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# Effects of Staffing and Expenditure Variables on After Surgery Patient Safety in Florida Hospitals

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EFFECTS OF STAFFING AND EXPENDITURE VARIABLES ON AFTER  
SURGERY PATIENT SAFETY IN FLORIDA HOSPITALS

By

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A thesis submitted in partial fulfillment  
of the requirement for the degree of  
Master's of Science in Public Health  
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Effects of staffing and expenditure variables  
on after-surgery patient safety in Florida hospitals

Shaila Khuspe

ABSTRACT

**Objective:** To investigate the association between hospital investment in human resources variables and patient safety, specifically after surgery adverse events in Florida hospitals. We performed the analysis to identify the association of after surgery complication rates with full time equivalent employees (FTEs) per admission and per patient day, expenses per admission and per patient day and, the percent of total operating expense accounted for by payroll expenses.

**Design:** A cross sectional analysis using inpatient hospital discharge data and financial data from seventy short-term general hospitals, both for-profit and not-for-profit.

**Methods:** Discharge data from year 2000 was obtained from Agency for Health Care Administration (AHCA). This data was used to calculate Agency for Healthcare Research and Quality (AHRQ) Patient Safety Indicators (PSIs) related to after surgery complications in 840,945 hospital discharge records from 70 short-term general hospitals across the state of Florida. The predictor variables include: payroll expenditures per admission, payroll expenditures per patient day, personnel (FTE) per admission, personnel (FTE) per patient day and payroll expense as a percent of total operating expenses.

Main outcome measures: Nine patient safety indicators defined by AHQR and specific to after surgery complications: complications of anesthesia, foreign body left during procedure, postoperative hemorrhage or hematoma, postoperative physiologic and metabolic derangement, postoperative pulmonary embolism or deep vein thrombosis, postoperative respiratory failure, postoperative sepsis, postoperative wound dehiscence.

Results: Patient safety indicator rate showed an inverse relationship with the percent of total operating expense represented by payroll, Personnel per patient day and personnel per admission. The patient safety indicators showing significant relationship with hospital human resource characteristics are postoperative hemorrhage or hematoma ( $p=0.0002$ ), postoperative hip fracture ( $p<0.0001$ ), postoperative physiologic and metabolic derangement ( $p<0.0012$ ), postoperative pulmonary embolism and deep vein thrombosis ( $p=0.0008$ ), postoperative respiratory failure ( $p<0.0001$ ), and postoperative sepsis ( $p=0.0371$ ).

Conclusion: Human resource investment is positively related to favorable outcomes, although the effect varies across the type of outcomes.

## Chapter one

### Introduction

Hospital care is the most costly component of the American health care system. For the past 20 years, substantial efforts by managed care have succeeded in reducing hospitalization rates. Redesigning and restructuring the workforce has been one of the means to reduce hospital costs as a response to changing patterns of care. This dangerous tradeoff of poor quality of care resulting from fewer resources has shaken the grounds for managed care and market forces.(Baer, 1996; Beurhaus, 1996; Bodenheimer, 1996)

Labor costs contribute about 55% of the total spending in a typical hospital budget. Strategically downsizing the workforce and utilizing less intensively trained personnel has been a matter of discussion (Rosenthal, 1997). Previous work shows an inverse relationship between nurse staffing and selected adverse events hypothesized to be sensitive to nursing care while controlling for other hospital characteristics. (Kovner, 1998; Kovner C, 2002) A few other studies have explored the relationship among hospital characteristics such as ownership, size, location, financial status, physician competency, teaching status and avoidable adverse events. (Al-Haider, 1991; Brennan T.A., 1991; Flood, 1982; Kelly, 1986; Palmer, 1979; Scott, 1976; Shortell, 1976) Most of these studies involve patient mortality and morbidity as an outcome variable.(Al-Haider, 1991; Scott, 1976) Other studies have considered excess length of stay and increased service charges as outcomes of interest. (Zhan, 2003) Though the primary aim of all these

studies involves determining the quality of care provided by different hospitals, the use of unbiased and valid outcome variables is a controversial issue. Researchers have started paying more attention to patient safety issues after release of the Institute of Medicine report on increased patient safety concerns. (Kohn, 1999)

The former Health Care Financing Administration (HCFA), now the Centers for Medicare and Medicaid Services (CMS), released a list of hospitals having significantly higher and lower mortality rates than national average values each year. According to this report, the rate of mortality for selected inpatient hospital admissions was considered a measure of quality of care. Such a measure is controversial since mortality is considered as only one of the treatment outcomes during patient's stay in hospital. A major subset of these hospitalizations includes the period after surgery when the patient may face maximum threat for infections and adverse events. The variation in post-surgical adverse events during hospital stay could be correlated with one of the three variable categories: patient characteristics, hospital organizational characteristics and community factors. In literature, researchers have emphasized patient characteristics but less attention have been paid to hospital characteristics, particularly those financial indicators of the human resources invested in the process of patient care. For the purpose of this research, we will evaluate the association of various measures of human resource investment in hospitals and avoidable adverse events after surgery.

#### Related Research

Research conducted by Kovner and Gergen studied nurse staffing across a set of 506 hospitals from 10 states, to determine its impact on avoidable adverse events - nurse sensitive and non-nurse sensitive. They found an inverse relationship between nurse

staffing and three of the four nurse sensitive adverse events. There was a less significant relationship between nurse staffing and one of the non-nurse sensitive adverse events. Also the hospitals showed a considerable variation between Full Time Equivalent (FTE) Registered Nurses (RN) to total adjusted patient days and FTE non-RN.

Kelly and Hellinger examined the relationship of hospital and surgeon volume for specific surgical procedures as well as other characteristics like patient severity of illness, patient age, hospital control, teaching status, size and location and patient mortality rates. Results are consistent with the previous research in that after surgery patient mortality rates are inversely proportional to the volume of that specific procedure for a given hospital. They also found out that geographical location does not have any significant influence on mortality rates. Teaching status gave conflicting relationships for different hospitals, which was attributed to the variation in definition of a teaching status hospital. Although teaching status was of less importance, the number of interns and residents showed a negative relationship with mortality rates. Hospital size and number of beds were found to be positively related to the mortality suggesting the need to have larger hospitals with fewer types of services and more volume per service provided to provide quality of care needed. Another alternative explanation for this finding is case-mix, i.e. larger hospitals admit sicker patients. Private nonprofit hospitals in urban area showed less probability of dying after surgery than their counterparts in rural areas and for profit institutions.

Brennan et al. found results, which differ somewhat from the Kelly and Hellinger study. The primary teaching hospitals in New York State were likely to have higher adverse event rates than other non-teaching ones and so were the rural hospitals.

However, the adverse events due to negligence remain lower in teaching hospitals and for profit hospitals. The hospitals with higher percentage of minority patient discharge showed significantly higher rates of negligible adverse events.

Another study of association between mortality rates and hospital characteristics, conducted in 1989 by Hartz et al, confirmed significant relationship between for profit hospitals and increased mortality rates. Private teaching hospitals showed lower mortality rates than private non-teaching hospitals. Adjusted mortality rates were lower in upper fourths than in lower fourths when different hospital characteristics like percentage of board-certified specialists, occupancy rate, payroll expense per hospital bed and percentage of registered nurses were considered.

