71-79.

Clarke, S. P., Sloane, D. M., & Aiken, L. H. (2002). Effects of hospital staffing and organizational climate on needlestick injuries to nurses. *Am.J.Public Health, 92,* 1115-1119.

Classen DC, Pestotnik SL, & et al. (1997). Adverse Drug events in Hospitalized Patients. *JAMA, 277,* 301-306.

Curtin, L. L. (2003). An integrated analysis of nurse staffing and related variables: effects on patient outcomes. *Online.J.Issues Nurs., 8,* 5.

Dimick, J. B., Swoboda, S. M., Pronovost, P. J., & Lipsett, P. A. (2001). Effect of nurse-to-patient ratio in the intensive care unit on pulmonary complications and resource use after hepatectomy. *Am.J.Crit Care, 10,* 376-382.

Gelinas, L. & Bohlen, C. (2002). The business case for retention. *Journal of Clinical Systems Management, 4,* 14-16.

Haberfelde, M., Bedecarre, D., & Buffum, M. (2005). Nurse-sensitive patient outcomes: an annotated bibliography. *J.Nurs.Adm, 35,* 293-299.

Haddon, W. (1972). A logical frameworrk for categorizing highway safety phenomena and activity. *Journal of Trauma, 12,* 197-207.

Hart, S. E. (2005). Hospital ethical climates and registered nurses' turnover intentions. *J.Nurs.Scholarsh., 37,* 173-177.

Hayes, L. J., O'Brien-Pallas, L., Duffield, C., Shamian, J., Buchan, J., Hughes, F., Spence Laschinger, H. K., North, N., & Stone, P. W. (2006). Nurse turnover: a literature review. *Int.J.Nurs.Stud., 43,* 237-263.

Hickam DH, Severance S, & Feldstein A, e. al. (2003). *The Effect of Health Care Working Conditions on Patient Safety* Rockville, MD: Agency for Healthcare Research and Quality.

Hoff, T., Jameson, L., Hannan, E., & Flink, E. (2004). A review of the literature examining linkages between organizational factors, medical errors, and patient safety. *Med.Care Res.Rev., 61,* 3-37.

Jones, C. B. (2004). The costs of nurse turnover: part 1: an economic perspective. *J.Nurs.Adm, 34,* 562-570.

Jones, C. B. (2005). The costs of nurse turnover, part 2: application of the Nursing Turnover Cost Calculation Methodology. *J.Nurs.Adm, 35,* 41-49.

Kaye, J., Ashline, V., Erickson, D., Zeiler, K., Gavigan, D., Gannon, L., Wynne, P., Cooper, J., Kittle, W., Sharma, K., & Morton, J. (2000). Critical care bug team: a multidisciplinary team approach to reducing ventilator-associated pneumonia. *Am.J.Infect.Control, 28,* 197-201.

Knaus, W., Draper, E., Wagner, D., & Zimmerman, J. (1987). An evaluation of outcome from intensive care in major medical centers. *Can.Crit Care Nurs.J., 4,* 15.

Kohn, L., Corrigan, J., & Donaldson, M. To err is human: building a safer health system. Linda T.Kohn, Janet M.Corrigan, and Molla S.Donaldson. 2000. Washington, DC, National Academy Press.
Ref Type: Serial (Book,Monograph)

Lankshear, A. J., Sheldon, T. A., & Maynard, A. (2005). Nurse staffing and healthcare outcomes: a systematic review of the international research evidence. *ANS Adv.Nurs.Sci., 28,* 163-174.

Malila, F. M. & Von Reuden, K. T. (2002). The impact of collaboration on patient outcomes. *Journal of Clinical Systems Management, 4,* 10-12.

Mark, B. A., Harless, D. W., McCue, M., & Xu, Y. (2004). A longitudinal examination of hospital registered nurse staffing and quality of care. *Health Serv.Res., 39,* 279-300.

Mueller, C. W. & McCloskey, J. C. (1990). Nurses' job satisfaction: a proposed measure. *Nurs.Res., 39,* 113-117.

Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K. (2002). Nurse-staffing levels and the quality of care in hospitals. *N.Engl.J.Med., 346,* 1715-1722.

O'Brien-Pallas, L., Thomson, D., Alksnis, C., & Bruce, S. (2001). The economic impact of nurse staffing decisions: time to turn down another road? *Hosp.Q., 4,* 42-50.

Pronovost, P. J., Dang, D., Dorman, T., Lipsett, P. A., Garrett, E., Jenckes, M., & Bass, E. B. (2001). Intensive care unit nurse staffing and the risk for complications after abdominal aortic surgery. *Eff.Clin.Pract., 4,* 199-206.

Pronovost, P. J., Jenckes, M. W., Dorman, T., Garrett, E., Breslow, M. J., Rosenfeld, B. A., Lipsett, P. A., & Bass, E. (1999). Organizational characteristics of intensive care units related to outcomes of abdominal aortic surgery. *JAMA, 281,* 1310-1317.

Reason, J. (1990). *Human Error.* Cambridge: Cambridge University Press.

Rigby K, Clark RB, & et al. (1999). Adverse events in health care: Setting priorities based on economic evaluation. *Journal of Quality Clinical Practice, 19,* 7-12.

Sexton, J. B. (2002). *A Matter of Life or Death: Social Psychological and Organizational Factors Related to Patient Outcomes in the Intensive Care Unit.* The University of Texas at Austin.

Shamian, J. & Villeneuve, M. (2000). Building a national nursing agenda. A timely response for the sickest workers in the country. *Hosp.Q., 4,* 16, 18.

Stone, P. W., Du, Y., & Gershon, R. R. (2007). Organizational climate and occupational health outcomes in hospital nurses. *J.Occup.Environ.Med., 49,* 50-58.

Stone, P. W., Larson, E. L., Mooney-Kane, C., Smolowitz, J., Lin, S. X., & Dick, A. W. (2006). Organizational climate and intensive care unit nurses' intention to leave. *Crit Care Med., 34,* 1907-1912.

Stordeur, S. & D'Hoore, W. (2007). Organizational configuration of hospitals succeeding in attracting and retaining nurses. *J.Adv.Nurs., 57,* 45-58.

Strachota, E., Normandin, P., O'Brien, N., Clary, M., & Krukow, B. (2003). Reasons registered nurses leave or change employment status. *J.Nurs.Adm, 33,* 111-117.

Tai, T. W. & Robinson, C. D. (1998). Reducing staff turnover: a case study of dialysis facilities. *Health Care Manage.Rev., 23,* 21-42.

Unruh, L. (2003). Licensed nurse staffing and adverse events in hospitals. *Med.Care, 41,* 142-152.

Whitman, G., Kim Y, Davidson LJ, Wolf GA, & Wang S (2002). Measuring nurse-sensitive patient outcomes across specialty units. *Outcomes.Manag., 6,* 152-158.

Young, M. P., Gooder, V. J., Oltermann, M. H., Bohman, C. B., French, T. K., & James, B. C. (1998). The impact of a multidisciplinary approach on caring for ventilator-dependent patients. *Int.J.Qual.Health Care, 10,* 15-26.

PART II: Correlations between Organizational Safety Climate and Nursing Sensitive Patient Safety Events

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Introduction

In March, 2000, the Institute of Medicine (IOM) released its seminal public health report, "To Err is Human: Building a Safer Health Care System" citing an annual estimate of 44,000 to 98,000 deaths due to medical errors (Kohn, LT, Corrigan, JM, & Donaldson, MS, 2000). Evidence suggests that medical errors contribute to poorer post-discharge prognosis, extended length of stay, extra costs, and attributable mortality (Classen DC, Pestotnik SL, & et al., 1997; Rigby K, Clark RB, & et al., 1999).

Working Conditions and Patient Safety

The literature on nurse staffing and patient outcomes in acute care settings shows that patient adverse events decreased with increased nursing hours per patient day and an increased proportion of registered nurses in the skill mix (Haberfelde, M., Bedecarre, D., & Buffum, M., 2005; Lankshear, A. J., Sheldon, T. A., & Maynard, A., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002). A curvilinear relationship between nurse staffing and improved patient outcomes has been reported, suggesting marginal returns when registered nurse levels reach a certain threshold (Blegen, M. A. & Vaughn, T., 1998).

Increased nurse turnover has been associated with longer patient length of stay and higher costs per discharge (Gelinas, L & Bohlen, C, 2002), but little is known about the effect of nurse turnover on patient or provider outcomes (Jones, C. B., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002). Economic studies have placed the annual cost of turnover to be approximately $1 million per hospital and have posited adverse effects to nurses and patients due to lost productivity and workforce instability (Jones, C. B., 2004; Jones, C. B., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002). Because of difficulty obtaining internal hospital data, these studies defined turnover as termination from hospitals, excluding internal transfers to other units (Jones, C. B., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002).

The Agency for Health Care Research and Quality (AHRQ) found valid evidence that supported several hypotheses about the effect of working conditions on patient outcomes: (1) increased staffing levels of licensed and unlicensed nurses leads to improved patient outcomes, (2) duration of experience was associated with better patient outcomes for some types of clinical care, (3) reductions in interruptions and distractions reduce medical errors, and (4) increased information exchange - including continuity of care and an understanding of who is in charge during patient handoffs - decreases medication errors and possibly hospital readmissions (Hickam DH, Severance S, & Feldstein A, et al., 2003). Encouraging collaboration and teamwork, investing in adequately prepared nurse managers and clinical leaders, increasing part-time staff to avoid excessive overtime, and increasing productive nursing time with patients have been offered as methods to avoid both nurse and patient injuries (Curtin, L. L., 2003).

Aiken and colleagues, in studying the nursing shortage, found that for each additional patient assigned to a nurse, the odds of nursing job dissatisfaction increased by 15% and the odds of nurse burnout increased by 23% (Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H., 2002). Longer shifts, mandatory overtime, and longer work weeks have all been associated with increased errors and near-misses by nurses during patient care (Rogers, A. E., Hwang, W. T., Scott, L. D., Aiken, L. H., & Dinges, D. F., 2004). Inadequate resources, poor management, and disorganization within nursing units have been suggested as factors contributing to needle stick injuries and near-misses in the nursing workforce (Clarke, S. P., Sloane, D. M., & Aiken, L. H., 2002). Clarke and colleagues posited that while needle stick injuries to nurses are not a patient safety issue *per se*, they might be indicators of an inadequate organizational commitment to safety that puts not only nurses at risk but also patients as well (Clarke, S. P., Sloane, D. M., & Aiken, L. H., 2002).

Study Objectives

The study aimed principally to examine associations between nurse perceptions of organizational safety climate, nursing unit characteristics, and patient injury. The study hypothesized that the odds of patient injury would be negatively associated with increasing agreement on safety climate domains as assessed by the Safety Attitudes Questionnaire (SAQ). This study conducted additional analyses to investigate whether nursing unit characteristics previously shown to be associated with patient injury (nursing hours per patient day, nurse turnover) were associated with the nurse injury outcomes used in this study.

Materials and Methods

Study Design

The study design was cross-sectional and used retrospective data.

Setting

The study was conducted at Johns Hopkins Hospital (Hospital), a level-one trauma center with Magnet nursing status. To be included, all units had to have (1) a 60% or greater SAQ survey response rate among nurse respondents only, (2) available turnover and termination data, (3) direct nursing care hours, and (4) patient outcome data. Twenty-nine of 75 inpatient nursing units met these criteria.

Data Sources

This study used data for calendar year 2005. The study acquired nursing hours and total patient days from the Department of Nursing. The Department of Human Resources provided data on nurse turnover, termination, transfer into units, and total full-time equivalent nurses for each nursing unit. The Department of Risk Management provided inpatient discharge data, Patient Safety Net (PSN), and Safety Attitudes Questionnaire (SAQ) data. The Johns Hopkins Quality and Safety Research Group provided technical support on the use of the 2004 SAQ survey data.

Participants

The SAQ was administered to all employees in the Hospital. Because this study sought to explore nursing-sensitive patient outcomes, it examined data from nurse respondents only. All study activities were approved by the institutional review board at the Johns Hopkins Bloomberg School of Public Health. HIPAA approval was given by the Hospital.

Assessment of Patient Injuries

The National Quality Forum (NQF) introduced 15 performance measures for Nursing-Sensitive Care in 2004. These indictors include nursing unit characteristics i.e. "System-Centered" and patient injuries, i.e. "Patient-Centered Outcome Measures" (National Quality Forum). The American Nurses Association developed a voluntary data reporting system to assess Nursing-Sensitive Care, the National Database of Nursing Quality Indicators (NDNQI, 2007). From these sources, as well as the literature, four patient outcomes were selected for examination in this study.

The nursing-sensitive patient outcomes of interest were identified by application of the AHRQ Patient Safety Indicators (PSI) to inpatient discharge data, and through events reported to Patient Safety Net (PSN), a voluntary error reporting system developed by the University HealthSystems Consortium. Specifically, PSI detected decubitus ulcer and post-operative pulmonary embolism/deep-vein thrombosis events, and PSN detected patient falls and medication errors.

Assessment of Organizational Climate: The Safety Attitudes Questionnaire (SAQ)

There are numerous instruments available to assess organizational climate. We used the Safety Attitudes Questionnaire (SAQ) because of nine surveys measuring the patient safety climate of an organization, only the SAQ has been used to explore the relationship between safety climate scores and patient outcomes. Favorable scores were associated with shorter lengths of stay and fewer medication errors. Favorable scores on four out of six domains of the SAQ were associated with lower nurse turnover (Colla, J. B., Bracken, A. C., Kinney, L. M., & Weeks, W. B., 2005). The SAQ is a survey which elicits frontline healthcare workers' perceptions of their organization's safety culture at the level of the clinical area (e.g. unit) on which they work. The SAQ has been described previously (Sexton, J. B., Thomas, E. J., & Helmreich, R. L., 2000; Sexton, J. B., 2002; Sexton, J. B. et al., 2006).

Main Outcome Measures

The nursing-sensitive patient outcomes of interest were pulmonary embolism/deep-vein thrombosis, decubitus ulcers, falls, and medication errors.

Patient falls and medication errors were extracted from Patient Safety Net (PSN). Decubitus ulcer and post-operative pulmonary embolism/deep-vein thrombosis events were extracted from the inpatient discharge data by application of the AHRQ Patient Safety Indicators (PSI). Events were expressed as absolute numbers.

Patient Safety Net (PSN)

In July 2004, the Hospital began using a voluntary, electronic occurrence reporting system for errors and near-misses. Patient Safety Net (PSN) v. 3.0© was developed by the University HealthSystems Consortium. It contains ten domains to describe errors, near misses and their circumstances (**Table 1**). Each error was given an event type to identify the mechanism and a score to indicate the extent of harm to the patient. In 2005, PSN had 9,013 events. We selected cases that had a harm score of "C" or higher (n=5,668), indicating that an event had reached the patient. Our rationale to include these events regardless of harm was that there was an opportunity to prevent the event from reaching the patient.

In consultation with the nursing-sensitive outcomes literature, falls and medication errors were selected for inclusion in this study. Of 28,876 patients on 29 inpatient units, 290 fall events and 845 medication error events were reported.

Patient Safety Indicators (PSI)

AHRQ's publicly available Windows QI software was applied to the Hospital's administrative discharge data. PSI use the principal and secondary diagnosis fields to indicate potentially preventable events (**Table 1**). These indicators are intended to designate an event that occurred either during or after (readmission) a single hospital encounter. PSI detected 1,463 events in the hospital's 2005 discharge data.

Consistent with the nursing-sensitive outcomes literature, post-operative pulmonary embolism/deep-vein thrombosis and decubitus ulcers were selected for inclusion in this study. Of 28,260 discharges on 29 inpatient units, 105 decubitus ulcer events and 167 post-operative pulmonary embolism/deep-vein thrombosis events were reported.

Main Explanatory Covariates

For each nursing unit, turnover, nursing hours per patient day, and the Stress, Safety, and Morale (Job Satisfaction) SAQ domains constituted the main explanatory variables.

Nursing Unit Characteristics

The total number of nurses who left a nursing unit in one year divided by the number of full-time equivalents assigned to that unit in one year constituted the turnover rate. These nurses did not leave the Hospital through termination, but rather joined another unit in the hospital. For the logistic regressions, the study rescaled this variable (multiplied by a factor of 10) and is interpreted as a 10% change in the rate.

Nursing hours per patient day was defined as the sum of registered nurse agency hours plus the sum of the hospital's productive registered nurses hours. The result was divided by the complete number of patient days in the calendar year.

