# Levels of Adoption of Electronic Health Records and Patient Safety: Effectiveness and Efficiency

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## Background

- Patient safety, including hospital acquired infections has become one of the major concerns in healthcare delivery in recent years
- Electronic health records are becoming an integral aspect of the health care delivery
- Health policies have been looking to improve quality / patient safety and efficiency of healthcare through the adoption of electronic health record (EHR) systems

## Research Questions & Hypotheses

- Can EHR adoption improve patient safety?
- Can EHR adoption reduce cost?
- H1: Patients treated at hospitals with a higher level of EHR adoption are less likely to incur poorer patient safety indicators
- H2: Patients treated at hospitals with a higher level of EHR adoption are more likely to incur lower costs for their respective patient safety indicators

## Methods

### Design and Data

- Study design: Cross-sectional
- Unit of analysis: Hospital discharge
- Data:
  - Mainly the 2009 National Inpatient Sample (NIS) and the 2009 American Hospital Association (AHA) electronic health record (EHR) implementation survey
  - Plus the AHA annual survey data and the Agency for Healthcare Research and Quality (AHRQ) cost-charge-ratio file.
  - 2,627,107 discharges in 365 hospitals

### Measures

- Dependent variable set I: 9 AHRQ patient safety indicators
  - Pressure ulcer
  - Death among surgeries
  - Postoperative hemorrhage or hematoma
  - Postoperative physiologic metabolism derangement
  - Postoperative respiratory failure
  - Postoperative pulmonary embolism or deep vein thrombosis
  - Postoperative sepsis
  - Postoperative wound dehiscence
  - Accidental puncture/laceration
  - Dependent variable set II: 9 costs for the 9 patient safety indicators, respectively
- Independent variable: Level of EHR adoption
  - Comprehensive EHR system (the highest level): 24 electronic functions present in all major clinical units
    - Electronic clinical documentation (e.g., patient demographics, MD notes, discharge summaries)
    - Results viewing (e.g., lab reports, diagnostic test images)
    - Computerized provider order entry (CPOE)
    - Decision support (e.g., clinical guidelines, drug allergy alerts)
    - Bar coding (e.g., tracking pharmaceuticals)
    - Others (e.g., telemedicine)
  - Basic EHR system
    - 8 electronic functions present in all major clinical units
  - Below basic EHR system or no “real” EHR systems
    - Neither comprehensive EHR nor basic HER

### Analyses

- Risk adjustment
  - Patient demographics: age, sex, race
  - The AHRQ’s 29 comorbidities, such as AMI, cancer, diabetes, obesity, paralysis, and weight loss.
- Control variables
  - Patient level: Health insurance status
  - Hospital level
    - Structure: Bed size, ownership type, teaching affiliation, system membership, and network participation
    - Operation: FTE nurses per 1,000 adjusted patient days and average daily census per staffed bed
    - Environment: Percentage of Medicare patients, percentage of Medicaid patients, capitation-based reimbursement, market competitiveness, rural or urban hospital, and hospital region

## Results

### 9 Patient Safety Indicators

- **7** had no differences across the level of EHR adoption and the remaining 2 showed mixed results
- Pressure ulcer
  - As compared to those who went to hospitals without EHR adoption, patients who stayed in hospitals with both full EHR and basic EHR were less likely to experience pressure ulcers (0.66 [0.56, 0.78] and 0.74 [0.68, 0.79])
- Postoperative hemorrhage or hematoma (PHH)
  - As compared to those who went to hospitals without EHR adoption, patients who stayed in hospitals with full EHR were more likely to experience PHH (1.41 [1.19, 1.66]) while patients who stayed in hospitals with basic EHR had comparable outcomes.

### 9 Costs

- As compared to patients who went to hospitals without EHR, patients who were treated in hospitals with comprehensive EHR incurred lower costs of care for all **9** costs of care
  - Ranging from $834 lower in the case of postoperative physiological metabolism derangement to $4,007 lower in the case death among surgeries
- As compared to patients who went to hospitals without EHR, patients who were treated in hospitals with basic EHR incurred lower costs of care in **6** indicators but higher costs in **3** indicators.

Hospital Characteristics by Level of EHR Adoption

| Variable | Comprehensive EHR (n = 19) | Basic EHR (n = 76) | Non-Adoption (n = 270) |
|---|---|---|---|
| Hospital structure | | | |
| Number of staffed beds | 207 (182) | 246 (192) | 187 (210) |
| Ownership, % | | | |
| - Public | 5.3 | 23.7 | 17.8 |
| - Not for profit | 89.4 | 68.4 | 73.7 |
| - Investor owned | 5.3 | 7.9 | 8.5 |
| Teaching hospital, % | 31.6 | 32.9 | 17.8 |
| Hospital operation | | | |
| Affiliated to a system, % | 80.0 | 61.8 | 50.0 |
| In a network, % | 25 | 43.4 | 31.1 |
| FTE nurses per 1,000 adjusted patient days | 4.15 (1.86) | 3.53 (1.60) | 3.14 (1.58) |
| Hospital environment | | | |
| Medicare discharges as % of total discharges | 43.1 (11.6) | 46.8 (43.3) | 55.3 (69.0) |
| Medicaid discharges as % of total discharges | 16.2 (7.7) | 21.1 (21.4) | 18.3 (32.1) |
| Having capitation-based reimbursement, % | 10.0 | 23.7 | 14.1 |
| Competitive market,% | 5.0 | 13.2 | 11.5 |
| Region, % | | | |
| - East | 10.5 | 22.4 | 23.0 |
| - Midwest | 42.1 | 26.3 | 27.0 |
| - South | 26.3 | 25.0 | 26.3 |
| - West | 21.1 | 26.3 | 23.7 |