A recent study published in October 2003 by Zhan and Miller evaluated the association between medical injuries during hospitalization and excess length of stay, charges, and mortality. Researchers used the data from inpatient discharge datasets and evaluated Patient Safety Indicators (PSIs) – as defined by Agency of Healthcare Research and Quality (AHRQ) – using AHQR software for quality indicators. Though the study uses these PSIs as independent variables unlike our analysis, the rationale behind using PSIs as a measure for quality of care remains the same.

Measuring patient safety during hospitalization is becoming a major component of the quality of care. The Agency for Healthcare Research and Quality (AHRQ) has developed a system to identify these adverse events during the patient's hospital stay. These quality indicators are classified into three types of indicators. The quality indicators of our interest are termed as Patient Safety Indicators (PSI). The technique has been made to use simple administrative data to yield valuable information about the

increasing number of avoidable complications during hospitalization. These are mainly surgery related indicators, which have been supported by literature and recommended by skilled medical professionals to be considered as avoidable, however debate over their definition and validity continues. Peer reviewed papers using the AHRQ PSIs are now appearing in the published literature. (Zhan, 2003)

#### Research Question and Hypothesis

Based on literature findings, we attempted to explore the association and its strength between patient safety indicators as defined by AHRQ and the hospital investment in the human resource component of its services. Our research question thus becomes “Is the patient safety - in terms of adverse events after surgery – associated with the relative amount of hospital resources expended on payroll relative to total expenses or per discharge or patient day?” The independent variables we are using represent the hospital resources in terms of personnel working, total expense and payroll expense. One of the types of variables is absolute dollar per unit (per admission and per patient day). Second type is number of personnel working equivalent to full time equivalents per unit (per admission and per patient day). Hospital spending and staff has been proved to be associated with adverse events in the past. Calculating these variables with respect to hospital admission or hospital work force makes them a better predictor of hospital outcome. Further, concentrating on the expenditure variable, the expense of hospital human resource relative to the total expense can be an important predictor and thus our area of interest.

### Importance of study

A series of reports published by Institute of Medicine has suggested that it is necessary to assess, monitor, track and improve the patient safety during medical care. (Kohn, 1999) Medical adverse events during hospitalization are under reported and are not frequently researched because of their variety of nature and lack of agreement as to what is called as avoidable adverse event. Clinical data on hospital discharges is one of the sources to obtain information about medical complications. Administrative type of data is the most convenient and while limited, promising source for insight into occurrence rates for medical adverse events. Another approach to this issue is self-reporting of the event. Around twenty US states mandate reporting of serious adverse events, but the data has been strictly guarded from researchers and the general public.

Likewise the ever-increasing commercialization and complexity of health care sector requires some attention from researchers to associate the changing characteristics of caregivers to quality of care.

Medical complications occur during all stages of medical care. The categorization of such complications remains a debatable issue. While medication errors and injuries contribute towards the larger fraction of these adverse events, surgery related complications are the uncommon ones and therefore less frequently investigated. Our study population constitutes people living in Florida, which has a disproportionately elderly population. Surgical complications are therefore of major importance for this susceptible age strata.

## Limitations and delimitations

Use of AHRQ quality indicators to predict the patient safety and thus quality of care is subject to many limitations. The identification of the adverse event is primarily done based on ICD-9 code of the condition. These are frequently underreported and; therefore, do not have a known frequency.(Romano P.S., 1994) Also while reporting such a complication, its occurrence in terms of time is not stated in clinical data, which makes the PSI calculation more clinically obscure.

Although these factors make the PSI calculation more difficult to interpret, it is the most sophisticated technique to date for identifying the preventable adverse events based on administrative data. The SAS software is so designed as to adjust for all demographic characteristics of patients such as age, gender, and severity of the disease at the time of admission.(AHRQ, 2003b) The co-morbidity categories are defined and applied to the discharge data for accurate categorization of any complication related to a particular procedure.

An important limitation is the nature of the independent variables, which are used to represent the hospital's overall investment in human resources devoted to patient care. Both absolute dollars and the proportion of personnel to total expenses are proxy measures of more sensitive indicators such as number, training, organization and leadership of patient care staff. Aside from the magnitude and proportion of personnel allocated resources, these other factors are likely contributors to the overall quality of patient care and therefore the likelihood of post surgical adverse events.

## Chapter Two

### Methods

#### Data and Variables

The main source of our data was AHCA inpatient discharge dataset for year 2000 from the state of Florida. We identified the general short-term hospitals, which were not government owned, and were present in the financial dataset from AHCA. Seventy (70) hospitals, which reported data to AHCA, were included in the analysis. This sample of hospitals reported 840,945 discharge records for year 2000 and was analyzed for its clinical characteristics. The discharge dataset consisted of information about demographic characteristics of patient, source and type of admission, length of stay (LOS), total charges, diagnosis related groups (DRGs), 10 diagnosis codes and 10 procedure codes, etc. Financial data from AHCA was used to obtain total admissions for each hospital and other characteristics like patient days, full-time-equivalents (FTEs), total expense on operating services per hospital and total operating payroll expense. Based on this administrative data we calculated our independent variables to appropriately depict the staff and payroll expenditure status of each hospital. Variables calculated to provide staffing information for each hospital were FTEs per admission and FTEs per patient day. Adding the acute and sub acute patient information for admissions and patient days yielded total admissions and patient days to be considered for staffing variables. The payroll expenditure variables were calculated in terms of total expenditure

per admission, total expenditure per patient day and percentage of total expense to be paid towards operating payroll. Our independent variables are created to reflect unbiased estimate of staffing and payroll variables. Calculating the variables per admission and per patient day standardizes the hospital performance in terms of variation in patient stay at hospital and patient flow for that year. Another confounding factor in this dataset is the hospital bed size which influences the staffing and total as well as payroll expense. Patient safety indicators, as outcome variables, were calculated according to AHRQ quality indicators. Agency of Healthcare Research and Quality defines patient safety indicator as “Quality indicators, which focus on potentially preventable instances of complications and other iatrogenic events resulting from the exposure to the healthcare system”. These quality indicators screen for preventable problems that a patient comes across at system or provider level. They were developed by the University of California-Stanford Evidence-Based Practice Center, with funding and collaboration from the AHRQ. (University of California, 2002) Initially, the literature was reviewed to develop an indicators list and to collect information about their validity and reliability. Later, all of these indicators were reviewed and revised by a panel of skilled clinicians to evaluate their clinical sensibility. ICD-9-CM coding experts were consulted to ensure that the definition of each indicator reflected the intended clinical situation. Promising indicators were analyzed using Healthcare Cost and Utilization Project data. Finally, PSI software was conducted using Healthcare Cost and Utilization Project data. This five-step process was concluded by release of PSI software and documentation for public by AHRQ. (Zhan, 2003)

This software detects incidence of complication at any secondary diagnosis code and thus reflects a patient safety indicator event. Two types of PSI as defined by AHRQ are provider level and area level. For the purpose of our study, the provider or hospital level indicators were calculated using the SAS software developed by AHRQ (AHRQ, 2003). In our analysis we used the numerator value of PSI calculation calculated by AHRQ software, which is the number of cases per 1000 admissions for a given hospital. Further the software calculates denominator, which is number of matched cases from population at risk to yield observed and smoothed rates. For the purpose of our study, the occurrence of adverse event is of primary importance since we have included small number of hospitals from one state only. Moreover the denominator for each PSI has different inclusion and exclusion criteria, which makes it difficult to compare different PSIs. The number in our dataset is a measure of prevalence of the complication after surgery in hospital and gives the burden of surgery related complications on admissions from that hospital.