Because of concerns raised in the literature that previous studies had not addressed the confounding of nursing-sensitive patient outcomes by the patient's condition, a variable to control for patient complexity was used. The APRDRG Patient Complexity Level was used from the hospital's discharge database. It was calculated using ICD9 diagnoses, ICD9 procedures, and patient age by the 3M APRDRG grouping software, Ver 12. Each patient was given a value of: 1 (Low) to 4 (High). For the analysis, complexity was dichotomized into high (3 or 4) and low (1 or 2) categories.

Safety Attitudes Questionnaire

The Hospital administered the SAQ to its employees in 2004. This 36-item survey uses a five-point Likert scale to elicit staff attitudes. The scale ranges from "strongly disagree" to "strongly agree". The SAQ questions were divided into six domains: Teamwork, Safety, Morale (Job Satisfaction), Stress Recognition, Perceptions of Hospital Management, and Working Conditions. The questions within each domain were calculated into a domain average for each respondent. The domain average score was then converted into a 100 point scale. A high score indicates greater agreement (consensus) of a positive safety climate on a given unit. These scores were then averaged for each nursing unit, yielding an average domain score. All average domains scores were rescaled (divided by a factor of 10) and are interpreted as a 10-unit change in the average domain score. **Table 2** shows the individual questions categorized by their corresponding domain.

Statistical Analysis

Descriptive statistics were used to compare characteristics among nursing units with and without the selected nursing-sensitive patient outcomes. Statistical significance was determined through Chi-square and t-tests. Only statistically significant results are shown in the descriptive table. Simple logistic regressions were conducted for all variables to investigate their independent associations with the outcome. All analyses used a two-sided *P* value of less than .05 to indicate a statistically significant difference. The study employed the STATA software package (Stata 8, StataCorp LP, College Station, TX) to perform all analyses. Correlations among variables were explored using Pearson's product moment.

Multivariate logistic regression was performed to assess the odds of patient injury. The nursing unit characteristics and SAQ domains included were determined to be of interest using the above descriptive analyses as well as a review of the literature. The study included the following variables in the multivariate logistic regressions: nursing hours per patient day, turnover rate, and the Safety, Stress Recognition, and Morale (Job Satisfaction) domains of the SAQ. Morale and Safety were highly correlated and were therefore examined in separate multivariate models. Stress Recognition was not highly correlated with Safety or Morale and was included in all models.

For multivariate analyses, ordinary logistic regressions and random intercept logistic regressions (multilevel models) were conducted. The random intercept was included for the nursing unit. Because associations found in the ordinary logistic regressions were mostly maintained in the random intercept logistic regressions, only the multilevel results are displayed and discussed. Compared to the ordinary logistic regression, use of the multilevel model slightly changed the odds ratio and confidence intervals. In most cases, the use of the multilevel model decreased the significance by a level (e.g. from <0.001 to <0.01). As expected, the 95% confidence intervals were wider under the multilevel model.

The nursing unit served as the unit of analysis for the SAQ survey responses. As such, this study presumed individual responses of the nurses on the same unit to be dependent. Multilevel logistic regression models with a random intercept for the nursing unit were used to account for this clustering. Intraclass correlation coefficients (ICC) for each model were calculated using the following formula (Hox J.):

ICC: $\rho = \sigma^2 / \sigma^2 + (\pi^2/3)$,

where σ^2 is the between-unit variance and $\pi^2/3$ is the within-unit variance expressed as a constant.

Results

Table 3 shows the descriptive data for the nursing unit characteristics. Two nursing units had higher turnover rates than average (35% and 142% versus 10% average rate). All analyses were run with and without these units. The overall effect size and significance levels were not affected by the inclusion or exclusion of these units and as such they remained in the study.

Patient Falls

Summary Data and Simple Logistic Regressions

Table 4 shows summary statistics comparing nursing units reporting falls to nursing units without falls. 90% of nursing units in this study reported at least one fall. Nurse turnover, termination, and transfer in rates were significantly higher on nursing units with falls compared to those without. Average SAQ scores were significantly lower on nursing units with falls, compared to those without. The exception was the Stress Recognition domain, which was significantly higher on units with falls (61.49 vs. 68.04, $p=0.000$).

In simple logistic regressions (**Table 5**), nursing hours per patient day and turnover were negatively associated with the odds of patient falls (OR: 0.906, $p<0.01$ and OR: 0.884, $p<0.01$, respectively) and were negatively correlated (**Table 6**) with the fall rate ($\rho=-0.192$, $p=0.000$ and $\rho=-0.140$., $p=0.000$, respectively). The Safety scale score was not associated with the odds of patient falls (OR: 0.879, $p=0.142$) and was not strongly correlated with the fall rate ($\rho=-0.068$, $p=0.000$). Stress Recognition was positively associated with the odds of patient falls (OR: 2.371, $p<0.01$) and was positively correlated with the fall rate ($\rho=0.366$, $p=0.000$). Morale (Job Satisfaction) was not associated with the odds of patient falls (OR: 1.067, p=0.205) and was not strongly correlated with the fall rate (ρ=-0.226, p=0.000).

Multivariate Models: Ordinary and Random Intercept Logistic Regressions

Safety and Stress

Controlling for all other covariates, each additional hour of productive nursing per patient day was associated with a 10% decrease in the odds of patient falls (OR: 0.90, p<0.05). Turnover was not associated with patient falls (OR: 0.83, p=0.054). As expected, high patient complexity was strongly associated with the odds of falls (OR: 3.43, p<0.001). For each 10-unit increase in the average Stress domain score, the odds of patient falls increased significantly (OR: 2.39, p<0.01). Safety was not associated with the odds of patient falls (OR: 0.92, p=0.756). The ICC for this model was 0.193 (**Table 7**).

Morale (Job Satisfaction) and Stress

Nursing hours per patient day, turnover, and Stress showed almost identical results as in the Stress and Safety model. Morale was not associated with the odds of patient falls (OR: 1.11, p=0.513). The ICC for this model was 0.187 (**Table 7**).

Medication Errors

Summary Data and Simple Logistic Regressions

Every nursing unit reported at least one medication error. For this reason, the descriptive data table shows units separated into high or low medication errors by dichotomizing them at the mean (**Table 4).** The mean nursing hours per patient day were significantly higher on units with high medication errors versus low (9.56 hours versus 7.88 hours, $p=0.000$). Nurse turnover and transfer in percentages were significantly higher on nursing units with low medication errors compared to those with high. Termination was higher on units with high medication errors. Most average SAQ scores were significantly higher on nursing units with low medication errors, compared to those with high. The exception was the Stress Recognition domain, which was significantly lower on units with low medication errors, compared to those with high (69.73 vs. 72.60, $p=0.000$). The Safety domain was not statistically significant.

In simple logistic regressions (**Table 5**), nursing hours per patient day were positively associated with the odds of medication errors (OR: 1.135, $p<0.01$) and were positively correlated with the medication error rate ($\rho=0.702$, $p=0.000$, data not shown). Turnover was negatively associated with the odds of medication errors (OR: 0.879, $p<0.01$). Safety was not associated with the odds of medication errors (OR: 0.905, $p=0.055$) and was not strongly correlated with the medication error rate ($\rho=-0.068$, $p=0.000$). Stress Recognition was positively associated with the odds of medication errors (OR: 1.567, $p<0.01$) and was positively correlated with the medication error rate ($\rho=0.272$, $p=0.000$). Morale (Job Satisfaction) was associated with the odds of medication errors (OR: 1.070, $p<0.05$) but was not strongly correlated with the medication error rate ($\rho=0.081$, $p=0.000$).

Multivariate Models: Ordinary and Random Intercept Logistic Regressions

Safety and Stress

Controlling for all other covariates, each additional hour of productive nursing per patient day was associated with an 8% increase in the odds of medication errors (OR: 1.08, $p<0.001$). Turnover was not associated with medication errors (OR: 0.92, $p=0.143$). As expected, high patient complexity was strongly associated with the odds of medication errors (OR: 3.38, $p<0.001$). For each 10-unit increase in the average Stress domain score, the odds of medication errors increased significantly (OR: 1.55, $p<0.05$). Safety was not associated with the odds of patient medication errors (OR: 1.05, $p=0.794$). The ICC for this model was 0.114 (**Table 7**).

Morale (Job Satisfaction) and Stress

Nursing hours per patient day, turnover, and Stress showed almost identical results as in the Stress and Safety model. Morale was not associated with the odds of medication errors (OR: 1.03, $p=0.783$). Of note was that Stress Recognition was statistically significant after applying the multilevel model (OR: 1.54, $p=0.051$). The ICC for this model was 0.114 (**Table 7**).

Decubitus Ulcer

Summary Data and Simple Logistic Regressions

Table 4 shows summary statistics for nursing units. 62% of nursing units in this study reported at least one event. Nurse turnover, termination, and transfer in rates were significantly lower on nursing units with decubitus ulcers compared to those without. Average SAQ scores were significantly lower on nursing units with decubitus ulcers, compared to those without decubitus ulcers. The exception were the Stress Recognition and Perceptions of Management domains, which were significantly higher on units with decubitus ulcers (73.20 vs. 71.10, p=0.000 and 63.02 vs. 62.68, p=0.043, respectively).

In simple logistic regressions (**Table 5**), nursing hours per patient day were negatively associated with the odds of decubitus ulcers (OR: 0.920, p<0.05) and were negatively correlated with the decubitus ulcer rate (ρ=-0.119, p=0.000, data not shown). Turnover was also negatively associated with the odds of decubitus ulcers (OR: 0.662, p<0.01).

Safety was associated with the odds of decubitus ulcers (OR: 0.383, p<0.01) and was strongly correlated with the decubitus ulcer rate (ρ=-0.366, p=0.000). Stress was positively associated with the odds of decubitus ulcers (OR: 3.921, p<0.01) and was positively correlated with the decubitus ulcer rate (ρ=0.328, p=0.000). Morale (Job Satisfaction) was negatively associated with the odds of decubitus ulcers (OR: 0.660, p<0.01) and was strongly correlated with the decubitus ulcer rate (ρ=-0.0296, p=0.000).

Multivariate Models: Ordinary and Random Intercept Logistic Regressions

Safety and Stress

Controlling for all other covariates, nursing hours per patient day and turnover were not associated with decubitus ulcers (OR: 0.94, p=0.117 and OR: 0.61, p=0.116, respectively). As expected, high patient complexity was strongly associated with the odds of decubitus ulcers (OR: 127.5, p<0.001). Safety was negatively associated with the odds of patient decubitus ulcers (OR: 0.60, p<0.05). For each 10-unit increase in the average Stress domain score, the odds of decubitus ulcers increased significantly (OR: 3.36, p<0.0001). The ICC for this model was 0.075 (**Table 7**).

Morale (Job Satisfaction) and Stress

Nursing hours per patient day and turnover showed almost identical results as in the Stress and Safety model. Stress demonstrated a higher odds ratio than in the Safety and Stress model (OR: 3.75, p<0.001). Morale was not associated with the odds of decubitus ulcers (OR: 0.78, p=0.059). The ICC for this model was 0.085 (**Table 7**).

Post-Operative Pulmonary Embolism and Deep Vein Thrombosis (PE/DVT)

Summary Data and Simple Logistic Regressions

Table 4 shows summary statistics comparing nursing units reporting post-operative PE/DVT to nursing units that did not have these events. 66% of nursing units in this study reported at least one event. Nurse turnover and transfer in rates were significantly higher on nursing units with post-operative PE/DVT. Average SAQ scores were significantly lower on nursing units with post-operative PE/DVT. The exception was the Stress Recognition domain, for which scores were significantly higher on units with post-operative PE/DVT (72.89 vs. 71.69, p=0.000).

In simple logistic regressions (**Table 5**), nursing hours per patient day were positively associated with the odds of post-operative PE/DVT (OR: 1.045, $p<0.05$) and were positively correlated with the post-operative PE/DVT rate ($\rho=0.152$, p=0.000, data not shown). Turnover also was positively associated with the odds of post-operative PE/DVT (OR: 1.072, $p<0.01$).

Safety was associated with the odds of post-operative PE/DVT(OR: 0.616, $p<0.01$) and was strongly correlated with the post-operative PE/DVT rate($\rho=-0.310$, p=0.000). Stress was not associated with the odds of post-operative PE/DVT (OR: 1.208, p=0.723) and was not strongly correlated with the post-operative PE/DVT rate ($\rho=0.084$, p=0.000). Morale (Job Satisfaction) was negatively associated with the odds of post-operative PE/DVT (OR: 0.820, $p<0.01$) and was strongly correlated with the post-operative PE/DVT rate ($\rho=-0.228$, p=0.000).

Multivariate Models: Ordinary and Random Intercept Logistic Regressions

Safety and Stress

Controlling for all other covariates, nursing hours per patient day and turnover were not associated with post-operative PE/DVT (OR: 1.07, p=0.149 and OR: 1.15, p=0.129, respectively). As expected, high patient complexity was strongly associated with the odds of post-operative PE/DVT (OR: 11.63, p<0.001). Safety was negatively associated with the odds of patient post-operative PE/DVT but was not statistically significant (OR: 0.65, p=252). The Stress domain was also not significant (OR: 1.22, p=0.723). The ICC for this model was 0.295 (**Table 7**).

Morale (Job Satisfaction) and Stress

Nursing hours per patient day, turnover, and Stress showed almost identical results as in the Stress and Safety model. Morale was not associated with the odds of post-operative PE/DVT (OR: 0.86, p=0.529). The ICC for this model was 0.301 (**Table 7**).

The ICC is a measure of the degree of dependence of nurses belonging to the same unit. The larger the intraclass correlation, the more likely it is that nurses share the same attitudes or perceptions. The ICC for the random intercept logistic regressions were in the "medium" to "large" range (Zyzanski, Flocke, and Dickinson 199-200). We calculated the effective sample size (Killip, Mahfoud, and Pearce 204-08) and found that the ICC did not significantly alter the effective sample size, thus preserving power (data not shown). Regardless of the ICC's size, the structure of the data and the study design still indicated the use of multilevel models as appropriate.

Discussion

This study considered four potential adverse patient outcomes. A 1.5 to 3-fold increase in the odds of patient falls, medication errors, and decubitus ulcers with increasing Stress Recognition (as measured by the SAQ) was observed. A negative association was observed between the SAQ Safety domain and the odds of decubitus ulcers. Nursing hours per patient day were negatively associated with patient falls and positively associated with medication errors. None of the covariates examined had any significant association with the odds of post-operative pulmonary embolism/deep-vein thrombosis.

Historically, the SAQ uses survey responses from all respondents, whereas this study used responses from nurses only. While SAQ administrations most commonly use all respondents, it is also valid to use responses from nurses only (Sexton, J. B. et al., 2006). In a subsequent analysis, we duplicated the regressions using all respondents and found that the Stress Recognition association with patient injury was lost (data not shown). It is possible that the Stress Recognition domain of the SAQ detects nurse attitudes more precisely than those of other respondents and that the inclusion of all respondents masks the effect of Stress Recognition on patient injury.

We observed an interesting juxtaposition with nursing hours per patient day and nursing-sensitive patient outcomes. For each additional hour of increased productive nursing hours per patient day, a 10% reduction in the odds of the patient falls was observed. Conversely, an 8% increase in the odds of medication errors was observed with each additional hour of productive nursing per patient day.

It is easier to see the advantage of increased nursing time with patients who are at risk for falls: more productive nursing time may lead to more direct observation and thus more opportunities for intervention prior to a fall.

In the case of medication errors, increased nursing time may not necessarily be better depending on how that time is used. Medication administration is an opportune time for error because the process contains multiple steps where interruptions can cause distraction. For instance, during the course of medication administration a nurse may engage in other tasks such as administrative responsibilities, returning pages, or responding to emergencies. In an adaptation of the "sterile cockpit" intervention from aviation safety, Teresa Pape was able to show an 86% decrease in self-reported distractions among nurses that administer medications (Pape, T. M., 2003). If protocols are not in place to ensure that nurses will not be distracted during medication administration, more nursing hours may unintentionally exacerbate the problem rather than ameliorate it. In addition, more nursing hours per patient say may indicate a positive threshold of appropriate nurse staffing is in place and therefore, nurses have time to report events.

Importantly, nurses are sensitized to report falls because falls are well-established patient safety events sensitive to nursing. By contrast, medication errors may be reported by nurses, but may not be caused by nurses. For example, the wrong drug could be ordered through a computerized system and given by the nurse to the patient. After the fact, the nurse may realize this mistake and report it, even though the nurse did not order the drug. Medication errors were included in this study because, while nurses sometimes may be the inheritors of poor system design, they nonetheless represent the last intervention opportunity within that system.

