RESEARCH ARTICLE

Exploring association between certified EHRs adoption and patient experience in U.S. psychiatric hospitals

Xuejun Hu¹,², Haiyan Qu², Shannon H. Houser², Jingmei Ding¹, Huoliang Chen¹, Xianzhi Zhang¹, Min Yu³*

¹ Department of Health Services Administration, Air Force Medical University, Xi’an, China, ² Department of Health Services Administration, University of Alabama at Birmingham, Birmingham, AL, United States of America, ³ Department of Health Services Administration, Academy of Military Medical Sciences, Beijing, China

*yumin@bmi.ac.cn

Abstract

Objective
Certified Electronic Health Records (EHR) have been shown to improve the health service quality in some health settings, but there is scant evidence related to its adoption in psychiatric hospitals. This paper aimed to examine the relationship between certified EHR adoption and patient experience across psychiatric hospitals in the United States.

Methods
A cross-sectional study design compared the difference in patient experience measures between psychiatric hospitals with and without certified EHR. Data were drawn from the American Hospital Association (AHA) Annual Survey Database and Hospital Compare datasets. Eleven publicly reported measures for patient experience from the Consumer Assessment of Healthcare Providers and Systems Hospital Survey (HCAHPS) were applied for analysis. Independent relationship of certified EHR adoption and patient experience was explored with multiple linear regression models adjusted for hospital organizational characteristics.

Results
Positive associations were identified between certified EHR adoption and five patient perception measures—“recommend hospital” (β = 0.66, 95% CI = [0.16, 1.16]; t = 2.68, p = 0.010), “overall hospital rating” (β = 0.39, 95% CI = [0.03, 0.75]; t = 2.11, p = 0.035), “discharge information” (β = 0.45, 95% CI = [0.03, 0.86]; t = 2.09, p = 0.037), “care transition” (β = 0.44, 95% CI = [0.14, 0.75]; t = 2.84, p = 0.005), and “responsiveness of hospital staff” (β = 0.47, 95% CI = [0.04, 0.90]; t = 2.13, p = 0.033).
Conclusion

Our results suggest the positive association between certified EHR adoption and patient experience. More studies are needed to explore impacts of certified EHR adoption and potential improvement in patient experience to quality of care.

Introduction

Enacted by Health Information Technology for Economic and Clinical Health (HITECH) Act in 2009, Electronic Health Records (EHR) Incentive Programs have been launched to drive nationwide EHR adoption and meaningful use of health information technology throughout health care settings in the United States (U.S.). [1] An unprecedented progress has been made in utilization of certified EHR in U.S. health settings and large numbers of studies have demonstrated its substantial influences on the quality, safety, and efficiency of health services. [2–4] However, psychiatric hospitals are ineligible for the financial incentive programs, and the rate of EHR adoption is noticeably lower among psychiatric hospitals [5, 6] compared to other hospitals. While more than 80 percent of general hospitals adopted EHR by 2015, only 15 percent of psychiatric hospitals adopted at least a basic EHR system produced by different vendors. [7] There might be multiple barriers impeding adoption of certified EHR, including initial financial pressure of providers, narrative and non-structure feature of patient records, confidentiality of psychiatric care and stigma of mental illness. [8, 9] Lag in certified EHR adoption among psychiatric hospitals might not only limit quality improvement of psychiatric care but also stymie efforts to achieve the targeted benefits, such as interoperability, across the health care continuum. [6, 10] Therefore, it is necessary to identify the evidence to prove if certified EHR adoption has positive impacts to quality improvement and patient experience in psychiatric hospitals, and also if health policymakers should expand the incentive programs to psychiatric hospitals.

According to prior published studies conducted in psychiatric settings, positive impacts of certified EHR utilization can be found on the therapeutic communications, [11, 12] hospital readmission, [13] adverse drug events [14] and psychiatrist-patient relationship [15–17] as well as other quality measures [18–20] based on psychiatric patient or practitioner level instead of hospital level. A gap was identified with very limited literature in the relationship between patient experience and certified EHR adoption in psychiatric care using nationally representative data.

As more emphasis is placed on the concept of patient-centered care, patient experience has become the integral component to evaluate the health quality. Some studies have examined the impact of the EHR adoption on the patient satisfaction in general health settings. [21, 22] However, previous findings about such relationship are mixed. Some studies suggested that EHR use could significantly improve patient experience [23–25] whereas other showed insignificant [26–30] or even inverse associations. [31, 32] Additionally, most literature on the relationship between patient experience and EHR adoption were conducted in non-psychiatric settings. [9, 22–28, 30] Due to the confidentiality and sensitive nature in psychiatric records, and the special reliance on information for psychiatric diagnosis and treatment, the findings of previous works in non-psychiatric hospitals may not apply equally to psychiatric hospitals. [17]

The aim of this cross-sectional study is to examine the relationship between certified EHR adoption and patient experience at hospital level in psychiatric care setting in the U.S. We
hypothesized that certified EHR use would positively influence the patient experience across psychiatric hospitals.