To assess the association of hospital personnel budget resources to patient safety, we identified the outcomes that are associated with the surgical complications. They include complications of anesthesia, foreign body left during procedure, postoperative hemorrhage or hematoma, postoperative physiologic and metabolic derangement, postoperative pulmonary embolism or deep vein thrombosis, postoperative respiratory failure, postoperative sepsis, postoperative wound dehiscence. The predictor variables include hospital resource variables - payroll expenditure per admission, payroll expenditure per patient day, personnel (FTE) per admission, personnel (FTE) per patient day and percentage of total expense paid toward payroll.

## Analytical Approach

Addressing potential confounders was a major challenge while identifying adverse events attributed to after surgery hospital stay of patients. Our first attempt was to adjust for hospital bed size, which had proved to be affecting hospital outcomes in previous research. Introducing the bed-size variables into our models adjusted for the confounding present due to hospital size as our dataset contained hospitals with varying capacity of beds and bed-size is proved to be an important predictor of hospital performance in past research. Using AHRQ patient safety indicator software for identifying the adverse events helped adjust the outcome for age, race, sex and severity of disease.

The main aim of our study is to look at the nature of association between hospital administrative characteristics and selected complication rates among surgery patients during hospitalization. Statistical methods used to determine these relationships are correlation and multiple regressions. Individual regression models for each outcome variable were run using PROC REG to determine the most significant independent variable. This model was then considered for various interaction combinations to see the effect on regression coefficient. Bed-size was introduced in all the models to control for the hospital size. Data transformation was attempted by log transforming the data but was not included in analysis as the results were not significantly different after the transformation.

## Chapter Three

### Results

There was large variation among the PSI rates ranging from zero to 142 complications per 1,000 admissions for individual hospitals with the combined mean complication rate of 6.31 per 1,000 admissions. The commonest complication was shown to be postoperative respiratory failure with total of 2,250 cases across 70 hospitals and foreign body left during procedure being the least frequent complication with total of 59 cases. The total number of admissions in the sample of 70 hospitals was 840,945 with total of 4,538 surgery related complications. Figure 1 shows the total PSIs per 1,000 discharge records in 70 hospitals included in our analysis.

Figure 1: Distribution of patient safety indicators in 70 hospitals across Florida

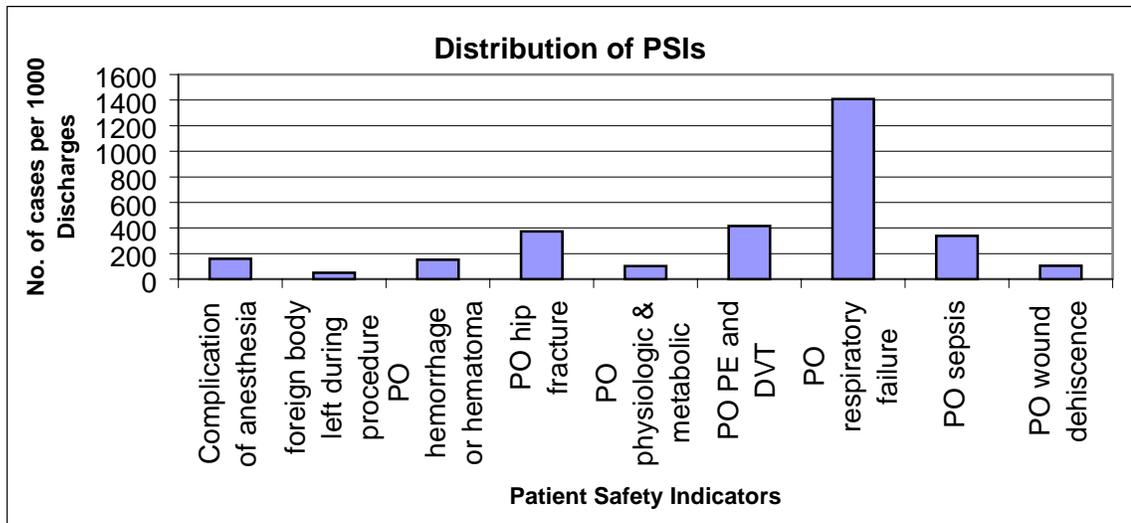


Table 1 and Table 2 show the descriptive statistics of predictor and outcome variables.

Table 1: PSI characteristics across seventy hospitals in Florida

Patient Safety Indicator	Mean (Rate per 1000 admissions)	Standard Deviation
Complication of anesthesia	2.88	3.33
Foreign body left during procedure	0.84	1.01
Postoperative hemorrhage or hematoma	1.88	1.83
Postoperative hip fracture	6.58	6.54
Postoperative physiologic and metabolic derangement	2.97	3.91
Postoperative pulmonary embolism and deep vein thrombosis	9.40	10.62
Postoperative respiratory failure	34.14	29.30
Postoperative sepsis	7.17	9.27
Postoperative wound dehiscence	1.64	2.12

Table 2: Hospital characteristics across seventy hospitals in Florida

Hospital resource variables	Mean	Standard Deviation
Total Admissions	12,013	10,130
Salary and wages for operating processes	\$ 27,443,493	\$ 27,957,568
Total operating cost	\$ 56,795,274	\$ 56,241,189
Full Time Equivalent for operating processes (FTEs)	7080	7132.1
Patient day	60862	52560
FTEs per patient day	0.00011	0.00002
FTEs per admission	0.59	0.36
Expense per patient day	\$ 883.57	\$ 225.84
Expense per admission	\$ 4527.52	\$ 1313.36
Percentage of total expense to be accounted for by salary	0.4887	0.0665

The hospitals were categorized based on bed size to control for confounding effects. Number of licensed beds in year 2000, obtained from AHCA financial dataset, was used to categorize the hospitals into small ( $\leq 150$  licensed beds), medium ( $> 150$ ,  $\leq 300$  licensed beds) and large ( $> 300$  licensed beds). Figure 1 gives the distribution of hospitals in three strata.

Figure 2: Distribution of Hospitals based on Bed size

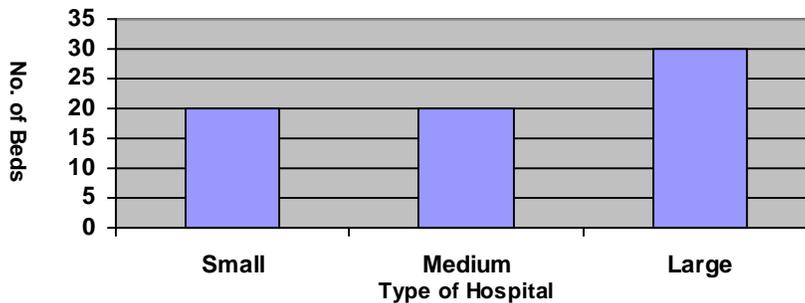


Table 3 shows means of all the hospital variables for all stratification levels. The bed size (small, medium and large) and hospital control as not-for-profit, investor owned (for-profit) and hospital district are the stratification levels for our analysis. Stratification of dataset based on hospital type and hospital control shows not much difference among the means of independent variables. The t-test for differences in means for different stratification levels fails to give significant results for all the variables (p value = 0.2). This non-significant p-value suggests that stratification at bed size level do not have much effect on the independent variables.