Cho found that increased nursing hours per patient day were associated with increased probability of decubitus ulcer. She posited that the increase might have been due to increased reporting: the more nursing hours available over a certain threshold, the more nurses become available to properly chart and submit incident reports (Cho, S. H., Ketefian, S., Barkauskas, V. H., & Smith, D. G., 2003). While increased nursing hours per patient day were associated with a decrease in decubitus ulcers in our study, this finding was not statistically significant. There were design differences between the two studies: (1) restriction to surgical patients in the Cho study versus inclusion of both surgical and medical care patients in our study, and (2) different case identification criteria. While both studies used ICD-9-CM codes, our study used these codes within the PSI algorithms, not the codes individually.

A limitation of our study is that we did not investigate skill mix. This metric describes the proportion of licensed versus unlicensed personnel involved in patient care. While a higher proportion of licensed personnel is usually associated with decreased patient injuries (Haberfelde, M., Bedecarre, D., & Buffum, M., 2005), not all patient outcomes benefit from a high rate of registered nurses in the skill mix. Unruh and colleagues found that patient falls decreased when the proportion of unlicensed assistive personnel increased, supporting the hypothesis that certain patient outcomes may be more sensitive to nursing skill mix and staffing than other types of outcomes (Unruh, L, 2003). Future studies should include this variable.

Sexton found decreased nurse turnover correlated with increased agreement on the Safety, Morale (Job Satisfaction), Working Conditions, and Perceptions of Management SAQ domains (Sexton, J. B., 2002). While increased nurse turnover has been associated with longer patient length of stay and higher costs per discharge (Gelinas, L & Bohlen, C, 2002), little is known about the effect of nurse turnover on patient or provider outcomes (Jones, C. B., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002). We did not find evidence of associations between nurse turnover and the patient outcomes examined.

Previous research has validated the strong association of caregiver safety climate attitudes with patient safety (Sexton, J. B., 2002). Moreover, Aiken and colleagues have show that, with increasing patient loads, job satisfaction decreases, burnout increases, and certain adverse patient outcomes increase (Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H., 2002). It was therefore expected that positive responses to the Safety and Morale domains of the SAQ would be associated with decreased odds of patient injury. However, only Safety demonstrated a statistically significant association and only in the decubitus ulcer model.

Stress Recognition was included because the current environment in nursing (longer hours, nursing shortage, etc) creates opportunities for stress-induced mistakes. Stress Recognition remained statistically significant after application of the multilevel model: increasingly positive agreement was associated with increasing odds of all nursing-sensitive patient outcomes (except post-operative PE/DVT).

In discussions with the SAQ developer, the Stress Recognition domain of the SAQ operates somewhat differently than the other domains. It represents the individual attitudes of the respondents rather than a consensus among those people working on the unit (Bryan Sexton, personal communication).

Increased awareness of the effect of stress on job performance may be associated with increased awareness of injury risk, and may manifest itself in increased reporting of injuries by those sensitized to injury's root causes. It may also be plausible that the Stress Recognition domain serves as a parallel indictor of the stress level among nurses (e.g. "The more stressed I feel, the more likely I am to report that I understand how stress affects my performance"). Alternatively, past experience with a stressful event that caused a nurse or patient injury may also increase agreement with the effect of stress. We speculate that nurses who are more aware of the effect that stress has on their ability to perform may also be better reporters of patient injuries.

This study heeded criticisms of previous studies of nurse staffing and patient safety in its design. Previous studies had (1) aggregated nurse staffing at the level of the hospital rather than at the individual nursing unit level thus inviting ecological fallacy, (2) investigated only one variable at a time, ignoring the potential interaction of organizational dynamics, (3) examined only one type of outcome, and (4) did not use hierarchical modeling to consider confounding caused by the structure of data (interdependence of nurses who work on the same units), (Hoff, T., Jameson, L., Hannan, E., & Flink, E., 2004; Lankshear, A. J., Sheldon, T. A., & Maynard, A., 2005). However, this study has several important limitations: it was neither able to use the longitudinal designs, nor entertain pre-and post designs that have been suggested as gold standards for these types of investigations (Hoff, T., Jameson, L., Hannan, E., & Flink, E., 2004).

Conclusions

The SAQ traditionally has been used to study associations between organizational safety climate and patient injury. This study affirms that the SAQ can detect associations with nursing-sensitive patient outcomes using nurse respondents only. The addition of unit characteristics previously described in the nursing literature further enriches our efforts to understand how organizational climate operates in the clinical setting.

In the future, more in-depth investigation of the other SAQ domains should be undertaken. The Teamwork domain is an especially promising candidate. It demonstrated patterns similar to Safety and Morale (Job Satisfaction) (data not shown) and has been shown to be associated with ICU-related mortality (Sexton, J. B., 2002). Other nursing unit characteristics such as termination from the hospital, and transfers in to a unit should also be examined.

Table 1. Patient Safety Net: Event Type and Harm Score, and Patient Safety Indicators

Patient Safety Net (PSN)	
Score	**Event Type**
A	Medication Error
B	Adverse Drug Reaction
C	Equipment/Supplies/Devices
D	Fall
E	Error related to Procedure/Treatment/Test
F	Complication of Procedure/treatment/Test
G	Transfusion
H	Behavioral
I	Skin Integrity
J	Care Coordination/Records
K	Other/Miscellaneous
Harm Score	**Description**
No Actual Harm	
A	Unsafe Conditions
Event, No Harm	
B1	The event did not reach the individual because of chance alone ("near-miss")
B2	The event did not reach the individual because of active recovery efforts by caregivers ("near-miss")
C	The event reached the individual but did not cause harm
D	The event reached the individual and required additional monitoring or treatment to prevent harm
Event, Harm	
E	The individual experienced temporary harm and required treatment or intervention
F	The individual experienced temporary harm and required initial or prolonged hospitalization
G	The individual experienced permanent harm
H	The individual experienced harm and required intervention necessary to sustain life (e.g. transfer to ICU)
Event, Death	
I	The individual died
	Source: University HealthSystem Consortium. Patient safety Net: Guide to Event Types, 7/05

Patient Safety Indicators (PSI)	
PSI	**Description**
1	Complications of Anesthesia
2	Death in Low-Mortality DRGs
3	Decubitus Ulcer
4	Failure to Rescue
5	Foreign Body Left During Procedure
6	Iatrogenic Pneumothorax
7	Selected Infections Due to Medical Care
8	Postoperative Hip Fracture
9	Postoperative Hemorrhage or Hematoma
10	Postoperative Physiologic and Metabolic Derangements
11	Postoperative Respiratory Failure
12	Postoperative Pulmonary Embolism or Deep Vein Thrombosis
13	Postoperative Sepsis
14	Postoperative Wound Dehiscence
15	Accidental Puncture or Laceration
16	Transfusion Reaction
17	Birth Trauma – Injury to Neonate
18	Obstetric Trauma – Vaginal with Instrument
19	Obstetric Trauma – Vaginal without Instrument
20	Obstetric Trauma – Cesarean Delivery
	Source: Guide to Patient Safety Indicators, v 3.0, AHRQ, 2005

Table 2. Safety Attitudes Questionnaire: Questions by Domain

Teamwork
Nurse input is well received in this clinical area
In this clinical area, it is difficult to speak up if I perceive a problem with patient care
Disagreements in this clinical area are resolved appropriately (i.e., not who is right, but what is best for the patient)
I have the support I need from other personnel to care for patients
It is easy for personnel here to ask questions when there is something that they do not understand
The physicians and nurses here work together as a well-coordinated team
Safety
I would feel safe being treated here as a patient
Medical errors are handled appropriately in this clinical area
I know the proper channels to direct questions regarding patient safety in this clinical area
I receive appropriate feedback about my performance
In this clinical area, it is difficult to discuss errors
I am encouraged by my colleagues to report any patient safety concerns I may have
The culture in this clinical area makes it easy to learn from the errors of others
Morale (Job Satisfaction)
I like my job
Working here is like being part of a large family
This is a good place to work
I am proud to work in this clinical area
Morale in this clinical area is high
Stress Recognition
When my workload becomes excessive, my performance is impaired
I am less effective at work when fatigued
I am more likely to make errors in tense or hostile situations
Fatigue impairs my performance during emergency situations (e.g. emergency resuscitation, seizure)
Perceptions of Hospital Management
Hospital management supports my daily efforts
Hospital management doesn't knowingly compromise the patient safety
Hospital management is doing a good job
Problem personnel are dealt with constructively by our hospital management
I get adequate, timely information about events that might affect my work from hospital management
Working Conditions
The levels of staffing in this clinical area are sufficient to handle the number of patients
This hospital does a good job of training new personnel
All the necessary information for diagnostic and therapeutic decisions is routinely available to me
Trainees in my discipline are adequately supervised

Table 3. Average and Range of Unit-Level Characteristics

Variable	Average	Range
Injury Count	11.6	0-36
Injury Rate	10.00%	0-94.6
Patients	996	96-2,337
Nursing Hours Per Patient Day	8.6	4.8-24
Turnover Rate	10.40%	0-142%
Teamwork	76.5	45.5-90.8
Safety	77.3	61.7-87.6
Morale (Job Satisfaction)	73.2	42.3-90.8
Stress Recognition	70.9	57.7-81
Perceptions of Management	62.5	43.1-82.5
Working Conditions	70.2	54.3-83.4

Table 4. Characteristics of Nursing Units and Patients

Nursing Unit Characteristics	Patient Falls			Decubitus Ulcer			Post-operative PE/DVT			Medication Errors		
	Total	Units without Patient Falls	Units with Patient Falls	Total	Units without Decubitus Ulcers	Units with Decubitus Ulcers	Total	Units without Post-operative PE/DVT	Units with Post-operative PE/DVT	Total	Units with high Medication Errors	Units with low Medication Errors
Number of Nursing Units	29	3	26	29	11	18	29	10	19	29	8	21
		10%	90%		38%	62%		34%	66%		28%	72%
Count of Patients	28,876	2268	26,608	28,260	7947	20,313	28,260	7475	20,785	28876	11588	17288
		8%	92%		28%	72%		26%	74%		40%	60%
Count of Events	290	0	290	105	0	105	167	0	167	845	845	0
Mean Nursing Hours Per Patient Day	8.55	11.12	8.33	8.46	10.04	7.85	8.46	9.77	7.99	8.55	9.56	7.88
se	0.02	0.09	0.02	0.02	0.04	0.02	0.02	0.04	0.02	0.02	0.03	0.02
Turnover (%)	10.38	7.71	10.61	10.49	24.85	4.87	10.49	3.41	13.04	10.38	5.89	13.39
se	0.16	0.12	0.18	0.17	0.56	0.03	0.17	0.06	0.22	0.16	0.05	0.27
Termination (%)	16.18	14.84	16.29	16.14	16.91	15.84	16.14	19.39	14.98	16.18	20.83	13.06
se	0.06	0.13	0.07	0.06	0.13	0.07	0.06	0.12	0.08	0.06	0.07	0.09
Transfer In (%)	13.62	3.00	14.53	13.69	23.63	9.80	13.69	3.60	17.32	13.62	4.96	19.43
se	0.16	0.11	0.18	0.17	0.56	0.06	0.17	0.06	0.22	0.16	0.04	0.26
Mean SAQ Domain Score												
Teamwork	76.50	88.34	75.49	77.31	82.73	75.19	77.31	82.55	75.42	76.50	76.63	76.41
se	0.05	0.03	0.05	0.05	0.10	0.06	0.05	0.14	0.05	0.05	0.07	0.07
Safety	77.30	84.55	76.69	77.97	79.60	77.33	77.97	80.36	77.11	77.30	76.03	78.16
se	0.14	0.04	0.04	0.04	0.08	0.05	0.04	0.09	0.04	0.04	0.06	0.05
Morale	71.47	80.61	70.69	72.27	73.61	71.75	72.27	75.40	71.14	71.47	68.51	73.45
se	0.07	0.04	0.07	0.07	0.14	0.08	0.07	0.15	0.08	0.07	0.10	0.09
Stress Recognition	70.88	68.04	71.12	72.61	71.10	73.20	72.61	71.85	72.89	70.88	72.60	69.73
se	0.04	0.02	0.04	0.03	0.03	0.04	0.03	0.04	0.04	0.04	0.04	0.05
Perceptions of Management	62.53	74.69	61.49	62.91	62.68	63.01	62.91	64.76	62.25	62.53	59.09	64.83
se	0.07	0.09	0.07	0.16	0.17	0.08	0.07	0.16	0.08	0.07	0.12	0.08
Working Conditions	70.16	78.07	69.48	70.27	72.39	70.10	70.74	71.69	70.40	70.16	70.39	70.00
se	0.04	0.03	0.05	0.05	0.10	0.05	0.05	0.11	0.05	0.04	0.08	0.05
Patient Characteristics												
Average Total Charges (dollars)	21255.30	28584.40	20630.58	17743.10	15228.06	18727.05	17743.10	14524.19	18900.73	21255.30	25267.63	18565.87
se	300.85	2517.46	245.73	181.59	420.68	191.23	181.59	358.43	210.00	300.85	429.38	410.66
Average Length of Stay (days)	6.18	7.48	6.07	5.28	5.19	5.32	5.28	6.63	4.80	6.18	6.78	5.78
se	0.08	0.55	0.07	0.52	0.11	0.06	0.05	0.13	0.53	0.08	0.13	0.10
Mean Age	42.73	14.23	45.16	42.83	21.99	50.98	42.83	19.34	51.27	42.73	31.61	50.18
se	0.14	0.28	0.14	0.14	0.27	0.13	0.14	0.26	0.13	0.14	0.24	0.15
Complexity (scale= 1-4)	%	%	%	%	%	%	%	%	%	%	%	%
0 (levels 1 and 2)	61.2	69.97	60.45	62.26	67.33	60.28	62.26	65.43	61.12	61.2	64.03	59.3
1(levels 3 and 4)	38.8	30.03	39.55	37.74	32.67	39.72	37.74	34.57	38.88	38.8	35.97	40.7
Sex	%	%	%	%	%	%	%	%	%	%	%	%
male	51.22	57.72	50.67	51.31	55.05	49.85	51.31	53.74	50.44	51.22	50.09	51.98
female	48.78	42.28	49.33	48.69	44.95	50.15	48.69	46.26	49.56	48.78	49.91	48.02
Race	%	%	%	%	%	%	%	%	%	%	%	%
Caucasian	59.57	49.43	60.43	59.52	53.73	61.79	59.52	53.7	61.62	59.57	64.96	55.96
African-American	35.36	44.89	34.55	35.44	39.51	33.85	35.44	39.92	33.83	35.36	28.7	39.83
Other	5.07	5.69	5.02	5.04	6.76	4.37	5.04	6.38	4.56	5.07	6.34	4.22

*P-values calculated using t-test for continuous variables and chi square test for categorical variables.
SAQ=RN Respondents only, ≥60% Response Rate
Medication Errors only: nursing units divided into "high" or "low" injury at the mean

Table 5. Simple Logistic Regressions: SAQ Domain and Nursing Unit Factors

	Patient Falls	Medication Errors	Decubitus Ulcer	Post-operative PE/DVT
Nursing Unit Characteristics	**OR**	**OR**	**OR**	**OR**
Nursing Hours Per Patient Day	0.906***	1.135***	0.920**	1.045**
Turnover Rate	0.884***	0.879***	0.662**	1.072***
Termination Rate	1.021	1.150***	1.157	0.879
Transfer In Rate	0.965	0.885***	1.015	1.081***
Mean SAQ Domain Score	**OR**	**OR**	**OR**	**OR**
Teamwork	0.806***	1.212***	0.459***	0.719***
Safety	0.879	0.905	0.383***	0.616***
Morale	1.067	1.070**	0.660***	0.820***
Stress Recognition	2.371***	1.567***	3.921***	1.208
Perceptions of Management	1.008	1.015	0.807***	0.784***
Working Conditions	1.032	1.109**	0.452***	0.884

***** $p<0.01$, ** $p<0.05$**

Note: Turnover rate has been rescaled and is interpreted as for every 10% increase in the rate.
SAQ Domains have been rescaled to be interpreted as for every 10 unit increase in the mean score.
SAQ=RN Respondents only, $\geq$ 60% Response Rate

