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The effect of health information technology implementation in Veterans Health Administration hospitals on patient outcomes

Joanne Spetz [a,*], James F. Burgess [b,c], Ciaran S. Phibbs [d,e]

[a] University of California, Philip R. Lee Institute for Health Policy Studies, 3333 California Street, Suite 265, San Francisco, CA 94118, United States
[b] VA Boston Healthcare System, 150 S Huntington Ave, Jamaica Plain, MA 02130, United States
[c] Boston University, Boston, MA 02215, United States
[d] VA Palo Alto Health Care System, 3801 Miranda Ave, Palo Alto, CA 94304, United States
[e] Stanford University, 450 Serra Mall, Stanford, CA 94305, United States

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ABSTRACT

Background: The impact of health information technology (HIT) in hospitals is dependent in large part on how it is used by nurses. This study examines the impact of HIT on the quality of care in hospitals in the Veterans Health Administration (VA), focusing on nurse-sensitive outcomes from 1995 to 2005.
Methods: Data were obtained from VA databases and original data collection. Fixed-effects Poisson regression was used, with the dependent variables measured using the Agency for Healthcare Research and Quality Inpatient Quality Indicators and Patient Safety Indicators software. Dummy variables indicated when each facility began and completed implementation of each type of HIT. Other explanatory variables included hospital volume, patient characteristics, nurse characteristics, and a quadratic time trend.
Results: The start of computerized patient record implementation was associated with significantly lower mortality for two diagnoses but significantly higher pressure ulcer rates, and full implementation was associated with significantly more hospital-acquired infections. The start of bar-code medication administration implementation was linked to significantly lower mortality for one diagnosis, but full implementation was not linked to any change in patient outcomes.
Conclusions: The commencement of HIT implementation had mixed effects on patient outcomes, and the completion of implementation had little or no effect on outcomes.
Implications: This longitudinal study provides little support for the perception of VA staff and leaders that HIT has improved mortality rates or nurse-sensitive patient outcomes. Future research should examine patient outcomes associated with specific care processes affected by HIT.

1. Introduction

Health information technology (HIT) has been diffusing gradually in the United States for more than a decade.[1,2] In the hospital setting, two of the most important technologies are computerized patient records and medication administration systems.[3–5] Although the adoption of these systems has accelerated, research on the impact of hospital HIT on patient care, process change, staff time commitment, and staff morale has been inconclusive. While some studies of the effects of hospital HIT on the quality of care have been encouraging,[6–13] others have found no or mixed benefits from these systems in acute-care settings.[14–22] In fact, some studies indicate that HIT might have negative effects on the process and quality of care.[23–31] Differences in the specific details of HIT implementation and process are undoubtedly partly related to differences in conclusions; this study focuses on a single HIT implementation and a set of processes important to the largest hospital staff component.

The impact of HIT within the hospital setting is likely to have significant dependence on the interactions of nurses with the systems. Nurses are the largest group of staff in hospitals, providing the majority of patient care at the bedside, and they are responsible for inpatient charts and the administration of medications.[32,33] They intensively use electronic patient records and charting systems, clinical reminders, and electronic medication administration systems.[34] In theory, HIT can enhance nursing care by improving information access, providing automated surveillance for error detection and prevention, facilitating communication among care providers, and standardizing practice patterns.[35] HIT implementation also could impact nursing workload in both positive and negative ways, which may influence the ultimate effect of HIT on patient care.[33] There is little evidence, however, regarding whether HIT improves the structure, process, and outcomes of nursing care. One prior study found higher rates of nurse-sensitive complications, although there were also lower mortality rates for selected diagnoses.[20] Another

* Corresponding author. Tel.: +1 415 502 4443.
E-mail address: joanne.spetz@ucsf.edu (J. Spetz).

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study measured improvements in the quality of nursing documentation only after retraining of staff in the use of the system.[36] Several studies have found that HIT can affect the process of nursing care and communication among providers negatively.[23,33]

This study examines the impact of HIT on the quality of care in hospitals, recognizing that nurse staffing is a mediating factor in the determination of patient outcomes. We focus on the implementation of two important types of HIT developed and implemented systematically in the U.S. Veterans Health Administration (VA): the Computerized Patient Record System (CPRS), and Bar Code Medication Administration (BCMA). CPRS is a fully-integrated electronic health record, with computerized physician order entry. BCMA is a bedside medication administration safety system, for which the pharmacy uses computerized physician orders to bar code all prescriptions delivered to patient care units. Nurses then scan the medication bar code and the patient's wristband. A mismatch between the patient and the ordered medication (wrong medication, wrong dose, wrong time) results in a warning sound, and the nurse then assesses the source of the error and makes a correction.