Table 3: Means of Independent variables for all stratification levels

Hospital resource variables	Small bed size	Medium bed size	Large bed size	Not-for-profit	Investor Owned	Hospital District
FTEs per patient day	0.8123	0.9161	0.9093	0.9196	0.7926	1.0484
FTEs per admission	4.3774	4.3510	4.7452	4.5818	4.3131	5.0470
Total expense per patient day	104.96	103.74	119.3	121.49	92.31	129.71
Total expense per admission	662.51	492.13	620.69	610.23	570.53	623.85
% of total expense for payroll	0.5185	0.447	0.4966	0.4978	0.4755	0.4961

There was a strong correlation among nine PSIs except between postoperative wound dehiscence and three other complications i.e. complications of anesthesia ( $r^2 = 0.0718$ ,  $p=0.5546$ ), foreign body left during procedure ( $r^2 = 0.0407$ ,  $p=0.7379$ ) and postoperative physiologic and metabolic derangement ( $r^2 = 0.1326$ ,  $p=0.2737$ ) and between complications of anesthesia and foreign body left during procedure ( $r^2 = 0.1614$ ,  $p=0.1819$ ). The independent variables in our study also showed strong correlation among themselves with few non-significant associations. Personnel per patient day were not significantly correlated with personnel per admission ( $r^2 = -0.0160$ ,  $p=0.8953$ ), dollars per admission ( $r^2 = 0.1227$ ,  $p=0.3114$ ) and percent of total operating expense to be paid for payroll ( $r^2 = -0.0380$ ,  $p=0.7547$ ). Dollars per admission and percent of total operating expense to be paid for payroll were also non-significantly correlated with each other ( $r^2 = 0.0901$ ,  $p=0.4580$ ).

Correlation of dependent and independent variables is shown in table 4. This explains the strength and direction of association between the variables. Here percentage of operating expense paid towards payroll shows consistently negative correlation with all the patient safety indicators. Although non-significant, correlation coefficients suggest that there is an inverse relationship between adverse effects and hospital investment in human resource.

Table 4: Correlational matrix of all dependent and independent variables

Patient Safety Indicator	Personnel per patient day	Personnel per admission	Expense per patient day	Expense per admission	% of expense towards payroll
Complication of anesthesia	0.1719	-0.0714	0.2251*	0.0368	-0.1440
Foreign body left during procedure	-0.0636	-0.0983	0.1520	0.0951	-0.2058
Postoperative hemorrhage or hematoma	0.0239	-0.0885	0.1737	0.1336	-0.1517
Postoperative hip fracture	0.2401*	-0.0388	0.4153*	0.2429*	-0.2368*
Postoperative physiologic and metabolic derangement	0.2063	0.0175	0.2858*	0.2476*	-0.2082
Postoperative pulmonary embolism and deep vein thrombosis	0.1159	-0.0495	0.2137	0.1394	-0.1851
Postoperative respiratory failure	0.23822*	-0.0004	0.2971*	0.2537*	-0.1423
Postoperative sepsis	0.0964	-0.0480	0.1773	0.1119	-0.1423
Postoperative wound dehiscence	0.2034	-0.0038	0.2631*	0.1845	-0.0141

Note: Values denoted by star are significant

Table 5 and 10 show statistical estimates showing relationship between PSIs and hospital characteristics. While overall models in analysis show statistically significant values, the individual variables have non-significant parameter estimates suggesting that the administrative and human resource variables together as well as their interaction with each other explains the variability in patient safety more than individual variables. Bed size proves to be highly significant predictor of patient safety indicators. The  $R^2$  values are reported in table 4 showing overall model with all the five predictor variables and bed-size as controlling variable. We see a significant increase in  $R^2$  after entering bed-size into the model, which suggests that variability in adverse events is more explained

by hospital characteristics after categorizing the hospitals base on their bed size. Though all the PSIs don't show this relationship, we can argue that the complexity of reporting process and rarity of event might be the explanation for it.

Table 5: Association between PSIs and all hospital characteristics\*

Patient Safety Indicators	Full Model Estimates
Complications of anesthesia	0.1627 (0.0883)
Foreign body left during procedure	0.1039 (0.3400)
Postoperative hemorrhage and hematoma	0.3424 (0.0002)
Postoperative hip fracture	0.4451 (<0.0001)
Postoperative physiologic and metabolic derangement	0.2997 (0.0012)
Postoperative pulmonary embolism and deep vein thrombosis	0.3091 (0.0008)
Postoperative respiratory failure	0.5102 (<0.0001)
Postoperative sepsis	0.1946 (0.0371)
Postoperative wound dehiscence	0.1564 (0.1039)

\*Note: Reported model estimates are R<sup>2</sup> values and p-values (in parenthesis)

Tables 6 to 11 give the parameter estimates, standard error and p value of all the variables in our model for six patient safety indicators showing significant full model. The table shows patient safety indicators having inverse relationship with three of the independent variables consistently. Those are FTEs per patient day; FTEs per admission and % of total expense for payroll, clarifying the influence of number of full time equivalent employee and the money spent for their payroll on patient safety of the hospital.

Table 6: Post-operative hemorrhage or hematoma

Variable	Parameter Estimate	Standard Error	P-value
Intercept	-2.36	2.55	0.35
Personnel per patient day	-0.01	0.01	0.46
Personnel per admission	-0.002	0.002	0.24
Dollars per patient day	0.0002	0.003	0.94
Dollars per admission	0.0006	0.0005	0.27
% of expense towards payroll	0.03	0.04	0.45
Bed size	1.1071	0.2634	<0.0001

Note: Full model  $R^2$  is 0.3424 with p value of 0.0002. The f-value for full model is 5.21 with 6 degrees of freedom for model and 60 degrees of freedom for error.

Table 7: Post-operative hip fracture

Variable	Parameter Estimate	Standard Error	P-value
Intercept	-11.82	8.37	0.16
Personnel per patient day	-0.08	0.05	0.10
Personnel per admission	0.005	0.006	0.42
Dollars per patient day*	0.02	0.009	0.03
Dollars per admission	-0.001	0.001	0.56
% of expense towards payroll	0.01	0.14	0.89
Bed size	4.4711	0.8550	<0.0001

Note: Full model  $R^2$  is 0.4451 with p value of <0.0001. The f-value for full model is 8.02 with 6 degrees of freedom for model and 60 degrees of freedom for error.

Table 8: Post-operative physiologic and metabolic derangement

Variable	Parameter Estimate	Standard Error	P-value
Intercept	-1.61	5.65	0.77
Personnel per patient day	0.01	0.03	0.61
Personnel per admission	-0.002	0.004	0.52
Dollars per patient day	-0.001	0.006	0.77
Dollars per admission	0.001	0.001	0.28
% of expense towards payroll	-0.07	0.09	0.43
Bed size	1.8565	0.5825	0.0023

Note: Full model  $R^2$  is 0.2997 with p value of 0.0012. The f-value for full model is 4.28 with 6 degrees of freedom for model and 60 degrees of freedom for error.

Table 9: Post-operative pulmonary embolism or deep vein thrombosis

Variable	Parameter Estimate	Standard Error	P-value
Intercept	-2.93	15.08	0.84
Personnel per patient day	-0.05	0.09	0.56
Personnel per admission	0.0009	0.01	0.93
Dollars per patient day	0.009	0.01	0.58
Dollars per admission	0.0003	0.003	0.91
% of expense towards payroll	-0.13	0.26	0.60
Bed size	6.5073	1.5539	<0.0001

Note: Full model  $R^2$  is 0.3091 with p value of 0.0008. The f-value for full model is 4.47 with 6 degrees of freedom for model and 60 degrees of freedom for error.