Table 6. Pearson Correlation Matrix: Patient Falls

Variable	fall_r~e	rnhrsppd	xferin~e	turnov~e	term_r~e	teamwo~n	safety~n	morale~n	stress~n	prcpmg~n	wrkcon~n
fall_rate	1.000	-0.192	-0.064	-0.140	0.018	-0.152	-0.068	0.058	0.366	0.007	0.019
(p)		(0.000)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.203)	(0.002)
rnhrsppd	-0.192	1.000	-0.208	-0.222	0.103	0.340	0.088	0.210	-0.010	0.175	0.017
(p)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.102)	(0.000)	(0.004)
xferin_rate	-0.064	-0.208	1.000	0.923	-0.231	-0.274	-0.326	-0.351	0.109	-0.352	-0.091
(p)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
turnover_rate	-0.140	-0.222	0.923	1.000	-0.376	-0.205	-0.253	-0.321	0.050	-0.320	0.014
(p)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.020)
term_rate	0.018	0.103	-0.231	-0.376	1.000	-0.200	-0.445	-0.377	-0.003	-0.451	-0.389
(p)	(0.003)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.604)	(0.000)	(0.000)
teamwork_rn	-0.152	0.340	-0.274	-0.205	-0.200	1.000	0.848	0.847	-0.009	0.757	0.694
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.109)	(0.000)	(0.000)
safety_rn	-0.068	0.088	-0.326	-0.253	-0.445	0.848	1.000	0.845	-0.013	0.909	0.731
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.033)	(0.000)	(0.000)
morale_rn	0.058	0.210	-0.351	-0.321	-0.377	0.847	0.845	1.000	0.071	0.873	0.649
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
stress_rn	0.366	-0.010	0.109	0.050	-0.003	-0.009	-0.013	0.071	1.000	0.111	0.389
(p)	(0.000)	(0.102)	(0.000)	(0.000)	(0.604)	(0.109)	(0.033)	(0.000)		(0.000)	(0.000)
prcpmgt_rn	0.007	0.175	-0.352	-0.320	-0.451	0.757	0.909	0.873	0.111	1.000	0.739
(p)	(0.203)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)
wrkcond_rn	0.019	0.017	-0.091	0.014	-0.389	0.694	0.731	0.649	0.389	0.739	1.000
(p)	(0.002)	(0.004)	(0.000)	(0.020)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

Table 7. Multilevel Logistic Regression with Random Intercept

	Fall		Medication Error		Decubitus Ulcer		Post-op PE/DVT	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Safety (10 unit change)	0.92	(0.54 - 1.56)	1.05	(0.72 - 1.53)	0.60*	(0.40 - 0.92)	0.65	(0.31 - 1.36)
Stress Recognition (10 unit change)	2.39**	(1.30 - 4.41)	1.55*	(1.00 - 2.41)	3.36***	(1.64 - 6.88)	1.22	(0.40 - 3.69)
Nursing Unit Characteristics								
Nursing Hours Per Patient Day (1 hour change)	0.90*	(0.83 - 0.98)	1.08***	(1.03 - 1.13)	0.94	(0.87 - 1.02)	1.07	(0.98 - 1.17)
Turnover Rate Safety (10% change)	0.83	(0.69 - 1.00)	0.92	(0.82 - 1.03)	0.61	(0.33 - 1.13)	1.15	(0.96 - 1.38)
Patient Level Characteristics								
Complexity	3.43***	(2.63 - 4.47)	3.38***	(2.88 - 3.95)	127.49***	(17.68 - 919.26)	11.63***	(7.36 - 18.37)
σ2 = variance of random effect for nursing unit	0.789		0.424		0.265		1.376	
ICC	0.193		0.114		0.075		0.295	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Morale (10 unit change)	1.11	(0.81 - 1.51)	1.03	(0.82 - 1.30)	0.78	(0.61 - 1.01)	0.86	(0.54 - 1.37)
Stress Recognition (10 unit change)	2.41**	(1.32 - 4.39)	1.54*	(1.00 - 2.39)	3.75***	(1.81 - 7.76)	1.31	(0.43 - 4.01)
Nursing Unit Characteristics								
Nursing Hours Per Patient Day (1 hour change)	0.90*	(0.83 - 0.98)	1.08**	(1.03 - 1.13)	0.95	(0.88 - 1.03)	1.08	(0.98 - 1.19)
Turnover Rate Safety (10% change)	0.85	(0.70 - 1.02)	0.92	(0.82 - 1.03)	0.6	(0.32 - 1.12)	1.16	(0.96 - 1.39)
Patient Level Characteristics								
Complexity	3.45***	(2.65 - 4.50)	3.38***	(2.88 - 3.95)	128.92***	(17.88 - 929.55)	11.68***	(7.40 - 18.45)
σ2 = variance of random effect for nursing unit	0.757		0.424		0.306		1.417	
ICC	0.187		0.114		0.085		0.301	

95% confidence intervals in parentheses
*** $p<0.001$, ** $p<0.01$, * $p<0.05$
ICC = Intraclass Correlation Coefficient

Reference List

Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H. (2002). Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA, 288,* 1987-1993.

Blegen, M. A. & Vaughn, T. (1998). A multisite study of nurse staffing and patient occurrences. *Nurs.Econ., 16,* 196-203.

Cho, S. H., Ketefian, S., Barkauskas, V. H., & Smith, D. G. (2003). The effects of nurse staffing on adverse events, morbidity, mortality, and medical costs. *Nurs.Res., 52,* 71-79.

Clarke, S. P., Sloane, D. M., & Aiken, L. H. (2002). Effects of hospital staffing and organizational climate on needlestick injuries to nurses. *Am.J.Public Health, 92,* 1115-1119.

Classen DC, Pestotnik SL, & et al. (1997). Adverse Drug events in Hospitalized Patients. *JAMA, 277,* 301-306.

Colla, J. B., Bracken, A. C., Kinney, L. M., & Weeks, W. B. (2005). Measuring patient safety climate: a review of surveys. *Qual.Saf Health Care, 14,* 364-366.

Curtin, L. L. (2003). An integrated analysis of nurse staffing and related variables: effects on patient outcomes. *Online.J.Issues Nurs., 8,* 5.

Gelinas, L. & Bohlen, C. (2002). The business case for retention. *Journal of Clinical Systems Management, 4,* 14-16.

Haberfelde, M., Bedecarre, D., & Buffum, M. (2005). Nurse-sensitive patient outcomes: an annotated bibliography. *J.Nurs.Adm, 35,* 293-299.

Hickam DH, Severance S, & Feldstein A, e. al. (2003). *The Effect of Health Care Working Conditions on Patient Safety* Rockville, MD: Agency for Healthcare Research and Quality.

Hoff, T., Jameson, L., Hannan, E., & Flink, E. (2004). A review of the literature examining linkages between organizational factors, medical errors, and patient safety. *Med.Care Res.Rev., 61,* 3-37.

Jones, C. B. (2004). The costs of nurse turnover: part 1: an economic perspective. *J.Nurs.Adm, 34,* 562-570.

Jones, C. B. (2005). The costs of nurse turnover, part 2: application of the Nursing Turnover Cost Calculation Methodology. *J.Nurs.Adm, 35,* 41-49.

Kohn, L., Corrigan, J., & Donaldson, M. To err is human: building a safer health system. Linda T.Kohn, Janet M.Corrigan, and Molla S.Donaldson. 2000. Washington, DC, National Academy Press.
Ref Type: Serial (Book,Monograph)

Lankshear, A. J., Sheldon, T. A., & Maynard, A. (2005). Nurse staffing and healthcare outcomes: a systematic review of the international research evidence. *ANS Adv.Nurs.Sci., 28,* 163-174.

NDNQI (2007). The National Center for Nursing Quality Indicators: The National Database of Nursing Quality Indicators (NDNQI)®. *http://www.nursingworld.org/quality/database.htm* [Announcement posted on the World Wide Web]. from the World Wide Web: http://www.nursingworld.org/quality/database.htm

Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K. (2002). Nurse-staffing levels and the quality of care in hospitals. *N.Engl.J.Med., 346,* 1715-1722.

Pape, T. M. (2003). Applying airline safety practices to medication administration. *Medsurg.Nurs., 12,* 77-93.

Rigby K, Clark RB, & et al. (1999). Adverse events in health care: Setting priorities based on economic evaluation. *Journal of Quality Clinical Practice, 19,* 7-12.

Rogers, A. E., Hwang, W. T., Scott, L. D., Aiken, L. H., & Dinges, D. F. (2004). The working hours of hospital staff nurses and patient safety. *Health Aff.(Millwood.), 23,* 202-212.

Sexton, J. B. (2002). *A Matter of Life or Death: Social Psychological and Organizational Factors Related to Patient Outcomes in the Intensive Care Unit.* The University of Texas at Austin.

Sexton, J. B., Helmreich, R. L., Neilands, T. B., Rowan, K., Vella, K., Boyden, J., Roberts, P. R., & Thomas, E. J. (2006). The Safety Attitudes Questionnaire: psychometric properties, benchmarking data, and emerging research. *BMC.Health Serv.Res., 6,* 44.

Sexton, J. B., Thomas, E. J., & Helmreich, R. L. (2000). Error, stress, and teamwork in medicine and aviation: cross sectional surveys. *BMJ, 320,* 745-749.

Unruh, L. (2003). Licensed nurse staffing and adverse events in hospitals. *Med.Care, 41,* 142-152.

PART III: Associations Among Organizational Patient Safety Climate, Nurse Staffing, and Work-Related Nurse Injury

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Introduction

Risk factors commonly known to be associated with error in occupational settings include: fatigue, shift rotation, staffing levels, deployment of new technology, extended work hours, communication and teamwork (hierarchy), equipment failure, and training.

Poor organizational culture and inadequate staffing have been suggested as contributors to needle stick injuries and near-misses in the nursing workforce (Clarke, S. P., Sloane, D. M., & Aiken, L. H., 2002b; Clarke, S. P., Sloane, D. M., & Aiken, L. H., 2002a; Clarke, S. P., Rockett, J. L., Sloane, D. M., & Aiken, L. H., 2002). Aiken and colleagues, in studying the nursing shortage, found that for each additional patient assigned to a nurse, the odds of nursing job dissatisfaction increased by 15% and the odds of nurse burnout increased by 23% (Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H., 2002). Clarke and Aiken posited that needle stick injuries to nurses may be an indicator of inadequate organizational commitment to safety that puts not only nurses at risk but patients as well (Clarke, S. P., Sloane, D. M., & Aiken, L. H., 2002a).

However, most of the literature on organizational safety culture and nursing characteristics has focused on the relationship to patient safety (Blegen, M. A., Goode, C. J., & Reed, L., 1998; Cho, S. H., Ketefian, S., Barkauskas, V. H., & Smith, D. G., 2003; Curtin, L. L., 2003; Haberfelde, M., Bedecarre, D., & Buffum, M., 2005; Hickam DH, Severance S, & Feldstein A, et al., 2003; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002). Evidence in the literature describing the relationship between organizational culture and nurse injury is only just emerging.

Increased nurse turnover has been associated with longer patent length of stay and higher costs per discharge (Gelinas, L & Bohlen, C, 2002), but little is known about the effect of nurse turnover on patient or provider outcomes (Jones, C. B., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002). Economic studies have placed the annual cost of turnover at approximately $1 million per hospital and have posited adverse effects to nurses and patients due to lost productivity and workforce instability (Jones, C. B., 2004; Jones, C. B., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002). Because of difficulty obtaining internal hospital data, these studies defined turnover as termination from hospitals, excluding internal transfers to other units (Jones, C. B., 2005; Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K., 2002).

Encouraging evidence links organizational climate and nurse turnover (Hart, S.

E., 2005; Stone, P. W. et al., 2006; Stordeur, S. & D'Hoore, W., 2007). Stone and colleagues have conducted two important studies measuring the effect of organizational climate with nurse burnout and a variety of nurse injuries in a multi-hospital study (Stone, P. W., Du, Y., & Gershon, R. R., 2007), and have examined organizational climate and its positive association with reduced body fluid and blood exposures in ICU settings (Stone, P. W. & Gershon, R. R., 2006). These studies used a variety of readily available surveys to measure organizational climate. We sought to augment these previous efforts by further exploring the relationship between nurse injury, nurse perceptions of organizational culture, and selected characteristics of the nursing unit. This study assessed organizational safety climate using the Safety Attitudes Questionnaire (SAQ).

The Safety Attitudes Questionnaire

The SAQ is a survey which elicits frontline healthcare workers' perceptions of their organization's safety culture at the level of the clinical area (e.g. unit) on which they work. The SAQ previously has been described (Sexton, J. B., Thomas, E. J., & Helmreich, R. L., 2000; Sexton, J. B., 2002; Sexton, J. B. et al., 2006). The SAQ was used in this study because, of nine surveys measuring the patient safety climate of an organization, only the SAQ has been used to explore the relationship between safety climate scores, patient outcomes, and nurse turnover.

Sexton found decreased nurse turnover correlated with increased agreement on the Safety, Morale (Job Satisfaction), Working Conditions, and Perceptions of Management SAQ domains (Sexton). Favorable scores were associated with shorter lengths of stay and fewer medication (Colla, J. B., Bracken, A. C., Kinney, L. M., &

Weeks, W. B., 2005).

Study Objectives

This study aimed principally to examine associations between nurse perceptions of organizational safety climate, nursing unit characteristics, and nurse injury. The study hypothesized that the odds of nurse injury would be negatively associated with positive responses to the SAQ. Additional analyses were conducted to investigate whether nurse staffing factors previously shown to be associated with patient injury were also associated with nurse injury in this study.

Materials and Methods

Study Design

The study design was cross-sectional and used retrospective data.

Setting

The study was conducted at Johns Hopkins Hospital, a level-one trauma center with Magnet nursing status. To be included, all units had to have (1) a 60% or greater SAQ survey response rate among nurse respondents only, (2) available turnover and termination data, and (3) hours of direct nursing care. Thirty of 75 inpatient nursing units satisfied these criteria.

Data Sources

This study used data for calendar year 2005. The study acquired nurse injury data from the Hospital's Department of Health, Safety and Environment - Division of Occupational Medicine. The study acquired nursing hours and total patient days from the Department of Nursing. The Department of Human Resources provided the study with data on nurse turnover, termination, transfer into units, and total full-time equivalent nurses for each nursing unit. The Department of Risk Management provided the study with SAQ data. The Johns Hopkins Quality and Safety Research Group provided technical support on the use of the 2004 SAQ survey data.

Participants

The SAQ was administered to all employees in the Hospital. Because this study sought to explore nurse injury risk factors, it examined data from nurse respondents only.

Main Outcome Measure

The study defined nurse injury to include a needle stick, splash, slip, trip, or fall occurring during 2005. Seventy-eight of 737 nurses experienced an injury of this type. The outcome was expressed as an odds ratio comparing nurses with injuries to those without. All study activities were approved by the institutional review board at the Johns Hopkins Bloomberg School of Public Health.

Main Explanatory Covariates

For each nursing unit, the main explanatory variables consisted of turnover, termination, transfer in, nursing hours per patient day, and the SAQ domains of Stress, Safety, and Morale (Job Satisfaction).

Nursing Unit Characteristics

The total number of nurses who left a nursing unit in one year divided by the number of full-time equivalents assigned to that unit in that same year constituted the turnover rate. These nurses did not leave the Hospital through termination, but rather joined another unit in the hospital. For the logistic regressions, this variable has been rescaled (multiplied by a factor of 10) and is interpreted as a 10% change in the rate.

Termination was defined as the number of nurses who left the Hospital (by nursing unit) divided by the number of fulltime equivalents for that unit. For the logistic regressions, this variable has been rescaled (multiplied by a factor of 10) and is interpreted as a 10% change in the rate.

The transfer in rate was defined as the number of nurses who became employed on a nursing unit divided by the number of fulltime equivalents for that unit. . For the logistic regressions, this variable has been rescaled (multiplied by a factor of 10) and is interpreted as a 10% change in the rate.

Nursing hours per patient day was defined as the sum of registered nurse agency hours plus the sum of the hospital's productive registered nurses hours. The result was divided by the complete number of patient days in the calendar year. Productive hours are those involving direct patent care activities as opposed to administrative or other job-associated tasks.

Safety Attitudes Questionnaire

The Hospital administered the SAQ to all of its employees in 2004. This 36-item survey uses a five-point Likert scale to elicit staff attitudes. The scale ranges from "strongly disagree" to "strongly agree". The SAQ questions were divided into six domains: Teamwork, Safety, Morale (Job Satisfaction), Stress Recognition, Perceptions of Hospital Management, and Working Conditions. The questions within each domain were calculated into a domain average for each respondent. The domain average score was then converted into a 100 point scale. A high score indicates greater agreement (consensus) of a positive safety climate on a given unit. These scores were then averaged for each nursing unit, yielding an average domain score. All average domains scores were rescaled (divided by a factor of 10) and are interpreted as a 10-unit change in the average domain score. **Table 1** shows the individual questions categorized by their corresponding domain. Because they reflected findings previously reported in the literature, this study used three domains from the SAQ: Safety, Morale (Job Satisfaction) and Stress Recognition.