Relationships between Level of EHR Adoption, Patient Safety Indicators, and Cost of Care

| | Occurrence | | | | | Cost | | |
|---|---|---|---|---|---|---|---|---|
| PSI | Odds Ratio | 95% CI | | p-Value | Parameter Estimate | Standard Error | p-Value |
| PSI03 | 4395 | 680452 | 684847 | 0.65% | | | |
| - ehr_comp | 0.67 | 0.57 | 0.80 | <.0001 | -1343 | 138 | <.0001 |
| - ehr_basic2 | 0.74 | 0.68 | 0.80 | <.0001 | -1505 | 71 | <.0001 |
| PSI04 | 3050 | 21237 | 24287 | 14.36% | | | |
| - ehr_comp | 0.94 | 0.80 | 1.10 | 0.42 | -4007 | 1274 | 0.0017 |
| - ehr_basic2 | 1.06 | 0.97 | 1.17 | 0.20 | -833 | 772 | 0.2804 |
| PSI09 | 1929 | 690643 | 692572 | 0.28% | | | |
| - ehr_comp | 1.41 | 1.19 | 1.66 | <.0001 | -1698 | 121 | <.0001 |
| - ehr_basic2 | 1.02 | 0.91 | 1.14 | 0.78 | -242 | 69 | 0.0004 |
| PSI10 | 397 | 309516 | 309913 | 0.13% | | | |
| - ehr_comp | 0.79 | 0.58 | 1.07 | 0.13 | -834 | 108 | <.0001 |
| - ehr_basic2 | 0.98 | 0.80 | 1.20 | 0.81 | 1058 | 68 | <.0001 |
| PSI11 | 2055 | 248136 | 250191 | 0.83% | | | |
| - ehr_comp | 0.90 | 0.75 | 1.09 | 0.28 | -1098 | 100 | <.0001 |
| - ehr_basic2 | 1.12 | 1.00 | 1.26 | 0.05 | 1027 | 63 | <.0001 |
| PSI12 | 7959 | 685103 | 693062 | 1.16% | | | |
| - ehr_comp | 0.97 | 0.88 | 1.08 | 0.59 | -1638 | 120 | <.0001 |
| - ehr_basic2 | 1.00 | 0.93 | 1.06 | 0.87 | -262 | 68 | 0.0001 |
| PSI13 | 1037 | 60111 | 61148 | 1.73% | | | |
| - ehr_comp | 0.99 | 0.79 | 1.25 | 0.93 | -1736 | 344 | <.0001 |
| - ehr_basic2 | 1.08 | 0.93 | 1.25 | 0.32 | 1615 | 213 | <.0001 |
| PSI14 | 234 | 109443 | 109677 | 0.21% | | | |
| - ehr_comp | 1.47 | 0.95 | 2.26 | 0.08 | -3107 | 329 | <.0001 |
| - ehr_basic2 | 1.03 | 0.75 | 1.41 | 0.86 | -647 | 201 | 0.0013 |
| PSI15 | 6493 | 2313659 | 2320152 | 0.28% | | | |
| - ehr_comp | 0.98 | 0.88 | 1.09 | 0.70 | -977 | 52 | <.0001 |
| - ehr_basic2 | 1.06 | 0.99 | 1.12 | 0.07 | -803 | 27 | <.0001 |

## Conclusions

- Our study did not detect many differences in patient safety indicators across levels of EHR adoption
- They, however, showed consistent patterns that patients in hospitals with comprehensive EHR systems incurred lower costs than those in hospitals without a comprehensive or basic EHR system
- EHR adoption is likely to reduce the cost of patient care before improving quality indicators
- Hospitals may not be using their EHR systems to improve quality, because they have not incorporated meaningful use criteria into their hospital EHR systems yet

## Limitations

- Lost many hospitals due to the multiple datasets merge, which compromised the generalizability of our findings
- Costs were not directly estimated, but rather they were converted from total charges using an average rate for the entire hospital provided by CMS
- The cross-sectional design cannot be used to establish causality between EHR adoption and quality and cost. The EHR adoption measures were also cross-sectional and they did not indicate how long hospitals had had the level of adoption attributed to them
- Longitudinal research is needed to further explore this relationship

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