Table 10: Post-operative respiratory failure

Variable	Parameter Estimate	Standard Error	P-value
Intercept	-57.86	35.10	0.10
Personnel per patient day	0.11	0.21	0.58
Personnel per admission	-0.04	0.02	0.15
Dollars per patient day	-0.01	0.04	0.66
Dollars per admission	0.01	0.007	0.08
% of expense towards payroll	0.27	0.61	0.65
Bed size	20.4640	3.6151	<0.0001

Note: Full model  $R^2$  is 0.5102 with p value of <0.0001. The f-value for full model is 10.41 with 6 degrees of freedom for model and 60 degrees of freedom for error.

Table 11: Post-operative sepsis

Variable	Parameter Estimate	Standard Error	P-value
Intercept	-2.66	14.22	0.85
Personnel per patient day	-0.02	0.08	0.76
Personnel per admission	-0.001	0.01	0.86
Dollars per patient day	0.004	0.01	0.79
Dollars per admission	0.0008	0.003	0.77
% of expense towards payroll	-0.07	0.24	0.76
Bed size	4.3411	1.4646	0.0044

Note: Full model  $R^2$  is 0.1946 with p value of 0.0371. The f-value for full model is 2.42 with 6 degrees of freedom for model and 60 degrees of freedom for error.

The logistic regression procedure used for our multivariate analysis showed more consistent results for six patient safety indicators. The most significant predictor is

percent of operating expense accounted for payroll. Table 12 shows the parameter estimates and point estimates of variables in logistic model.

Table 12: Maximum likelihood and odds ratio estimates for all variables in model

Patient Safety Indicator	Personnel per patient day	Personnel per admission	Dollars per patient day	Dollars per admission	% of expense towards payroll	Bed size
Postoperative hemorrhage or hematoma	0.070 (1.073)	-0.017* (0.983)	-0.009* (0.991)	0.002* (1.002)	0.006 (1.007)	-0.06 (0.93)
Postoperative hip fracture	-0.017 (0.983)	0.002 (1.002)	0.0035* (1.004)	-0.0004 (1.00)	-0.0336* (0.967)	0.133 (1.14)
Postoperative physiologic and metabolic derangement	0.0007 (1.00)	0.001 (1.001)	-0.0003 (1.00)	0.00007 (1.00)	-0.0744* (0.928)	0.148 (1.16)
Postoperative pulmonary embolism and deep vein thrombosis	0.0085 (1.009)	-0.002 (0.998)	-0.0011 (0.999)	0.00016 (1.00)	-0.0567* (0.945)	0.247 (1.28)
Postoperative respiratory failure	0.0041 (1.004)	-0.0004 (1.00)	-0.0013* (0.999)	0.0002* (1.00)	-0.025* (0.975)	0.047 (1.04)
Postoperative sepsis	0.0474* (1.049)	-0.0101* (0.99)	-0.0058* (0.994)	0.0011* (1.001)	-0.039* (0.962)	0.040 (1.04)

Note: Maximum likelihood estimates are reported with odds ratio (in parenthesis). Significant maximum likelihood estimates are denoted using star.

Percent of operating cost paid for payroll is the only variable with consistently negative significant parameter estimate, suggesting increase in expense towards the payroll of personnel in operating units decreases the rate of complications after surgery. Interestingly, personnel variables showed conflicting relationship before and after stratification of hospitals. Parameter estimates after categorization were negative values, showing an inverse relationship. Looking at the analysis outcomes, we can conclude that

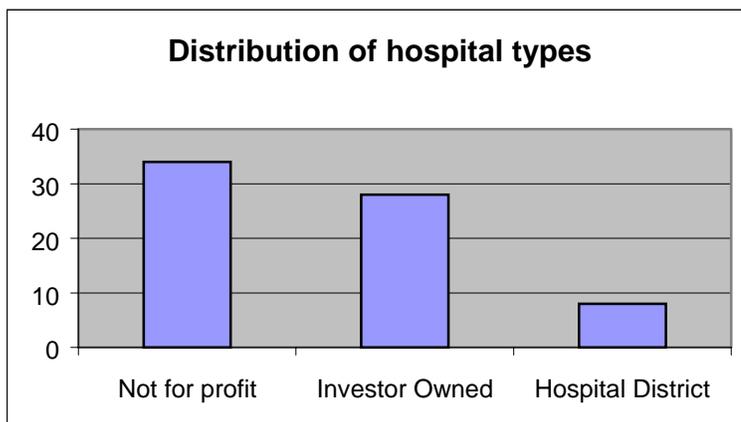
the payment variables are most important to predict the patient safety for hospitals based on their bed-size.

## Chapter four

### Discussion

The key findings from our analysis seem to be consistent with one of the hypothesized associations between hospital resources and patient safety. At the same time a few of our outcome variables did not show any relationship with hospital variables. The reason can be attributed to those outcomes being rare events and thus not counted frequently. Also the relatively small sample size of 70 hospitals might be the reason of lack of this association. Furthermore, the association can be significantly elevated with stratification of hospitals based on their ownership and type. Controlling for these confounding variables was beyond the scope of this exploratory analysis, but can serve as a guide for future research.

Figure 3: Distribution of hospitals based on their controls



The role of ownership status of the hospital depends on the administrative characteristics of those hospitals. According to previous research, not-for-profit and investor owned type of hospitals do not differ much in their patient mix as measured by their Medicare patient mix indexes or the proportion of their patients covered by Medicare or Medicaid. (Watt, 1986) Table 3 shows investor owned hospitals with smaller values for total employees (FTEs) working per patient day and per admission as well as for all the expense variables. These findings remain consistent with investor owned organizations magnifying profitability. Investor owned hospitals adapt strict management practices to reduce the expenses and increase profit margins. Another type of hospital control in our dataset is Hospital District, which is a government/ municipal hospital. These hospitals may behave differently with respect to non-governmental counterparts. However, due to uneven distribution of hospitals in all these three categories shown in Figure 3, we fail to perform any inferential analysis based on type of control of the given hospital.

Looking at the descriptive statistics of different hospital strata based on bed size, it is observed that the hospitals falling into medium bed size strata show much smaller values of all the administrative variables with exception of FTEs per patient day. Based on our analysis, the hospitals variables, which seem to explain most of the variability in patient safety indicators, are associated with expense and number of staff per patient day than per admission. Figure 4-7 in appendix one describes the behavior of Expense variable with respect to all the other variables.

This association though significant for all the strata of hospital size, does not explain lot about the complication rate variation. Past researchers have looked into this

issue by comparing the hospital characteristics to patient characteristics and concluded that individual patient characteristics are most important and explain most of this variability. (Silber, 1995)

For future studies, it will be interesting to see the interactions of these variables and their contribution in explaining the complication rate. Most of the hospital variables are highly correlated and suggest that interaction among them can explain the association with outcome variable.

In summary, the percentage of total operating cost to be paid for payroll expense, total cost per patient day and number of FTEs per patient day were the most significant variables to explain variation in complication rate after surgery in 70 general hospitals from Florida. These results are based on a small number of hospitals but they definitely suggest that hospital resource intensity characteristics contribute towards the varying adverse event rates during hospitalization.