Statistical Analysis

Descriptive statistics were used to compare characteristics among nursing units with and without nurse injuries. Statistical significance was determined through Chi-square and t-tests. Simple logistic regressions were conducted for all variables to investigate their independent associations with the outcome. All analyses used a two-sided *P* value of less than .05 to indicate a statistically significant difference. The study employed the STATA software package (Stata 8, StataCorp LP, College Station, TX) to perform all analyses. Correlations among variables were explored using Pearson's product moment.

Multivariate logistic regression was performed to assess the odds of nurse injury. The nursing unit characteristics and SAQ domains included were determined to be of interest using the above descriptive analyses as well as a review of the literature. The study included the following variables in the multivariate logistic regressions: nursing hours per patient day, turnover rate, and the Safety, Stress Recognition, and Morale (Job Satisfaction) domains of the SAQ.

The nursing unit served as the unit of analysis for the SAQ survey responses. As such, this study presumed individual responses of the nurses on the same unit to be dependent. Multilevel logistic regression models with a random intercept for the nursing unit were used to account for this clustering. Intraclass correlation coefficients (ICC) for each model were calculated using the following formula (Hox J.):

ICC: $\rho = \sigma^2/\sigma^2 + (\pi^2/3)$,

where σ^2 is the between-unit variance and $\pi^2/3$ is the within-unit variance expressed as a constant.

Results

Nursing Hours per Patient Day

Table 2 summarizes various characteristics by nursing units that reported injuries and those that did not. Twenty-one (70%) of the nursing units in the study reported at least one injury. Of 737 nurses, 78 injury events were reported (11%). Nursing units with injuries showed significantly greater mean nursing hours per patient day compared to those without injuries (14.62 vs. 8.14, p=0.000). While increased nursing hours per patient day have been found to be associated with decreased patient safety events, it is not known if it also is a risk factor for nurse injuries. Because increased nursing hours can be thought of as a measurement of exposure for potential injury, this study retained nursing hours per patient day in subsequent analyses. **Table 3** shows the results of simple logistic regressions. Nursing hours per patient day did not show a significant association with the odds of nurse injury (OR: 0.985, p= 0.376) and was not significantly correlated (**Table 4**) with the injury rate (ρ=-0.025, p=0.505).

Nurse Turnover

The percent turnover on units with and without nurse injury was not statistically significant in the descriptive data (p=0.400). However, the turnover rate was positively associated with nurse injury in a simple logistic regression (OR: 1.76, p<0.01) and was significantly correlated (**Table 4**) with the injury rate (ρ=0.353, p=0.000). For each 10% increase in the turnover rate, the odds of nurse injury increased 76%.

The turnover data did not include the reasons for leaving a unit. Promotion, educational opportunities, and dissatisfaction with the organizational climate are all valid reasons nurses may leave one unit for another. The analysis did not address if the same units that reported increasing Stress Recognition also reported increasing turnover. We examined nursing units with and without turnover and found significantly higher average Stress Recognition scores, but no significant differences for Safety or Morale (data not shown).

The multivariate analyses did not consider the other nursing unit characteristics of termination rate or transfer in rate either because they were not statistically significant in the logistic regression (termination rate, OR: 1.014, $p=0.914$) or because of high correlation (transfer in rate, $\rho=0.600$, $p=0.000$) with turnover. Moreover, these last two variables, while of interest, remain poorly characterized in the literature and deserve their own careful examination in a separate study.

SAQ Domains

In a simple logistic regression, Safety was negatively associated with the odds of nurse injury (OR: 0.556, $p<0.01$) and was negatively correlated (**Table 4**) with the injury rate ($\rho=-0.252$, $p=0.000$). Stress was positively associated with the odds of nurse injury (OR: 2.669, $p<0.01$) and was positively correlated (**Table 4**) with the injury rate ($\rho=0.455$, $p=0.000$). Because Safety and Stress were not highly correlated ($\rho=-0.062$, $p=0.090$), they were used simultaneously in the regression models. In addition, nursing hours per patient day and turnover had negligible or small correlations with Stress and Safety and were included simultaneously. An interaction term created for nursing hours per patient day and Stress ($\rho=0.201$, $p=0.000$) was not found to be significant ($p=0.797$).

In a simple logistic regression, Morale (Job Satisfaction) was negatively associated with the odds of nurse injury (OR: 0.703, $p<0.01$) and was negatively correlated (**Table 3**) with the injury rate ($\rho=-0.226$, $p=0.000$). The Morale (Job Satisfaction) domain was highly correlated with the Safety domain ($\rho=0.745$, $p=0.000$) and was therefore examined in a separate multivariate model. As with the Safety domain, Stress was included because it was not highly correlated with Morale (Job Satisfaction) (ρ=0.100, p=0.007). Nursing hours per patient day and turnover had small correlations with Morale (Job Satisfaction) and were included simultaneously. Interaction terms created for nursing hours per patient day and Morale (Job Satisfaction) (ρ=0.260, p=0.000) and turnover and Morale (Job Satisfaction) (ρ=-0.126, p=0.001) were not found to be significant (p=0.128 and p=0.324, respectively) and these terms were included in the same model.

Multivariate Models: Ordinary and Random Intercept Logistic Regressions

For multivariate analyses, ordinary logistic regressions and random intercept logistic regressions (multilevel models) were conducted. The random intercept was included for the nursing unit. Because associations found in the ordinary logistic regressions were maintained in the random intercept logistic regressions, only the multilevel results are discussed here. **Table 5** shows results for both regression types.

The multilevel model, controlling for the dependence of nurse responses by nursing unit, did not change the direction of the odds ratios, but did slightly change their magnitude and confidence intervals. In most cases, the use of the multilevel model decreased the significance level from either <0.01 to <0.05. As expected, the 95% confidence intervals were wider under the multilevel model.

Safety and Stress

Controlling for all other covariates, nursing hours per patient day were not associated with nurse injury (OR: 1.00, p=0.882). Increasing rates of turnover were associated with increased odds of nurse injury (OR: 1.92, p<0.05). The association of turnover with nurse injury was slightly reduced in the multilevel model, but was still statistically significant. As has been suggested in the literature, this reduction in the effect size demonstrates the importance of controlling for the clustering of nursing responses by units.

For each 10-unit increase in the average Safety domain score, a 39% reduction in the odds of nurse injury was observed (OR: 0.61, $p<0.05$). For each 10-unit increase in the average Stress domain score, the odds of nurse injury increased significantly (OR: 3.27, $p<0.001$). The intraclass correlation coefficient for this model was 0.041 (**Table 5**).

Morale (Job Satisfaction) and Stress

Controlling for all other covariates, nursing hours per patient day were not associated with nurse injury (OR: 1.01, $p=0.539$). Increasing rates of turnover were associated with increased odds of nurse injury (OR: 1.94, $p<0.05$). For each 10-unit increase in the average Morale (Job Satisfaction) domain score, a 27% reduction in the odds of nurse injury was observed (OR: 0.73, $p<0.05$). For each 10-unit increase in the average Stress domain score, the odds of nurse injury increased significantly (OR: 3.47, $p<0.001$). The intraclass correlation coefficient for this model was 0.034 (**Table 5**).

The results were presented in both ordinary logistic regression and random intercept logistic regression (multilevel model) to demonstrate the importance of using multilevel models when investigating clustered data as has been advised by the nursing literature (Cho 61-65). This study adds its findings as additional evidence of this point.

The Intraclass correlation coefficient (ICC) is a measure of the degree of dependence of nurses belonging to the same unit. The larger the intraclass correlation the more likely it is that nurses share the same attitudes or perceptions. The ICC for the Safety and Stress versus Morale and Stress Recognition random intercept logistic regressions were considered to be relatively small (Zyzanski, Flocke, and Dickinson 199-200). We calculated the effective sample size (Killip, Mahfoud, and Pearce 204-08) and found that the ICC did not significantly alter the effective sample size, thus preserving power (data not shown). While the ICC was small, the structure of the data and the study design still indicated the use of multilevel models as appropriate.

Discussion

The SAQ traditionally has demonstrated associations between organizational safety climate and patient injuries. This study extends the utility of the SAQ to nurse injury. A two-fold increase in the odds of nurse injury with each 10% increase in the turnover rate was observed. The odds of nurse injury also increased with increasing Stress Recognition as assessed through the SAQ. Conversely, the odds of nurse injury decreased with increasing agreement on the Safety and Morale scales of the SAQ.

Historically, the SAQ uses survey responses from all respondents, whereas this study used responses from nurses only. While SAQ administrations most commonly use all respondents, it is also valid to use responses from nurses only (Sexton, J. B. et al., 2006). In the current study, we duplicated the regressions using all respondents and found that the Stress Recognition association with nurse injury was not significant (data not shown). It is possible that the Stress Recognition domain of the SAQ is more responsive to nursing-sensitive outcomes than other outcomes. Alternatively, the SAQ may detect nurse attitudes more precisely than those of other respondents and therefore the inclusion of all respondents masks the effect of Stress Recognition on nurse injury.

Based on a review of the literature, we believe this study is among the first to show an association between nurse injury and nurse turnover. While the literature offers evidence of associations between organizational climate and nurse turnover (Hayes, L. J. et al., 2006), little is known about the direct effect of turnover on patient or nurse injury (Hart, S. E., 2005; Stone, P. W. et al., 2006; Stordeur, S. & D'Hoore, W., 2007).

Because previous studies have shown that some of the same organizational climate characteristics are related to nurse burnout and nurse turnover (Stone, P. W., Du, Y., & Gershon, R. R., 2007), we wanted to explore a proxy for nurse burnout (the SAQ Stress, and Morale/Job Satisfaction domains) with nurse turnover and nursing hours per patient day in the same regression models. One interpretation would be that nurses who have positive responses to the organizational safety climate would be less likely to leave their current units or the hospital in which they work.

The relationship between job satisfaction and nurse turnover is well-established (Mueller, C. W. & McCloskey, J. C., 1990). While we did not look at turnover directly, we were able to demonstrate that increasing agreement with Safety and Morale (Job Satisfaction) was associated with lower odds of nurse injury. This finding was not entirely unexpected as previous research has validated the strong association of caregiver safety climate attitudes with patient outcomes (Sexton, J. B., 2002). Moreover, inclusion of safety climate as a domain in the SAQ was based on the initial recognition of the role of safety climate in both occupational injuries and injures in non-healthcare settings (lifting injuries, proper disposal of hazardous materials, etc).

The nursing shortage has shown a concerning effect on nurse burnout and job dissatisfaction (Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H., 2002). The SAQ Morale (Job Satisfaction) scale reflects a workers' job happiness. The experience of an occupational injury might change this attitude because a nurse might become disillusioned by the effect of injury due to pain or a shift to light duty. A nurse may also become dissatisfied with a job because he or she does not perceive the organization as supportive of a nurse continuing to work post-injury.

Stress Recognition was included in this study because the current environment in nursing (longer hours, nursing shortage, etc) creates opportunities for stress-induced mistakes. In nursing, aviation safety interventions such as adaptation of the sterile cockpit protocol to medication administration have witnessed an 86% decrease in nurse-reported distractions induced by stressful working environments (Pape, T. M., 2003). Stress has long been associated with occupational injury (rushing, fatigue, etc). Moreover, stress has been found to be one of the leading causes of nursing job dissatisfaction (Bratt et al. 307-17) along with workload and burnout (Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H., 2002; Strachota, E., Normandin, P., O'Brien, N., Clary, M., & Krukow, B., 2003).

This study found a three-fold increase in the odds of nurse injury with each 10-unit increase in agreement with Stress Recognition. We hypothesize that low levels of Stress Recognition may reflect the vulnerability of a certain unit to bad outcomes: units with low acuity patients that witness little harm do not have the opportunity to learn from those episodes. Increased awareness of the effect of stress on job performance may be associated with increased awareness of injury risk, and may manifest itself in increased reporting of injuries by those sensitized to injury's root causes. Alternatively, past experience with a stressful event that caused a nurse or patient injury may also increase agreement with the effect of stress. We speculate that nurses who are more aware of the effect stress has on their ability to effect their performance may also be better reporters of work-related injury.

In discussions with the SAQ developer, the Stress Recognition domain of the SAQ operates somewhat differently than the other domains. Stress Recognition represents the individual attitudes of the respondents rather than a consensus among people working on the unit (Bryan Sexton, personal communication). Since the nurse injuries in this study are voluntary reports to the Hospital's Occupational Health Department, the effect of increased stress recognition may represent an increased awareness of the importance of reporting injuries due either to heightened awareness of stress or because of a past stress-related experience.

This study design did not address the question, "Did high stress recognition cause increased nurse injury or the increased reporting of nurse injury?" However, it is known that organizational climate is a latent condition. As such, its characteristics are pervasive, slow to change, and represent error-inducing conditions by creating stress, distraction, inadequate resources, and inexperience (Reason, J., 2000). This is the main reason that recent patient safety initiatives have focused on organizational climate: these conditions are stable, stubborn, unintentionally designed flaws in systems waiting for opportunities to induce error. If prevention strategies can address their modification, errors and their subsequent injuries may be ameliorated.

This study heeded criticisms of previous studies of nurse staffing and patient safety in its design. Previous studies had (1) aggregated nurse staffing at the level of the hospital rather than at the individual nursing unit level thus inviting ecological fallacy, (2) investigated only one variable at a time, ignoring the potential interaction of organizational dynamics, and (3) did not use hierarchical modeling to consider any confounding caused by the structure of data (interdependence of nurses who work on the same units) (Hoff, T., Jameson, L., Hannan, E., & Flink, E., 2004; Lankshear, A. J., Sheldon, T. A., & Maynard, A., 2005). This study, however, was neither able to use the longitudinal designs, nor entertain pre-and post designs that have been suggested as gold standards for these types of investigations (Hoff, T., Jameson, L., Hannan, E., & Flink, E., 2004).

Conclusions

The study found a positive association between nurse turnover and nurse injury. It also demonstrated the utility of the SAQ, a well-regarded patient safety tool, to better understand nurse injury. Future investigations should continue to explore common factors between patient and caregiver injuries to better understand the effect of organizational safety climate in its entirety. Organizational safety climate is a large construct that affects not only the final outcome of healthcare delivery (positive patient outcomes) but everything in between; including the safety of the healthcare workforce dedicated to ensuring the final product's outcome.

In the future, additional in-depth investigation of the other SAQ domains should be undertaken. The Teamwork domain is an especially promising candidate. It demonstrated patterns similar to Safety and Morale (Job Satisfaction) (data not shown) and has been shown to be association with ICU-related mortality(Sexton, J. B., 2002). Other nursing unit characteristics such as termination from the hospital, and transfers into a unit should also be examined. We would like to have explored in greater detail the effect of transfers in on nurse injury, but we were not able to ascertain if the nurses transferring into a unit were new to the profession, new to the hospital, or nurses transferring from other units.

Termination (nurses leaving the hospital) is also deserving of further study. Termination may be more of a macro-level indicator of dissatisfaction with the organizational culture and represent an indictor of severity: nurses who have very poor perceptions of the organizational culture are more likely to leave the hospital entirely, rather than transferring to other units. By contrast, nurses who have less severe perceptions may elect to stay with the organization, but leave one nursing unit for another in the hope of a more amenable environment. Future studies should investigate this issue to determine how it operates and consider its addition to the analytic framework used to guide the study of the relationship between organizational climate and injury.