These systems were developed and then implemented in VA facilities nationwide, with CPRS gradually phased in over a decade starting in the early 1990s, and BCMA implemented over a 2-year period ending in 2001.[37,38] These are among the largest investments in information technology in the hospital industry over the past two decades,[38–40] but there has been little research objectively assessing the effect of CPRS and BCMA on hospital staff or patients. Early studies of the effects of CPRS indicate that the system improved the specificity of medical orders,[41] improved health screening rates with automated alerts,[42] decreased the rate of indwelling urinary catheterization,[43] reduced redundant laboratory orders,[44] and improved overall hospital efficiency.[45] A number of studies have demonstrated that BCMA reduced the rate of medication errors,[39,46–48] but BCMA has also been associated with some problems, such as lack of reliability,[39] difficulty coordinating activities of staff,[23] and changing priorities of nursing staff in favor of monitored activities.[23] We add to this literature by examining mortality associated with five common diagnoses and four nurse-sensitive adverse inpatient outcomes, while controlling for characteristics of the facility and its nurse staff that may affect the ultimate impact of HIT on nurse-sensitive quality of hospital care.

2. Data and methods

2.1. Data sources

We extracted data from multiple VA databases and engaged in original data collection. Our data span the period from 1995 through 2005; we selected this time period to have roughly 5 years of data prior to and following the implementation of BCMA; BCMA was phased in over an intense 2-year period with some beta testers and laggers. All data were aggregated so each observation represents a hospital for one quarter.

2.1.1. IT implementation data

Data on the implementation of CPRS and BCMA were obtained through a web-based survey of VA facilities. The VA Chief Nurse's office communicated with all VA sites to solicit participation in the survey, resulting in 120 respondents from 147 facilities. These data identify when CPRS and BCMA were launched at each facility, as well as when implementation was started and completed for each major component of CPRS and BCMA.

2.1.2. VA databases

To measure the effects of CPRS and BCMA on patient safety in the VA, we used the Agency for Healthcare Research and Quality (AHRQ) Inpatient Quality Indicators (IQIs) and Patient Safety Indicators (PSIs) software, version 3.1b/apr, 4/26/07. The IQIs measure patient volumes and inpatient mortality for specific medical conditions and surgical procedures. We focus on the mortality rates for coronary artery bypass graft (CABG), heart attack (AMI), congestive heart failure (CHF), stroke, and pneumonia. The PSIs measure rates of potentially avoidable complications and iatrogenic events, such nosocomial infections, death in low-mortality DRGs, and pressure ulcers. We focused on four PSIs that have been demonstrated to be sensitive to nursing care: pressure ulcers, mortality following a postsurgical complication (failure to rescue), selected infections due to medical care, and postoperative sepsis.[49] Both the PSI and IQI software produce several key measures: the observed number of cases of the adverse event (or death), the number of patients included in the calculation of the adverse event, the expected number of cases based on a risk-adjustment algorithm, the observed rate of the adverse event (number of cases divided by patients included), and the risk-adjusted rate of the adverse event.

The VA collects patient discharge data similar to that in the AHRQ Statewide Inpatient Database in their Patient Treatment File (PTF). The PTF is different from standard discharge abstracts since it is an annual operations database, not a billing system; in addition to the normal discharge record, it includes a census file with one record for every patient in the hospital at the end of the fiscal year, and a "bed section" (unit type) file which has a separate record for each bed section stay. Combined, these files provide a more complete picture of the care provided by each VA facility, and they were used to both compute the PSIs and IQIs, and to adjust for patient case-mix. These data also allowed us to accurately determine the number of inpatient days provided by each VA facility in each quarter. Previous research has analyzed the usefulness of the PSIs for understanding patient outcomes in VA hospitals;[50–52] we compared our PSI computations with those of Rosen for the 2000–2001 fiscal year[50] and obtained similar estimates of the numbers of affected patients in our calendar year 2001.

The PTF also was used to measure characteristics of VA patients. We control for differences in the severity of illness by measuring patient case-mix, measured as the average of patient DRG weights, and the average count of Elixhauser comorbidities.[53] The PTF also was used to calculate the number of patient days in inpatient units, and days squared, which accounts for possible economies of scale and/or diminishing returns in the prevention of adverse events.[54–56]

The VA Payroll data system (PAID) was used to measure some aspects of nurse staffing and the characteristics of nursing staff. The data include hours worked by registered nurses (RNs), licensed practical nurses (LPNs), and aides, as well as nurses' age and education. From these data we constructed variables that measure the intensity of nursing care provided to patients: the number of nursing hours per patient day and percent of nursing hours worked by RNs. Many studies have linked nurse staffing levels to patient outcomes.[56–60] We also measure the human capital of nurses, which has been shown to affect nursing skill and patient outcomes, as the percent of RNs over 50 years old and percent with a bachelor's or master's degree.[61–65] The PAID data do not include the actual work experience of RNs, and thus age of the nurse is used as a proxy. We measure the share of nursing personnel represented by unions, which has been associated with patient outcomes.[66] Finally, we measure the share of nurses who work part time, which controls for the exposure of nurses to new technologies during the implementation period.

The panel of data is unbalanced; for some hospitals, the PAID data did not provide information about nurse characteristics and thus the observations were not included. We elected to estimate