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## Appendices

## Appendix 1: Graphs

Figure 4: Behavior of percent of total expense for payroll with respect to the total expense per patient day

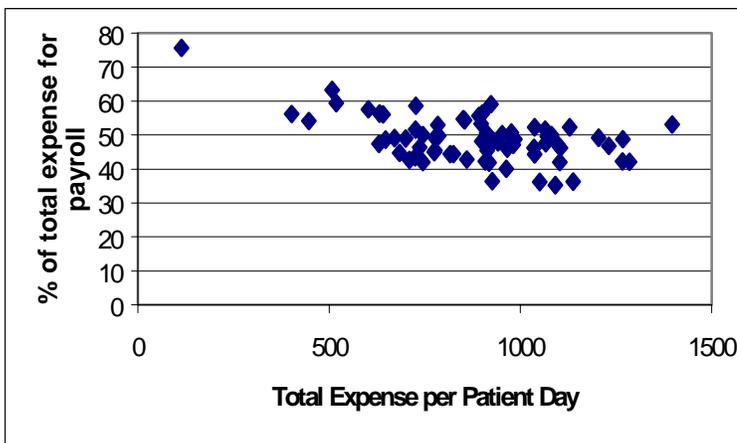
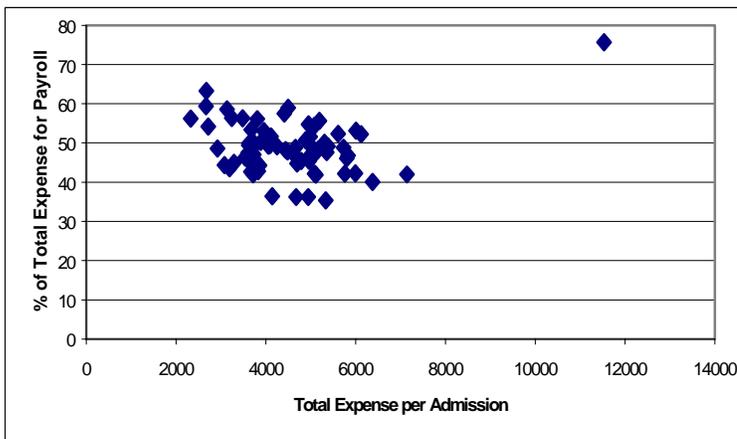


Figure 5: Behavior of percent of total expense for payroll with respect to the total expense per admission



Appendix 1: (Continued)

Figure 6: Behavior of percent of total expense for payroll with respect to the personnel per patient day

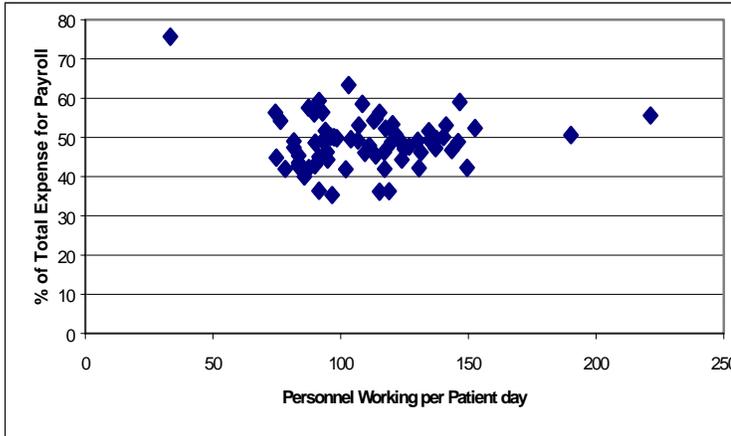
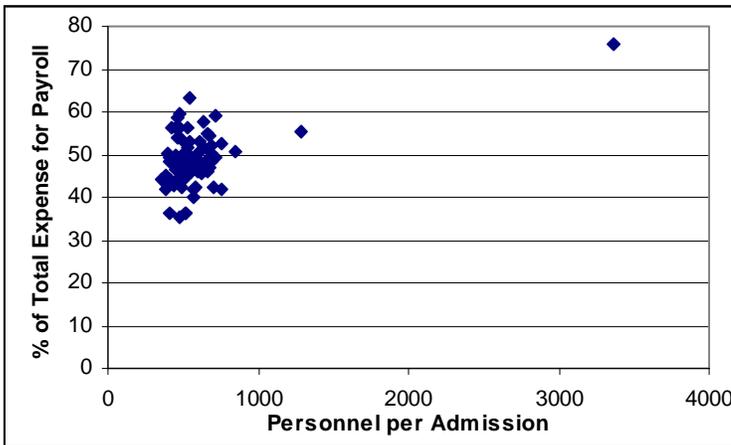


Figure 7: Behavior of percent of total expense for payroll with respect to the personnel per admission



Appendix 1: (Continued)

Figure 8: Behavior of percent of total expense for payroll with respect to the personnel per patient day for small bed size hospitals (bedsize < 150)

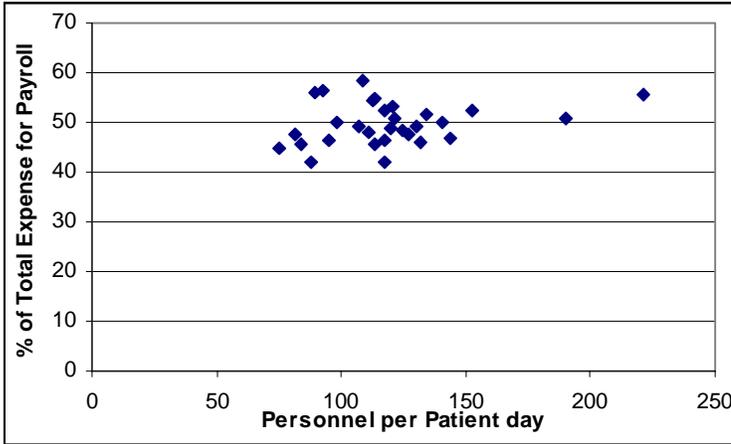
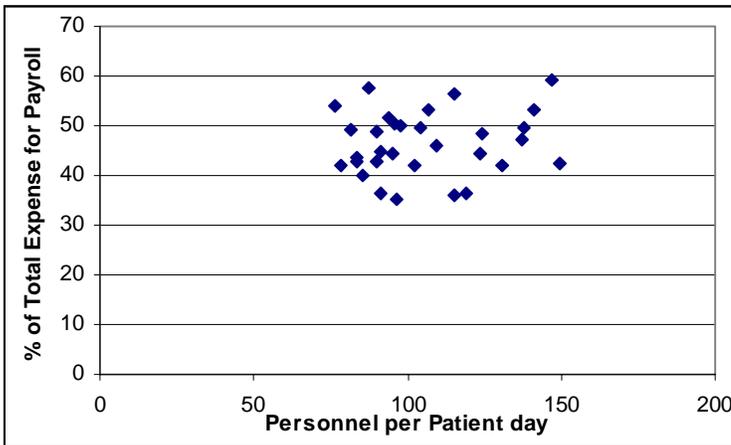


Figure 9: Behavior of percent of total expense for payroll with respect to the personnel per patient day for medium bed size hospitals (bedsize = > 150 but < 300)



Appendix 1: (Continued)

Figure 10: Behavior of percent of total expense for payroll with respect to the personnel per patient day for large bed size hospitals (bedsize => 300)