Table 1. Safety Attitudes Questionnaire: Questions by Domain

Teamwork
Nurse input is well received in this clinical area
In this clinical area, it is difficult to speak up if I perceive a problem with patient care
Disagreements in this clinical area are resolved appropriately (i.e., not who is right, but what is best for the patient)
I have the support I need from other personnel to care for patients
It is easy for personnel here to ask questions when there is something that they do not understand
The physicians and nurses here work together as a well-coordinated team
Safety
I would feel safe being treated here as a patient
Medical errors are handled appropriately in this clinical area
I know the proper channels to direct questions regarding patient safety in this clinical area
I receive appropriate feedback about my performance
In this clinical area, it is difficult to discuss errors
I am encouraged by my colleagues to report any patient safety concerns I may have
The culture in this clinical area makes it easy to learn from the errors of others
Morale (Job Satisfaction)
I like my job
Working here is like being part of a large family
This is a good place to work
I am proud to work in this clinical area
Morale in this clinical area is high
Stress Recognition
When my workload becomes excessive, my performance is impaired
I am less effective at work when fatigued
I am more likely to make errors in tense or hostile situations
Fatigue impairs my performance during emergency situations (e.g. emergency resuscitation, seizure)
Perceptions of Hospital Management
Hospital management supports my daily efforts
Hospital management doesn't knowingly compromise the patient safety
Hospital management is doing a good job
Problem personnel are dealt with constructively by our hospital management
I get adequate, timely information about events that might affect my work from hospital management
Working Conditions
The levels of staffing in this clinical area are sufficient to handle the number of patients
This hospital does a good job of training new personnel
All the necessary information for diagnostic and therapeutic decisions is routinely available to me
Trainees in my discipline are adequately supervised

Table 2. Characteristics of Nursing Units: Nurse Injury Events

Nursing Unit Characteristics		Total	Nursing Units without RN Injury	Nursing Units with RN Injury	pvalue*
Number of Nursing Units		30	9	21	---
			30.0%	70.0%	
Count of Nurses		737	172	565	---
			23.3%	76.7%	
Count of Injuries		78	0	78	---
Mean Nursing Hours Per Patient Day		13.11	8.14	14.62	0.000
	se	0.26	0.27	0.31	
Turnover (%)		4.65	4.07	4.83	0.400
Termination (%)		15.63	17.77	14.98	0.005
Transfer In (%)		10.57	4.12	12.53	0.000
Mean SAQ Domain Score					
Teamwork		78.33	78.59	78.25	0.636
	se	0.30	0.53	0.36	
Safety		77.16	78.07	76.88	0.023
	se	0.22	0.40	0.26	
Morale		74.48	73.39	74.81	0.094
	se	0.36	0.61	0.43	
Stress Recognition		71.46	65.75	73.20	0.000
	se	0.21	0.43	0.18	
Perceptions of Management		64.11	60.85	65.10	0.000
	se	0.37	0.77	0.41	
Working Conditions		70.83	67.55	71.83	0.000
	se	0.26	0.58	0.28	

***P-values calculated using t-test for continuous variables or chi square test for categorical**
SAQ=RN Respondents only, ≥ 60% Response Rate

Table 3. Bivariate Results: Nurse Injury with SAQ Domain and Nursing Unit Factors

Nurse Injury **Nursing Unit Characteristics**	**OR**
Nursing Hours Per Patient Day	0.985
Turnover Rate	1.755***
Termination Rate	1.014
Transfer In Rate	1.354***
Mean SAQ Domain Score	**OR**
Teamwork	0.637***
Safety	0.556***
Morale	0.703***
Stress Recognition	2.669***
Perceptions of Management	0.884
Working Conditions	1.151

***** p<0.01, ** p<0.05, * p<0.1**

Note: Turnover rate has been rescaled and is interpreted as for every 10% increase in the rate. SAQ Domains have been rescaled to be interpreted as for every 10 unit increase in the mean score.

SAQ=RN Respondents only, ≥ 60% Response Rate

Table 4. Pearson Correlation Matrix: Nurse Injury

Variable	inj_rate	rnhrsppd	xferin~e	turnov~e	term_r~e	teamwo~n	safety~n	morale~n	stress~n	prcpmg~n	wrkcon~n
inj_rate	1.000	-0.025	0.464	0.353	0.088	-0.252	-0.252	-0.226	0.455	-0.012	0.182
(p)		(0.505)	(0.000)	(0.000)	(0.017)	(0.000)	(0.000)	(0.000)	(0.000)	(0.744)	(0.000)
rnhrsppd	-0.025	1.000	0.101	-0.182	-0.194	0.296	-0.021	0.270	0.201	0.246	0.162
(p)	(0.505)		(0.006)	(0.000)	(0.000)	(0.000)	(0.564)	(0.000)	(0.000)	(0.000)	(0.000)
xferin_rate	0.464	0.101	1.000	0.600	-0.079	0.007	-0.112	-0.067	0.023	-0.020	0.004
(p)	(0.000)	(0.006)		(0.000)	(0.032)	(0.846)	(0.002)	(0.068)	(0.540)	(0.593)	(0.920)
turnover_rate	0.353	-0.182	0.600	1.000	-0.260	-0.069	-0.047	-0.126	-0.008	-0.065	0.131
(p)	(0.000)	(0.000)	(0.000)		(0.000)	(0.062)	(0.200)	(0.001)	(0.831)	(0.078)	(0.000)
term_rate	0.088	-0.194	-0.079	-0.260	1.000	-0.250	-0.388	-0.531	-0.021	-0.487	-0.382
(p)	(0.017)	(0.000)	(0.032)	(0.000)		(0.000)	(0.000)	(0.000)	(0.564)	(0.000)	(0.000)
teamwork_rn	-0.252	0.296	0.007	-0.069	-0.250	1.000	0.825	0.775	-0.022	0.711	0.690
(p)	(0.000)	(0.000)	(0.846)	(0.062)	(0.000)		(0.000)	(0.000)	(0.545)	(0.000)	(0.000)
safety_rn	-0.252	-0.021	-0.112	-0.047	-0.388	0.825	1.000	0.745	-0.062	0.836	0.757
(p)	(0.000)	(0.564)	(0.002)	(0.200)	(0.000)	(0.000)		(0.000)	(0.090)	(0.000)	(0.000)
morale_rn	-0.226	0.270	-0.067	-0.126	-0.531	0.775	0.745	1.000	0.100	0.814	0.644
(p)	(0.000)	(0.000)	(0.068)	(0.001)	(0.000)	(0.000)	(0.000)		(0.007)	(0.000)	(0.000)
stress_rn	0.455	0.201	0.023	-0.008	-0.021	-0.022	-0.062	0.100	1.000	0.156	0.298
(p)	(0.000)	(0.000)	(0.540)	(0.831)	(0.564)	(0.545)	(0.090)	(0.007)	(0.000)	(0.000)	(0.000)
prcpmgt_rn	-0.012	0.246	-0.020	-0.065	-0.487	0.711	0.836	0.814	0.156	1.000	0.825
(p)	(0.744)	(0.000)	(0.593)	(0.078)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)
wrkcond_rn	0.182	0.162	0.004	0.131	-0.382	0.690	0.757	0.644	0.298	0.825	1.000
(p)	(0.000)	(0.000)	(0.920)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

Table 5. Logistic Regression and Multilevel Logistic Regression with Random Intercept: Nurse Injury

SAQ Domains	Ordinary Logistic OR	(95% CI)	Random Int. Logistic OR	(95% CI)
Safety	0.63*	(0.43 - 0.91)	0.61*	(0.39 - 0.96)
Stress Recognition	3.24***	(1.82 - 5.79)	3.27***	(1.69 - 6.32)
Nursing Unit Characteristics				
Nursing Hours Per Patient Day	1	(0.97 - 1.04)	1	(0.96 - 1.05)
Turnover Rate	2.10**	(1.33 - 3.30)	1.92*	(1.11 - 3.32)
σ2 = variance of random effect for nursing unit			0.141	
ICC			0.041	
95% confidence intervals in parentheses *** p<0.001, ** p<0.01, * p<0.05 ICC = Interclass Correlation Coefficient				

SAQ Domains	Ordinary Logistic OR	(95% CI)	Random Int. Logistic OR	(95% CI)
Morale	0.73**	(0.58 - 0.92)	0.73*	(0.56 - 0.95)
Stress Recognition	3.43***	(1.92 - 6.12)	3.47***	(1.81 - 6.66)
Nursing Unit Characteristics				
Nursing Hours Per Patient Day	1.02	(0.98 - 1.06)	1.01	(0.97 - 1.06)
Turnover Rate	2.10**	(1.33 - 3.31)	1.94*	(1.11 - 3.39)
σ2 = variance of random effect for nursing unit			0.115	
ICC			0.034	
95% confidence intervals in parentheses *** p<0.001, ** p<0.01, * p<0.05 ICC = Interclass Correlation Coefficient				

Note: Turnover rate has been rescaled and is interpreted as for every 10% increase in the rate.
SAQ Domains have been rescaled to be interpreted as for every 10 unit increase in the mean score.
SAQ=RN Respondents only, ≥ 60% Response Rate

Reference List

Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H. (2002). Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA, 288,* 1987-1993.

Blegen, M. A., Goode, C. J., & Reed, L. (1998). Nurse staffing and patient outcomes. *Nurs.Res., 47,* 43-50.

Cho, S. H., Ketefian, S., Barkauskas, V. H., & Smith, D. G. (2003). The effects of nurse staffing on adverse events, morbidity, mortality, and medical costs. *Nurs.Res., 52,* 71-79.

Clarke, S. P., Rockett, J. L., Sloane, D. M., & Aiken, L. H. (2002). Organizational climate, staffing, and safety equipment as predictors of needlestick injuries and near-misses in hospital nurses. *Am.J.Infect.Control, 30,* 207-216.

Clarke, S. P., Sloane, D. M., & Aiken, L. H. (2002a). Effects of hospital staffing and organizational climate on needlestick injuries to nurses. *Am.J.Public Health, 92,* 1115-1119.

Clarke, S. P., Sloane, D. M., & Aiken, L. H. (2002b). Needlestick injuries to nurses, in context. *LDI.Issue.Brief., 8,* 1-4.

Colla, J. B., Bracken, A. C., Kinney, L. M., & Weeks, W. B. (2005). Measuring patient safety climate: a review of surveys. *Qual.Saf Health Care, 14,* 364-366.

Curtin, L. L. (2003). An integrated analysis of nurse staffing and related variables: effects on patient outcomes. *Online.J.Issues Nurs., 8,* 5.

Gelinas, L. & Bohlen, C. (2002). The business case for retention. *Journal of Clinical Systems Management, 4,* 14-16.

Haberfelde, M., Bedecarre, D., & Buffum, M. (2005). Nurse-sensitive patient outcomes: an annotated bibliography. *J.Nurs.Adm, 35,* 293-299.

Hart, S. E. (2005). Hospital ethical climates and registered nurses' turnover intentions. *J.Nurs.Scholarsh., 37,* 173-177.

Hayes, L. J., O'Brien-Pallas, L., Duffield, C., Shamian, J., Buchan, J., Hughes, F., Spence Laschinger, H. K., North, N., & Stone, P. W. (2006). Nurse turnover: a literature review. *Int.J.Nurs.Stud., 43,* 237-263.

Hickam DH, Severance S, & Feldstein A, e. al. (2003). *The Effect of Health Care Working Conditions on Patient Safety* Rockville, MD: Agency for Healthcare Research and Quality.

Hoff, T., Jameson, L., Hannan, E., & Flink, E. (2004). A review of the literature examining linkages between organizational factors, medical errors, and patient safety. *Med.Care Res.Rev., 61,* 3-37.

Jones, C. B. (2004). The costs of nurse turnover: part 1: an economic perspective. *J.Nurs.Adm, 34,* 562-570.

Jones, C. B. (2005). The costs of nurse turnover, part 2: application of the Nursing Turnover Cost Calculation Methodology. *J.Nurs.Adm, 35,* 41-49.

Lankshear, A. J., Sheldon, T. A., & Maynard, A. (2005). Nurse staffing and healthcare outcomes: a systematic review of the international research evidence. *ANS Adv.Nurs.Sci., 28,* 163-174.

Mueller, C. W. & McCloskey, J. C. (1990). Nurses' job satisfaction: a proposed measure. *Nurs.Res., 39,* 113-117.

Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K. (2002). Nurse-staffing levels and the quality of care in hospitals. *N.Engl.J.Med., 346,* 1715-1722.

Pape, T. M. (2003). Applying airline safety practices to medication administration. *Medsurg.Nurs., 12,* 77-93.

Reason, J. (2000). Human error: models and management. *West J.Med., 172,* 393-396.

Sexton, J. B. (2002). *A Matter of Life or Death: Social Psychological and Organizational Factors Related to Patient Outcomes in the Intensive Care Unit.* The University of Texas at Austin.

Sexton, J. B., Helmreich, R. L., Neilands, T. B., Rowan, K., Vella, K., Boyden, J., Roberts, P. R., & Thomas, E. J. (2006). The Safety Attitudes Questionnaire: psychometric properties, benchmarking data, and emerging research. *BMC.Health Serv.Res., 6,* 44.

Sexton, J. B., Thomas, E. J., & Helmreich, R. L. (2000). Error, stress, and teamwork in medicine and aviation: cross sectional surveys. *BMJ, 320,* 745-749.

Stone, P. W., Du, Y., & Gershon, R. R. (2007). Organizational climate and occupational health outcomes in hospital nurses. *J.Occup.Environ.Med., 49,* 50-58.

Stone, P. W. & Gershon, R. R. (2006). Nurse work environments and occupational safety in intensive care units. *Policy Polit.Nurs.Pract., 7,* 240-247.

Stone, P. W., Larson, E. L., Mooney-Kane, C., Smolowitz, J., Lin, S. X., & Dick, A. W. (2006). Organizational climate and intensive care unit nurses' intention to leave. *Crit Care Med., 34,* 1907-1912.

Stordeur, S. & D'Hoore, W. (2007). Organizational configuration of hospitals succeeding in attracting and retaining nurses. *J.Adv.Nurs., 57,* 45-58.

Strachota, E., Normandin, P., O'Brien, N., Clary, M., & Krukow, B. (2003). Reasons registered nurses leave or change employment status. *J.Nurs.Adm, 33,* 111-117.

Appendix

Additional Analyses

Parts II and III of this dissertation mention that the Teamwork domain of the Safety Attitudes Questionnaire (SAQ) is deserving of future study. While it was not included in the manuscripts, the results of the Teamwork domain analyses are presented here for nurse and patient injury (**Tables 1 and 2**).

Table 1. Odds Ratios for Ordinary and Multilevel Logistic Regression of Nurse Injury as a Function of Average SAQ Safety Scores and Nursing Unit Characteristics: Teamwork SAQ Domain

	Ordinary Logistic		Random Int. Logistic	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Teamwork	0.68**	(0.51 - 0.90)	0.67*	(0.48 - 0.93)
Stress Recognition	3.00***	(1.70 - 5.26)	3.06***	(1.61 - 5.81)
Nursing Unit Characteristics				
Nursing Hours Per Patient Day	1.02	(0.98 - 1.06)	1.02	(0.97 - 1.07)
Turnover Rate	2.13**	(1.35 - 3.35)	1.95*	(1.12 - 3.38)
σ2 = variance of random effect for nursing unit			0.125	
ICC			0.037	
95% confidence intervals in parentheses *** p<0.001, ** p<0.01, * p<0.05 ICC = Interclass Correlation Coefficient				

Note: Turnover rate has been rescaled and is interpreted as for every 10% increase in the rate.
SAQ Domains have been rescaled to be interpreted as for every 10 unit increase in the mean score.
SAQ=RN Respondents only, ≥ 60% Response Rate

Table 2. Odds Ratios for Ordinary and Multilevel Logistic Regression of Patient Injury as a Function of Average SAQ Safety Scores and Nursing Unit Characteristics: Teamwork SAQ Domain

	Falls				Medication Error				Decubitus Ulcer				Post-op PE/DVT			
	Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic	
SAQ Domains	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Teamwork	0.99	(0.87 - 1.12)	0.95	(0.64 - 1.41)	1.09	(1.00 - 1.19)	1.15	(0.88 - 1.51)	0.62***	(0.52 - 0.74)	0.62***	(0.52 - 0.74)	0.80*	(0.67 - 0.95)	0.65	(0.37 - 1.14)
Stress Recognition	2.05***	(1.67 - 2.53)	2.38**	(1.29 - 4.41)	1.48***	(1.31 - 1.68)	1.60*	(1.04 - 2.47)	3.07***	(1.88 - 5.01)	3.07***	(1.88 - 5.01)	1.18	(0.84 - 1.65)	1.21	(0.41 - 3.58)
Nursing Unit Characteristics																
Nursing Hours Per Patient Day	0.89***	(0.85 - 0.94)	0.91*	(0.83 - 0.99)	1.09***	(1.08 - 1.11)	1.08**	(1.03 - 1.13)	0.97	(0.91 - 1.03)	0.97	(0.91 - 1.03)	1.05*	(1.01 - 1.09)	1.09	(0.99 - 1.19)
Turnover Rate	0.87**	(0.79 - 0.95)	0.84	(0.70 - 1.00)	0.95*	(0.91 - 0.99)	0.92	(0.83 - 1.03)	0.58*	(0.36 - 0.93)	0.58*	(0.36 - 0.93)	1.10***	(1.06 - 1.14)	1.15	(0.97 - 1.37)
Patient Level Characteristics																
Complexity	3.46***	(2.68 - 4.47)	3.43***	(2.64 - 4.47)	3.15***	(2.71 - 3.68)	3.39***	(2.89 - 3.97)	132.50***	(18.43 - 952.68)	132.50***	(18.43 - 952.72)	10.23***	(6.54 - 15.98)	11.60***	(7.34 - 18.32)
σ2 = variance of random effect for nursing unit			0.789				0.408				N/A				1.310	
ICC			0.193				0.110				N/A				0.285	

95% confidence intervals in parentheses
*** p<0.001, ** p<0.01, * p<0.05
ICC = Interclass Correlation Coefficient

SAQ: Use of Nurse Respondents Only Versus All Respondents

This study used the SAQ in an unconventional manner. Traditionally, the SAQ uses survey responses from all respondents, whereas this study used nurse respondents only in order to meet its study goals. In **Tables 3 and 4**, the regressions were duplicated using all respondents resulting in the loss of the association between Stress Recognition and nurse and patient injury. It is possible that the Stress Recognition domain of the SAQ detects nurse attitudes more precisely than those of other respondents and that the inclusion of all respondents masks the effect of Stress Recognition on patient injury.