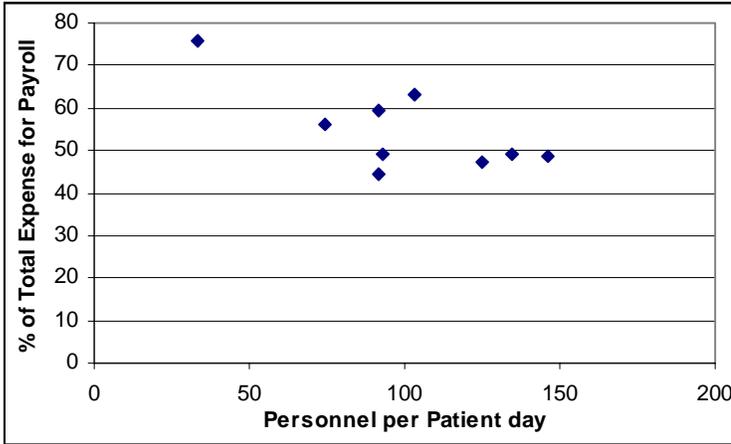
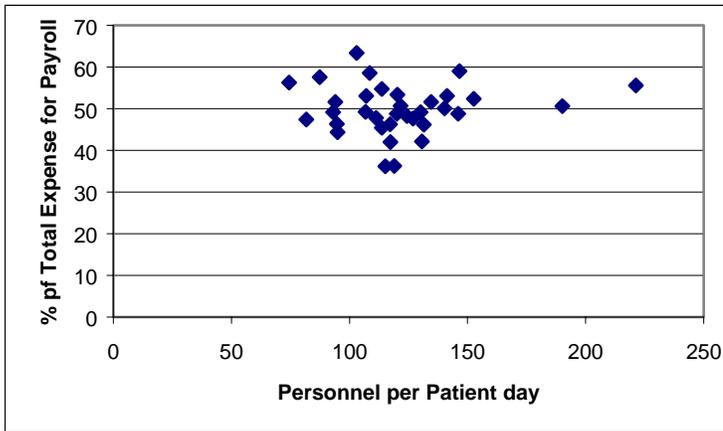


Figure 11: Behavior of percent of total expense for payroll with respect to the personnel per patient day for not-for-profit hospitals



Appendix 1: (Continued)

Figure 12: Behavior of percent of total expense for payroll with respect to the personnel per patient day for investor owned hospitals

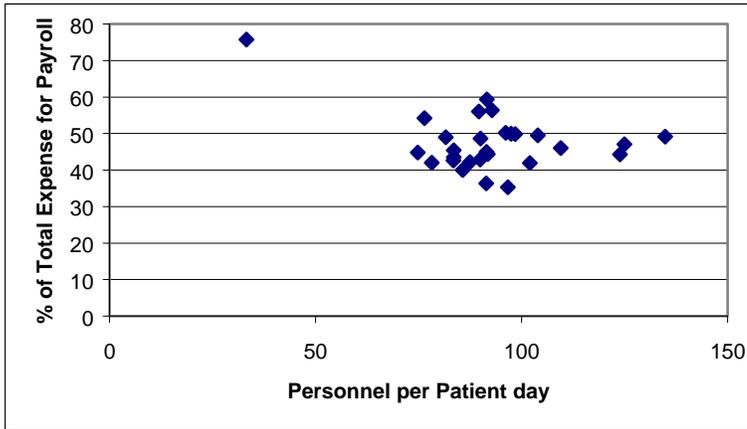
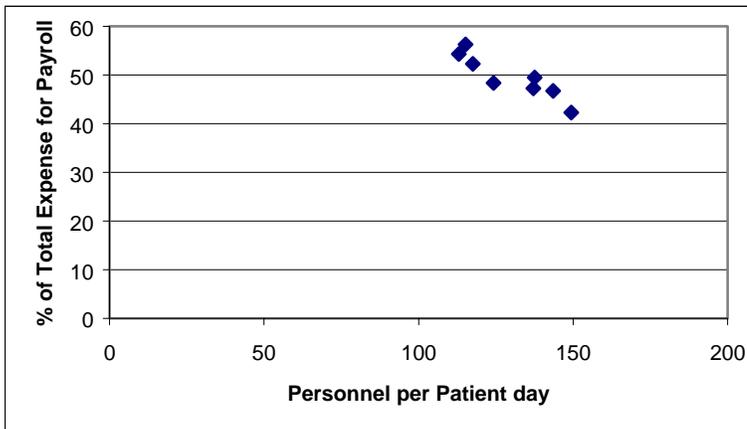


Figure 13: Behavior of percent of total expense for payroll with respect to the personnel per patient day for county district hospitals



Appendix 2: AHRQ Hospital Level Patient Safety Indicators

Indicator Name	Definition	Validity Concerns	Empirical Performance	Strength of Evidence
Complications of Anesthesia	Cases of anesthetic overdose, reaction, or endotracheal tube misplacement per 1,000 surgery discharges. Excludes codes for drug use and self-inflicted injury.	Condition definition varies Underreporting or screening Denominator unspecific	Rate = 0.80 Deviation = 7.15 Bias = Not detected	0 Coding 0 Explicit Process 0 Implicit Process 0 Staffing
Foreign body left during procedure	Discharges with foreign body accidentally left in during procedure per 1,000 discharges	Rare Stratification suggested Denominator unspecific	Rate = 0.08 Deviation = 0.18 Bias = N/A	0 Coding 0 Explicit Process 0 Implicit Process 0 Staffing
Postoperative hemorrhage or hematoma	Cases of hematoma or hemorrhage requiring a procedure per 1,000 surgical discharges. Excludes obstetrical patients in MDC 14.	Stratification suggested Case mix bias Denominator unspecific	Rate = 1.83 Deviation = 3.366 Bias = Not Detected	± Coding ± Explicit Process + Implicit Process 0 Staffing
Postoperative hip fracture	Cases of in-hospital hip fracture per 1,000 surgical discharges. Excludes patients in MDC 8, with conditions suggesting fracture present on admission and obstetrical patients in MDC 14.	Case mix bias Denominator unspecific	Rate = 1.12 Deviation = 5.94 Bias = X	+ Coding + Explicit Process + Implicit Process 0 Staffing

Appendix 2: (Continued)

Indicator Name	Definition	Validity Concerns	Empirical Performance	Strength of Evidence
Postoperative physiologic and metabolic derangement	Cases of specified physiologic or metabolic derangement per 1,000 elective surgical discharges. Excludes patients with principal diagnosis of diabetes and with diagnoses suggesting increased susceptibility to derangement. Excludes obstetric admissions.	Condition definition varies	Rate = 0.92 Deviation = 11.1 Bias = X	- Coding 0 Explicit Process 0 Implicit Process - Staffing
Postoperative PE or DVT	Cases of deep vein thrombosis or pulmonary embolism per 1,000 surgical discharges. Excludes obstetric patients	Underreporting or screening Stratification suggested	Rate = 6.95 Deviation = 12.3 Bias = X+	+ Coding + Explicit Process + Implicit Process ± Staffing
Postoperative respiratory failure	Cases of acute respiratory failure per 1,000 elective surgical discharges. Excludes MDC 4 and 5 and obstetric admissions.	Unclear preventability Case mix bias	Rate = 2.68 Deviation = 5.01 Bias = X+	+ Coding ± Explicit Process + Implicit Process ± Staffing
Postoperative sepsis	Cases of sepsis per 1,000 elective surgery patients, with length of stay more than 3 days. Excludes principal diagnosis of infection, or any diagnosis of immunocompromised state or cancer, and obstetric admissions	Condition definition varies Adverse consequences	Rate = 10.0 Deviation = 29.6 Bias = X+	± Coding 0 Explicit Process 0 Implicit Process - Staffing