Table 3. Comparison of SAQ using All Respondents versus Nurse only: Nurse Injury

SAQ=ALL respondents	**Ordinary Logistic**		**Random Int. Logistic**	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Safety	0.59**	(0.42 - 0.83)	0.55*	(0.33 - 0.92)
Stress Recognition	1.09	(0.76 - 1.56)	1.18	(0.66 - 2.10)
Nursing Unit Characteristics				
Nursing Hours Per Patient Day	0.99	(0.96 - 1.02)	1	(0.95 - 1.05)
Turnover Rate	1.82**	(1.26 - 2.64)	1.69*	(1.01 - 2.84)
σ2 = variance of random effect for nursing unit			0.512	
ICC			0.135	
95% confidence intervals in parentheses *** p<0.001, ** p<0.01, * p<0.05 ICC = Interclass Correlation Coefficient				
SAQ=Nurse respondents only, 60% RR	**Ordinary Logistic**		**Random Int. Logistic**	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Safety	0.63*	(0.43 - 0.91)	0.61*	(0.39 - 0.96)
Stress Recognition	3.24***	(1.82 - 5.79)	3.27***	(1.69 - 6.32)
Nursing Unit Characteristics				
Nursing Hours Per Patient Day	1	(0.97 - 1.04)	1	(0.96 - 1.05)
Turnover Rate	2.10**	(1.33 - 3.30)	1.92*	(1.11 - 3.32)
σ2 = variance of random effect for nursing unit			0.141	
ICC			0.041	
95% confidence intervals in parentheses *** p<0.001, ** p<0.01, * p<0.05 ICC = Interclass Correlation Coefficient				
Note: Turnover rate has been rescaled and is interpreted as for every 10% increase in the rate. SAQ Domains have been rescaled to be interpreted as for every 10 unit increase in the mean score.				

Table 4. Comparison of SAQ using All Respondents versus Nurse only: Patient Injury

	Falls				Medication Errors				Decubitus Ulcer				Post-op PE/DVT			
	Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic	
SAQ Domains	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Safety	0.96	(0.81 - 1.13)	0.81	(0.46 - 1.42)	0.93	(0.84 - 1.03)	0.97	(0.69 - 1.38)	0.50***	(0.38 - 0.67)	0.59*	(0.35 - 0.99)	0.73**	(0.58 - 0.92)	0.72	(0.34 - 1.55)
Stress	0.95	(0.79 - 1.14)	0.91	(0.48 - 1.72)	1.16**	(1.05 - 1.29)	1.22	(0.82 - 1.82)	1.23	(0.89 - 1.70)	1.03	(0.58 - 1.85)	1.25	(0.98 - 1.59)	1.04	(0.44 - 2.43)
Nursing Unit Characteristics																
Nursing Hours Per Patient Day	0.90***	(0.87 - 0.93)	0.90**	(0.83 - 0.97)	1.10***	(1.09 - 1.11)	1.08***	(1.04 - 1.13)	0.92**	(0.87 - 0.97)	0.94	(0.87 - 1.02)	1.02	(0.99 - 1.06)	1.07	(0.98 - 1.17)
Turnover Rate	0.86**	(0.79 - 0.95)	0.82	(0.68 - 1.00)	0.95**	(0.91 - 0.99)	0.91	(0.82 - 1.02)	0.69*	(0.48 - 0.99)	0.67	(0.37 - 1.21)	1.10***	(1.06 - 1.14)	1.18	(0.97 - 1.42)
Patient Level Characteristics																
Complexity	3.50***	(2.83 - 4.33)	3.27***	(2.61 - 4.10)	3.05***	(2.69 - 3.46)	3.33***	(2.91 - 3.80)	48.27***	(17.82 - 130.70)	43.47***	(15.96 - 118.41)	12.50***	(8.29 - 18.86)	14.36***	(9.44 - 21.86)
σ2 = varience of random effect for nursing unit			1.032				0.435				0.567				1.649	
ICC			0.239				0.117				0.147				0.334	

95% confidence intervals in parentheses
*** $p<0.001$, ** $p<0.01$, * $p<0.05$
ICC = Interclass Correlation Coefficicient
Note: Turnover rate has been rescaled and is interpreted as for every 10% increase in the rate.
SAQ Domains have been resclaed to be interpreted as for every 10 unit increase in the mean score.
SAQ=all respondents

Traditional Use of SAQ: Results Using Percent Positive Agreement

The average domain scores on the SAQ are intended to be converted into percent positive agreement scores for each nursing unit (Brian Sexton, personal communication). Percent positive agreement is a reflection of how many people on the unit gave "agree or strongly agree" responses 75% or more of the time. For this reason, percent positive agreement represents a *consensus* about the safety climate among people who work on that nursing unit. Dr. Sexton describes the Stress Recognition domain as rather different than the other domains of the SAQ, in that it represents more of an individual attitude than group consensus. We felt comfortable using the average SAQ domain score because Stress was strongly suggested as an injury risk factor in the literature. The results of the multilevel analyses for patient and nurse injury (using nurse respondents only) when using percent positive agreement. is shown in **Tables 5 and 6**. As with the average SAQ score, Safety and Teamwork still hold their general findings, but the association between Stress Recognition and Nurse Injury disappears.

Table 5. Odds Ratios for Ordinary and Multilevel Logistic Regression of Nurse Injury as a Function of Percent Positive SAQ Agreement and Nursing Unit Characteristics

	Ordinary Logistic		Random Int. Logistic	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Safety	0.81**	(0.70 - 0.94)	0.78*	(0.63 - 0.97)
Stress Recognition	1.23	(0.94 - 1.60)	1.19	(0.83 - 1.71)
Nursing Unit Characteristics				
Nursing Hours Per Patient Day	1.01	(0.97 - 1.05)	1.01	(0.96 - 1.07)
Turnover Rate	1.96**	(1.28 - 3.00)	1.66	(0.89 - 3.10)
σ2 = variance of random effect for nursing unit			0.419	
ICC			0.113	
95% confidence intervals in parentheses *** p<0.001, ** p<0.01, * p<0.05 ICC = Interclass Correlation Coefficient				

	Ordinary Logistic		Random Int. Logistic	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Morale	0.86*	(0.76 - 0.97)	0.86	(0.72 - 1.02)
Stress Recognition	1.32*	(1.02 - 1.71)	1.3	(0.90 - 1.87)
Nursing Unit Characteristics				
Nursing Hours Per Patient Day	1.02	(0.98 - 1.06)	1.02	(0.96 - 1.09)
Turnover Rate	1.95**	(1.28 - 2.96)	1.62	(0.86 - 3.07)
σ2 = variance of random effect for nursing unit			0.495	
ICC			0.131	
95% confidence intervals in parentheses *** p<0.001, ** p<0.01, * p<0.05 ICC = Interclass Correlation Coefficient				

	Ordinary Logistic		Random Int. Logistic	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Teamwork	0.80***	(0.70 - 0.91)	0.78**	(0.65 - 0.93)
Stress Recognition	1.28	(0.98 - 1.66)	1.26	(0.90 - 1.76)
Nursing Unit Characteristics				
Nursing Hours Per Patient Day	1.03	(0.99 - 1.07)	1.03	(0.98 - 1.09)
Turnover Rate	1.97**	(1.29 - 3.03)	1.71	(0.94 - 3.10)
σ2 = variance of random effect for nursing unit			0.326	
ICC			0.090	
95% confidence intervals in parentheses *** p<0.001, ** p<0.01, * p<0.05 ICC = Interclass Correlation Coefficient				

Note: Turnover rate has been rescaled and is interpreted as for every 10% increase in the rate.
SAQ Domains have been rescaled to be interpreted as for every 10 unit increase in percent positive agreem
SAQ=RN Respondents only, ≥ 60% Response Rate

Table 6. Odds Ratios for Ordinary and Multilevel Logistic Regression of Patient Injury as a Function of Percent Positive SAQ Agreement and Nursing Unit Characteristics

	Falls				Medication Errors				Decubitus Ulcer				Post-operative PE/DVT			
	Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Safety	1.01	(0.95 - 1.08)	0.96	(0.77 - 1.19)	0.98	(0.94 - 1.02)	1	(0.86 - 1.16)	0.80***	(0.72 - 0.90)	0.82*	(0.70 - 0.97)	0.89*	(0.81 - 0.98)	0.8	(0.59 - 1.09)
Stress Recognition	1.31***	(1.18 - 1.46)	1.4	(0.99 - 1.96)	1.16***	(1.08 - 1.24)	1.16	(0.92 - 1.47)	1.55***	(1.24 - 1.93)	1.47**	(1.10 - 1.96)	0.94	(0.81 - 1.08)	0.89	(0.56 - 1.43)
Nursing Unit Characteristics																
Nursing Hours Per Patient Day	0.88***	(0.84 - 0.92)	0.89*	(0.82 - 0.97)	1.09***	(1.07 - 1.10)	1.07**	(1.02 - 1.12)	0.88***	(0.82 - 0.94)	0.89**	(0.83 - 0.96)	1	(0.96 - 1.04)	1.03	(0.94 - 1.13)
Turnover Rate	0.99	(0.82 - 1.21)	0.89	(0.50 - 1.59)	1.26***	(1.12 - 1.42)	1.13	(0.77 - 1.65)	0.66	(0.43 - 1.03)	0.62	(0.33 - 1.17)	1.38*	(1.06 - 1.80)	1.6	(0.76 - 3.35)
Patient Level Characteristics																
Complexity	2.38***	(2.08 - 2.72)	2.26***	(1.96 - 2.60)	2.07***	(1.91 - 2.24)	2.14***	(1.97 - 2.33)	7.83***	(5.59 - 10.97)	7.69***	(5.46 - 10.84)	4.52***	(3.60 - 5.68)	4.76***	(3.76 - 6.02)
σ2 = variance of random effect for nursing unit			0.825				0.408				0.210				1.341	
ICC			0.201				0.110				0.060				0.290	
	Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Morale	1.07**	(1.02 - 1.13)	1.05	(0.89 - 1.23)	0.97	(0.94 - 1.01)	0.99	(0.88 - 1.11)	0.89**	(0.82 - 0.97)	0.92	(0.80 - 1.05)	0.94	(0.88 - 1.01)	0.9	(0.70 - 1.15)
Stress Recognition	1.28***	(1.15 - 1.43)	1.41*	(1.02 - 1.96)	1.16***	(1.09 - 1.24)	1.16	(0.93 - 1.46)	1.69***	(1.36 - 2.09)	1.56**	(1.15 - 2.11)	0.96	(0.84 - 1.11)	0.95	(0.60 - 1.52)
Nursing Unit Characteristics																
Nursing Hours Per Patient Day	0.86***	(0.82 - 0.91)	0.89**	(0.82 - 0.97)	1.09***	(1.07 - 1.10)	1.07**	(1.02 - 1.12)	0.89***	(0.83 - 0.95)	0.89**	(0.82 - 0.97)	1	(0.96 - 1.04)	1.04	(0.94 - 1.14)
Turnover Rate	0.96	(0.79 - 1.17)	0.86	(0.49 - 1.52)	1.28***	(1.14 - 1.44)	1.14	(0.78 - 1.66)	0.75	(0.50 - 1.13)	0.64	(0.33 - 1.26)	1.41**	(1.09 - 1.83)	1.54	(0.73 - 3.25)
Patient Level Characteristics																
Complexity	2.43***	(2.12 - 2.78)	2.26***	(1.97 - 2.60)	2.06***	(1.91 - 2.24)	2.14***	(1.97 - 2.32)	7.83***	(5.60 - 10.94)	7.69***	(5.46 - 10.84)	4.56***	(3.64 - 5.73)	4.78***	(3.78 - 6.04)
σ2 = variance of random effect for nursing unit			0.795				0.408				0.325				1.416	
ICC			0.195				0.110				0.090				0.301	
	Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic		Ordinary Logistic		Random Int. Logistic	
SAQ Domains	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Teamwork	0.98	(0.92 - 1.04)	0.93	(0.78 - 1.12)	1.04*	(1.00 - 1.08)	1.05	(0.93 - 1.18)	0.78***	(0.70 - 0.88)	0.80**	(0.69 - 0.92)	0.89**	(0.81 - 0.97)	0.78	(0.59 - 1.01)
Stress Recognition	1.32***	(1.18 - 1.47)	1.40*	(1.00 - 1.96)	1.16***	(1.09 - 1.24)	1.18	(0.94 - 1.48)	1.66***	(1.34 - 2.05)	1.55**	(1.19 - 2.03)	0.97	(0.84 - 1.11)	0.94	(0.60 - 1.48)
Nursing Unit Characteristics																
Nursing Hours Per Patient Day	0.88***	(0.84 - 0.93)	0.90*	(0.83 - 0.98)	1.08***	(1.06 - 1.10)	1.07**	(1.02 - 1.12)	0.92*	(0.87 - 0.99)	0.92*	(0.85 - 0.99)	1.02	(0.98 - 1.06)	1.05	(0.96 - 1.16)
Turnover Rate	1.01	(0.83 - 1.23)	0.9	(0.50 - 1.60)	1.23***	(1.10 - 1.39)	1.11	(0.76 - 1.61)	0.77	(0.50 - 1.17)	0.67	(0.37 - 1.22)	1.42**	(1.09 - 1.85)	1.62	(0.78 - 3.37)
Patient Level Characteristics																
Complexity	2.35***	(2.05 - 2.69)	2.25***	(1.96 - 2.59)	2.11***	(1.95 - 2.29)	2.15***	(1.98 - 2.33)	7.59***	(5.41 - 10.65)	7.61***	(5.40 - 10.72)	4.44***	(3.53 - 5.59)	4.74***	(3.75 - 5.99)
σ2 = variance of random effect for nursing unit			0.821				0.397				0.147				1.304	
ICC			0.200				0.108				0.043				0.284	

95% confidence intervals in parentheses
*** $p<0.001$, ** $p<0.01$, * $p<0.05$
ICC = Interclass Correlation Coefficient
Note: Turnover rate has been rescaled and is interpreted as for every 10% increase in the rate.
SAQ Domains have been rescaled to be interpreted as for every 10 unit increase in percent positive agreement.
SAQ=RN Respondents only, ≥ 60% Response Rate

Pearson Correlations

The Results sections of Parts II and III describe the use of Pearson correlations as useful to discerning which variables and should go in the multilevel models. As only one correlation table is shown in each manuscript, **Tables 7, 8, and 9** show the results of the outcomes for which data were not shown.

Unit-Level Characteristics

Responses to the SAQ, nursing hours per patient day, and turnover were aggregated at the nursing unit level. **Table 10** shows lists these characteristics by cost center (nursing unit).

Table 7. Correlation Matrix: Medication Errors

Pearson correlations

Variable	mederr~e	rnhrsppd	xferin~e	turnov~e	term_r~e	teamwo~n	safety~n	morale~n	stress~n	prcpmg~n	wrkcon~n
mederr_rate	1.000	0.702	-0.200	-0.194	0.158	0.164	-0.070	0.081	0.272	0.019	0.082
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
rnhrsppd	0.702	1.000	-0.208	-0.222	0.103	0.340	0.088	0.210	-0.010	0.175	0.017
(p)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.102)	(0.000)	(0.004)
xferin_rate	-0.200	-0.208	1.000	0.923	-0.231	-0.274	-0.326	-0.351	0.109	-0.352	-0.091
(p)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
turnover_rate	-0.194	-0.222	0.923	1.000	-0.376	-0.205	-0.253	-0.321	0.050	-0.320	0.014
(p)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.020)
term_rate	0.158	0.103	-0.231	-0.376	1.000	-0.200	-0.445	-0.377	-0.003	-0.451	-0.389
(p)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.604)	(0.000)	(0.000)
teamwork_rn	0.164	0.340	-0.274	-0.205	-0.200	1.000	0.848	0.847	-0.009	0.757	0.694
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.109)	(0.000)	(0.000)
safety_rn	-0.070	0.088	-0.326	-0.253	-0.445	0.848	1.000	0.845	-0.013	0.909	0.731
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.033)	(0.000)	(0.000)
morale_rn	0.081	0.210	-0.351	-0.321	-0.377	0.847	0.845	1.000	0.071	0.873	0.649
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
stress_rn	0.272	-0.010	0.109	0.050	-0.003	-0.009	-0.013	0.071	1.000	0.111	0.389
(p)	(0.000)	(0.102)	(0.000)	(0.000)	(0.604)	(0.109)	(0.033)	(0.000)		(0.000)	(0.000)
prcpmgt_rn	0.019	0.175	-0.352	-0.320	-0.451	0.757	0.909	0.873	0.111	1.000	0.739
(p)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)
wrkcond_rn	0.082	0.017	-0.091	0.014	-0.389	0.694	0.731	0.649	0.389	0.739	1.000
(p)	(0.000)	(0.004)	(0.000)	(0.020)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

Table 8. Correlation Matrix: Decubitus Ulcer

Pearson correlations

Variable	psi3_r~e	rnhrsppd	xferin~e	turnov~e	term_r~e	teamwo~n	safety~n	morale~n	stress~n	prcpmg~n	wrkcon~n
psi3_rate	1.000	-0.119	0.026	-0.137	0.089	-0.510	-0.366	-0.296	0.328	-0.146	-0.304
(p)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
rnhrsppd	-0.119	1.000	-0.217	-0.225	0.109	0.349	0.095	0.218	-0.080	0.173	0.056
(p)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
xferin_rate	0.026	-0.217	1.000	0.923	-0.231	-0.305	-0.357	-0.370	-0.006	-0.359	-0.132
(p)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.281)	(0.000)	(0.000)
turnover_rate	-0.137	-0.225	0.923	1.000	-0.377	-0.220	-0.263	-0.315	0.005	-0.315	-0.000
(p)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.440)	(0.000)	(0.988)
term_rate	0.089	0.109	-0.231	-0.377	1.000	-0.151	-0.396	-0.361	-0.011	-0.425	-0.305
(p)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.059)	(0.000)	(0.000)
teamwork_rn	-0.510	0.349	-0.305	-0.220	-0.151	1.000	0.858	0.857	0.036	0.734	0.711
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
safety_rn	-0.366	0.095	-0.357	-0.263	-0.396	0.858	1.000	0.859	-0.028	0.892	0.743
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)
morale_rn	-0.296	0.218	-0.370	-0.315	-0.361	0.857	0.859	1.000	0.105	0.882	0.673
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
stress_rn	0.328	-0.080	-0.006	0.005	-0.011	0.036	-0.028	0.105	1.000	0.053	0.352
(p)	(0.000)	(0.000)	(0.281)	(0.440)	(0.059)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)
prcpmgt_rn	-0.146	0.173	-0.359	-0.315	-0.425	0.734	0.892	0.882	0.053	1.000	0.744
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)
wrkcond_rn	-0.304	0.056	-0.132	-0.000	-0.305	0.711	0.743	0.673	0.352	0.744	1.000
(p)	(0.000)	(0.000)	(0.000)	(0.988)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 9. Correlation Matrix: Post-operative Pulmonary Embolism/Deep-Vein Thrombosis

Pearson correlations

Variable	psi12_~e	rnhrsppd	xferin~e	turnov~e	term_r~e	teamwo~n	safety~n	morale~n	stress~n	prcpmg~n	wrkcon~n
psi12_rate	1.000	0.152	0.314	0.278	-0.127	-0.294	-0.310	-0.228	0.084	-0.270	-0.085
(p)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
rnhrsppd	0.152	1.000	-0.217	-0.225	0.109	0.349	0.095	0.218	-0.080	0.173	0.056
(p)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
xferin_rate	0.314	-0.217	1.000	0.923	-0.231	-0.305	-0.357	-0.370	-0.006	-0.359	-0.132
(p)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.281)	(0.000)	(0.000)
turnover_rate	0.278	-0.225	0.923	1.000	-0.377	-0.220	-0.263	-0.315	0.005	-0.315	-0.000
(p)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.440)	(0.000)	(0.988)
term_rate	-0.127	0.109	-0.231	-0.377	1.000	-0.151	-0.396	-0.361	-0.011	-0.425	-0.305
(p)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.059)	(0.000)	(0.000)
teamwork_rn	-0.294	0.349	-0.305	-0.220	-0.151	1.000	0.858	0.857	0.036	0.734	0.711
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
safety_rn	-0.310	0.095	-0.357	-0.263	-0.396	0.858	1.000	0.859	-0.028	0.892	0.743
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)
morale_rn	-0.228	0.218	-0.370	-0.315	-0.361	0.857	0.859	1.000	0.105	0.882	0.673
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
stress_rn	0.084	-0.080	-0.006	0.005	-0.011	0.036	-0.028	0.105	1.000	0.053	0.352
(p)	(0.000)	(0.000)	(0.281)	(0.440)	(0.059)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)
prcpmgt_rn	-0.270	0.173	-0.359	-0.315	-0.425	0.734	0.892	0.882	0.053	1.000	0.744
(p)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)
wrkcond_rn	-0.085	0.056	-0.132	-0.000	-0.305	0.711	0.743	0.673	0.352	0.744	1.000
(p)	(0.000)	(0.000)	(0.000)	(0.988)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 10. Unit-Level Characteristics by Cost Center (Nursing Unit)

CC	INJ_count	INJ_rate	RN_denom	RNhrsPPD	XFERin_rate	Turnover_rate	Term_Rate	Teamwork_RN	Safety_RN	Morale_RN	Stress_RN	Prcpmgt_RN	Wrkcond_RN
264	0	0.00	25.50	9.94	0.00	0.12	0.12	87.94	84.25	79.55	67.90	77.65	79.26
265	6	0.20	30.10	12.15	0.03	0.13	0.07	74.55	74.53	78.93	71.65	68.45	76.19
266	3	0.15	20.55	7.00	0.15	0.00	0.24	66.06	71.96	56.67	71.53	52.78	60.53
295	5	0.35	14.15	7.01	0.28	0.00	0.35	74.31	68.35	79.69	76.74	59.03	65.10
305	2	0.12	16.62	6.65	0.30	0.00	0.24	75.88	79.70	68.68	76.64	69.41	75.00
341	0	0.00	13.67	0.00	0.22	0.07	0.15	66.67	75.43	70.56	55.90	59.49	63.43
432	1	0.13	7.45	8.21	0.13	0.00	0.27	90.76	87.65	84.38	67.19	70.31	76.04
491	5	0.39	12.88	4.92	0.16	0.08	0.08	45.51	61.68	42.31	80.77	46.63	54.33
665	0	0.00	56.60	11.88	0.00	0.00	0.30	76.36	73.52	65.69	67.26	50.31	58.76
683	1	0.03	35.90	10.75	0.06	0.03	0.25	75.00	73.81	64.20	74.87	57.89	67.80
704	3	0.18	16.70	8.74	0.00	0.12	0.00	85.42	85.71	90.83	78.65	82.47	83.33
717	3	0.04	71.35	21.32	0.01	0.00	0.11	86.54	81.22	79.93	70.04	67.13	75.46
730	8	0.17	46.32	23.84	0.13	0.00	0.24	78.52	74.55	72.47	77.50	69.38	73.96
731	8	0.19	43.17	22.78	0.44	0.12	0.09	88.46	80.33	80.19	69.71	71.39	76.04
745	0	0.00	5.90	5.17	0.00	0.00	0.41	60.26	66.03	59.88	63.59	50.21	66.88
762	2	0.15	12.92	12.99	0.00	0.00	0.15	90.28	83.63	76.25	71.88	77.60	80.21
798	2	0.08	24.80	11.07	0.12	0.00	0.16	87.10	83.45	87.62	69.94	75.60	72.02
835	0	0.00	19.75	6.86	0.10	0.00	0.10	86.91	83.33	82.16	59.40	66.39	72.80
836	0	0.00	18.50	5.10	0.05	0.05	0.05	82.10	83.54	85.17	75.57	67.46	74.07
838	1	0.08	12.75	4.87	0.08	0.08	0.24	84.40	83.73	85.83	77.43	71.18	75.81
843	0	0.00	14.75	5.82	0.07	0.07	0.00	76.70	81.28	79.38	70.92	68.23	71.79
850	4	0.07	60.85	24.24	0.05	0.00	0.08	72.99	73.91	79.15	74.03	65.63	68.53
872	5	0.16	31.55	7.79	0.03	0.03	0.13	85.83	87.23	84.81	81.00	75.24	83.41
927	2	0.08	25.60	7.90	0.08	0.04	0.08	74.05	81.66	74.55	60.61	71.12	64.20
931	0	0.00	14.00	7.89	0.00	0.00	0.21	75.38	74.40	66.65	57.74	52.94	64.49
943	7	0.25	28.05	4.85	0.07	0.14	0.29	68.17	68.75	53.02	71.88	43.11	68.34
944	3	0.43	7.00	5.77	1.43	1.43	0.00	68.17	68.75	53.02	71.88	43.11	68.34
945	0	0.00	2.85	5.74	0.00	0.35	0.00	83.42	82.45	81.25	64.46	72.14	76.39
957	1	0.03	34.32	14.17	0.15	0.03	0.09	73.93	66.97	73.25	75.00	48.21	58.93
965	6	0.24	25.47	8.41	0.12	0.08	0.16	66.86	71.81	62.27	71.31	55.97	71.02

Curriculum Vitae

Jennifer Ann Taylor

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Education

Johns Hopkins Bloomberg School of Public Health, Baltimore, MD 2003-present
Ph.D. Candidate - Department of Health Policy and Management
Health and Public Policy Track: Specialization in Injury Prevention and Control

Research Areas: Patient safety, quality improvement, healthcare workforce culture, injury epidemiology

Dissertation Topic: "Utility Of Patient Safety Case Finding Methods And Correlations Among Organizational Safety Climate, Nurse Injuries, And Errors."

Awards

- The William Haddon, Jr. Fellowship in Injury Prevention, 2003
- National Institute of Occupational Safety and Health (NIOSH) Training Fellowship in Occupational Injury, 2003-present
- NIOSH Pilot Project Training Award from the Johns Hopkins Bloomberg School of Public Health, Environmental Health Sciences Education and Research Center (ERC), 2005-present. Project Title, "Injuries in the Nursing Workforce: Are the Same Cultural Risk Factors Putting Patients at Risk?"

Teaching Assistant Experience

- Introduction to the US Healthcare System, Instructor: Christopher Forrest
- Medical Errors and Patient Safety, Instructors: Albert Wu, Laura Morlock, Peter Pronovost
- Graduate Seminar in Injury Research and Policy, Instructor: Susan Baker
- Summer Institute in Injury Prevention and Control, Instructor: Professor Carolyn Fowler

Service

- Academic Policy and Curriculum committee

Education (continued)

Boston University School of Public Health, Boston, MA 1996-1999
MPH, Health Services

Service

- Strategic Planning Committee, Student Representative
- DrPH Committee, Alumni Representative

Albright College, Reading, PA 1985-1989
BS, Biochemistry

Professional Experience

New Hampshire Department of Health and Human Services, Concord, NH 2000-2003
Bureau Chief - Health Statistics and Data Management
Office of Community and Public Health: Division of Epidemiology and Vital Statistics
Grants and contracts:

1. Project Director, CORE Injury Surveillance Cooperative Agreement, Centers for Disease Control and Prevention (CDC) grant
   - CCU17/CCU122372, $76,734 awarded 2002
2. Project Director, Behavioral Risk Factor Surveillance System (BRFSS), CDC grant
   - CCU58/CCU58102103, $158,426, awarded 2000, 2001, 2002
3. Project Director, National Program of Cancer Registries CDC grant
   - CCU75/CCU118722, $489,249, awarded 2000, 2001, 2002
4. Co-Project Director, Empowering Communities with Data, New Hampshire Endowment for Health
   - $85,000 awarded 2001, 2002
5. Co-PI, New England Bladder Cancer Study, National Cancer Institute (NCI), 2001-2002
6. Co-PI, New Hampshire Access Project (coordinated with Dartmouth College), 2002

Massachusetts Department of Public Health, Boston, MA 1998-2000
Project Director - Emergency Department Surveillance and Coordinated Injury Prevention
Bureau of Health Statistics, Research and Evaluation: Injury Surveillance Program

New England Medical Center, Boston, MA 1996-1997
Outcomes Project Associate - Quality Support Services: Department of Outcomes Analysis and Improvement

ARIAD Pharmaceuticals, Cambridge, MA 1992-1996
Research Associate - Allergy/Immunosuppression Group

Professional Experience (continued)

University of Pennsylvania, Philadelphia, PA 1991-1992
Research Assistant - Signal Transduction Molecular Biology

The Wistar Institute, Philadelphia, PA 1990-1991
Research Assistant - Multiple Sclerosis Molecular Biology

Alternative Ways, Inc., Belmar, NJ 1989-1990
Electron Microscopist - Environmental consulting

Memberships

American Public Health Association 1996-present
Co-Chair, Data Committee - Injury Control and Emergency Health Services Section

Academy Health 2004-present

Conference Presentations and Invited Talks

"Establishing an Evidence-based Emergency Department Patient Safety Research Program." Drexel University School of Medicine, May 2006.

"Investigating Rural Health Issues in New Hampshire Using BRFSS." Porter J, Taylor J, Chalsma A, Horne J, Ayars B, Turer E. Poster presentation, 20th Annual BRFSS Conference; St. Louis, MO, March 2003.

"Building a Case for Unique Identifiers: The Potential of Linked Data in Health Services Research" at the National Association of Health Data Organizations Annual Meeting, Atlanta, GA, December 2002.

"Statistical Issues in Community Health Indicators" at the American Public Health Association's Annual meeting, November, 2002

"Data Assessment for Adolescent Health" at the New Hampshire Adolescent Health Summit, June 2002.

"The state of New Hampshire's Cancer Registry" at the Cancer Registrars Association of New England meeting, November 2001.

"Investigation of Adverse Effects in New Hampshire" at the American Public Health Association's Annual meeting, October 2001.

Conference Presentations and Invited Talks (continued)

"A New Data Release Policy" at the New Hampshire Turning Point Executive Committee and Data Subcommittee, August, 2001.

"The New Hampshire State Cancer Registry" at the New Hampshire Commission to Study the Relationship between Public Health and the Environment, August, 2001.
"How Data Supports Program Development" at the New Hampshire Minority Health Data Symposium, December, 2000.

"How To Establish An Injury Surveillance Program In Your State: three state describe their unique paths" at the American Public Health Association's Annual meeting, November 2000.

"Using Data for Grant Writing and Advocacy" at the Massachusetts Violence Prevention Task Force, May 1999

"Health Statistics Jeopardy" at the Massachusetts Ounce of Prevention Conference, November 1999

Peer-Reviewed Publications

1. **Taylor, J.A.,** Karas, J., Green, O.M., and Seidel-Dugan, C. Activation of the high-affinity immunoglobulin E receptor FcERI in RBL cells is inhibited by SYK SH2 domains. Molecular and Cellular Biology, 1995 August, 15(8): 4149-4157.

2. Weng, Z., Thomas, S., Rickles, R., **Taylor, J.A.,** Brauer, A., Seidel-Dugan, C., Michael, W., Dreyfuss, G., Brugge, J.S. Identification of Src, Fyn, and SH3 binding proteins: implications for a function of SH3 domains. Molecular and Cellular Biology, 1994 July, 14(7): 4509-4521.

3. Rickles, R., Botfield, M.C., Weng, Z., **Taylor, J.A.**, Green, O.M., Brugge, J.S., and Zoller, M.J. Identification of Src, Fyn, Lyn, PI3k, and Abl domain ligands using phage display libraries. EMBO Journal, 1994, 13(23): 5598–5604.

4. Weng, Z., **Taylor, J.A.,** Turner, C., Brugge, J.S., Seidel-Dugan, C. Detection of Src homology 3-binding proteins, including paxillin, in normal and v-src-transformed balb/c 3T3 cells. Journal of Biological Chemistry, 1993 July, 268: 14956-14963.