Appendix 2: (Continued)

Indicator Name	Definition	Validity Concerns	Empirical Performance	Strength of Evidence
Postoperative wound dehiscence	Cases of reclosure of postoperative disruption of abdominal wall per 1,000 cases of abdominopelvic surgery. Excludes obstetric admissions.	Case mix bias	Rate = 2.43 Deviation = 8.77 Bias = X	0 Coding 0 Explicit Process 0 Implicit Process 0 Staffing

### Appendix 3: SAS Program

```
option nodate nonumber;
libname shaila 'my documents\sha\thesis\';
data final; set shaila.final_type;
adm = (adm_acute + adm_sub);
inpat = (inpat_acute + inpat_sub);
per_adm = (ftes/adm)*1000;
per_patday = (ftes/inpat)*1000;
pay_adm = (tot_exp/adm);
pay_patday = (tot_exp/inpat);
pay_exp = (salary/tot_exp)*100;
label
    adm = 'Admissions'
    inpat = 'Inpatient days'
    per_adm = 'Personnel per admission'
    per_patday = 'personnel per patient days'
    pay_adm = 'Dollars per admission'
    pay_patday = 'Dollars per patient days'
    pay_exp = '% total expense to be paid for payroll'
    psi1 = 'complications of anesthesia'
    psi2 = 'foreign body left during procedure'
    psi3 = 'PO hemorrhage or hematoma'
    psi4 = 'PO hip fracture'
    psi5 = 'PO physiologic & Metabolic derangement'
    psi6 = 'PO PE or DVT'
    psi7 = 'PO respiratory failure'
    psi8 = 'PO sepsis'
    psi9 = 'PO wound dehiscence';

run;
data final_a; set final;
if bedsize LE 150 then bed = 1;
if bedsize LT 300 and bedsize GT 150 then bed=2;
if bedsize GT 300 then bed=3;
if control in ('A' 'B') then hosp_con = 1;
if control in ('C' 'D' 'E') then hosp_con = 2;
if control in ('J') then hosp_con = 3;
if hosp_type in ('A') then hosptype = 1;
if hosp_type in ('D') then hosptype = 2;
run;
data final_bed_a final_bed_b final_bed_c; set final_a;
if bed = 1 then output final_bed_a;
if bed = 2 then output final_bed_b;
if bed = 3 then output final_bed_c;
run;
```

```

data final_con_a final_con_b final_con_c; set final_a;
if control in ('A' 'B') then output final_con_a;
if control in ('D' 'E') then output final_con_b;
if control in ('J') then output final_con_c;
run;
data final_type_a final_type_b; set final_a;
if hosp_type in ('A') then output final_type_a;
if hosp_type in ('D') then output final_type_b;
run;

proc contents data=final_a;
Title 'Contents of the dataset';
run;
proc sort data=final_a;
by bed;
run;
proc univariate data=final_a;
by bed;
var per_patday per_adm pay_patday pay_adm pay_exp;
output out=disc
      N = N_bedsizes N_ftes N_adm N_inpat N_salary N_tot_exp
      N_per_patday N_per_adm N_pay_patday
      N_pay_adm N_pay_exp

      MEDIAN = MED_bedsizes MED_ftes MED_adm MED_inpat MED_salary
      MED_tot_exp MED_per_patday
      MED_per_adm MED_pay_patday MED_pay_adm MED_pay_exp

      MEAN = MEAN_bedsizes MEAN_ftes MEAN_adm MEAN_inpat MEAN_salary
      MEAN_tot_exp MEAN_per_patday
      MEAN_per_adm MEAN_pay_patday MEAN_pay_adm MEAN_pay_exp;

Title 'Means of all dependent and independent variables';
run;
proc means data=final_a;
var per_patday per_adm pay_patday pay_adm pay_exp;
run;
proc univariate data=final_a;
var PSI1 PSI2 PSI3 PSI4 PSI5 PSI6 PSI7 PSI8 PSI9;
run;
proc corr data=final_a;
var per_patday per_adm pay_patday pay_adm pay_exp PSI1 PSI2 PSI3 PSI4
      PSI5 PSI6 PSI7 PSI8 PSI9;
run;
proc reg data=final_a;
model psi1 = per_patday per_adm pay_patday pay_adm pay_exp
      bed/selection = maxr
      ;
model psi2 = per_patday per_adm pay_patday pay_adm pay_exp
      bed/selection = maxr
      ;
model psi3 = per_patday per_adm pay_patday pay_adm pay_exp
      bed/selection = maxr
      ;

```

```

model psi4 = per_patday per_adm pay_patday pay_adm pay_exp
bed/selection = maxr
;
model psi5 = per_patday per_adm pay_patday pay_adm pay_exp
bed/selection = maxr
;
model psi6 = per_patday per_adm pay_patday pay_adm pay_exp
bed/selection = maxr
;
model psi7 = per_patday per_adm pay_patday pay_adm pay_exp
bed/selection = maxr
;
model psi8 = per_patday per_adm pay_patday pay_adm pay_exp
bed/selection = maxr
;
model psi9 = per_patday per_adm pay_patday pay_adm pay_exp
bed/selection = maxr
;
run;
proc genmod data=final_a;
class bed;
model psi1=per_patday per_adm pay_patday pay_adm pay_exp bed;
run;
proc genmod data=final_a;
class bed;
model psi2=per_patday per_adm pay_patday pay_adm pay_exp bed;
run;
proc genmod data=final_a;
class bed;
model psi3=per_patday per_adm pay_patday pay_adm pay_exp bed;
run;
proc genmod data=final_a;
class bed;
model psi4=per_patday per_adm pay_patday pay_adm pay_exp bed;
run;
proc genmod data=final_a;
class bed;
model psi5=per_patday per_adm pay_patday pay_adm pay_exp bed;
run;
proc genmod data=final_a;
class bed;
model psi6=per_patday per_adm pay_patday pay_adm pay_exp bed;
run;
proc genmod data=final_a;
class bed;
model psi7=per_patday per_adm pay_patday pay_adm pay_exp bed;
run;
proc genmod data=final_a;
class bed;
model psi8=per_patday per_adm pay_patday pay_adm pay_exp bed;
run;
proc genmod data=final_a;
class bed;
model psi9=per_patday per_adm pay_patday pay_adm pay_exp bed;
run;

```

```
proc logistic descending data=final_a;  
model psi3/adm = per_patday pay_patday pay_adm per_adm pay_exp bed;  
run;  
proc logistic descending data=final_a;  
model psi4/adm = per_patday pay_patday pay_adm per_adm pay_exp bed;  
run;  
proc logistic descending data=final_a;  
model psi5/adm = per_patday pay_patday pay_adm per_adm pay_exp bed;  
run;  
proc logistic descending data=final_a;  
model psi6/adm = per_patday pay_patday pay_adm per_adm pay_exp bed;  
run;  
proc logistic descending data=final_a;  
model psi7/adm = per_patday pay_patday pay_adm per_adm pay_exp bed;  
run;  
proc logistic descending data=final_a;  
model psi8/adm = per_patday pay_patday pay_adm per_adm pay_exp bed;  
run;
```