Methods

Data source and sample

This study was a cross-sectional, secondary analysis based on data from two primary databases which were open and publicly available: American Hospital Association (AHA) Annual Survey Database and the Centers for Medicare and Medicaid Services (CMS) Hospital Compare datasets. AHA Annual Survey Database provides the characteristics information for 6,251 hospitals, including teaching status, bed size, metropolitan status, ownership, system membership status, primary service classification, and length of stay. Hospital Compare datasets include information on the patient experience from the Consumer Assessment of Healthcare Providers and Systems Hospital Survey (HCAHPS) conducted in 4,806 hospitals during the period from April 1st 2016 to March 31st 2017. The HCAHPS survey is administered to a random sample of adult patients across medical conditions between 48 hours and 6 weeks after discharge. Hospital Compare datasets provide data on the adoption of certified EHR from the Inpatient Psychiatric Facility Quality Reporting (IPFQR) Program in 2016, with data for 1,655 psychiatric hospitals.

Using the Medicare identification number issued by the Medicare Administrative Contractor’s (MAC) Provider Enrollment Department to a unique provider, data from different sources were merged into a master dataset. For the purpose of better assess the reliable of hospital performance from the HCAHPS survey, 649 hospitals that received fewer than 100 responses to HCAHPS surveys were excluded from the total 1,655 psychiatric hospitals in our analysis. The final study sample included 1,006 psychiatric hospitals with total 1,101,140 unique patients involved as respondents to the HCAHPS surveys from those hospitals. Because the information was anonymous and no personal information was collected, this study was exempt from requirement for institutional review board approval.

Certified EHR adoption and cohorts

In IPFQR Program, there was a structural measure evaluating the degree to which hospitals adopted certified EHR in health services. Hospitals were required to attest to one of three statements that best represented hospital’s highest typical adoption of EHR: 1) Certified EHR technology (certified under the Office of the National Coordinator (ONC) for Health Information Technology (HIT) Certification Program) is employed most commonly to exchange health information at times of transitions in care; 2) Non-Certified EHR Technology (that is, not certified under the ONC HIT Certification Program) is used most commonly to transfer health information at times of transitions in care; 3) Paper or Other Form (for example, email) is the most common approach to conduct information exchange not involving the transfer of health information using EHR technology at times of transitions in care. The psychiatric hospitals choosing the first statement were included into observation group defined as hospitals with Certified EHR, whereas those responding with the second or third statement were categorized into a control group defined as hospitals with non-certified EHR. Only 20 hospitals using “non-certified EHR” in our dataset, which we combined with those hospitals using “Paper or Other Form” into the control group as “Paper-based/Non-Certified” (refers to without certified EHR).
Outcome measures of patient experience

There were 11 publicly reported measures for patient experience in HCAHPS database: communication with nurses, communication with doctors, responsiveness of hospital staff, pain management, communication about medicines, discharge information, care transition, cleanliness of hospital environment, quietness of hospital environment, overall hospital rating and recommend the hospital. Each measure was constructed from an individual item or composited based on two/three items on the HCAHPS survey which includes 25 items in total. A 0–100 linear-scaled score (“Linear Score”) for each measure was calculated using a set of algorithms based on the responses to the survey items. [33, 34] Details regarding the specifics of how these measures were constructed and how the ”Linear Score” were calculated are available online at www.hcahpsonline.org/en/hcahps-star-ratings/.

We hypothesize that there will be positive associations between certified EHR adoption and those measures related to information communication: communication with nurses, communication with doctors, responsiveness of hospital staff, communication about medicines, discharge information, care transition, overall hospital rating and recommend the hospital.

Hospital characteristics

All included hospitals were community hospitals, long-term hospitals, and acute care hospitals that provided inpatient medical care. Hospitals affiliated to a certain health care system were coded as “system affiliation” ("1") and other hospitals coded as “non-system affiliation” ("0"). Teaching status included non-teaching ("0") and teaching ("1") that combined major and micro teaching hospitals defined in AHA. Hospital locations were divided into rural area ("0") and urban area ("1"). Bed-size was coded as small (< 200 beds, coded as "0"), medium (200–400 beds, "1"), and large (> 400 beds, "2"). Hospital ownership was classified as government (coded as "0"), non-profit ("1"), and for-profit ("2").

Data analysis

Independent samples t-tests were employed to examine the statistic differences in patient experience between certified EHR adoption (coded as “1” ) and paper-based/non-certified EHR (coded as “0”). However, previous research have indicated that patient experience may potentially be correlated to hospital characteristics including ownership, [35, 36] hospital location, [36, 37] hospital bed size, [38, 39] and teaching status [40]. To determine independent association between certified EHR adoption and outcome of patient perception, variables about hospital characteristics were entered into a multiple linear regression model that also accounted for significant correlations between variables. The regression model is given below/ was as follows.

\[
\text{Patient experience} = f(\text{certified EHR adoption, bed size, urban location, teaching status, ownership, affiliation}).
\]

All p values were 2-tailed and p < 0.05 was considered statistically significant. Data analyses were conducted using IBM SPSS statistical software program, version 24.0 (IBM SPSS, 2017).

Results

Hospital characteristics and certified EHR adoption

Hospital organizational characteristics, presented by certified EHR adoption status, are summarized in Table 1. Of the 1,006 sampled psychiatric hospitals in the U.S., the majority were affiliated with the healthcare systems (71.3%), located in urban area (77.8%), and belong to
teaching hospitals (61.7%); slightly more than half (51.4%) were non-government & non-profit entities. The majority (74.1%) had less than 400 beds.

Among the 1,006 hospitals, 564 (56.1%) have adopted certified EHR technology. There was significant difference in ownership type ($p = 0.043$), teaching status ($p = 0.001$), system affiliation ($p = 0.011$), bed-size ($p < 0.001$), and location ($p = 0.003$) between hospitals with and without certified EHR adoption.

## Association of patient experience and certified EHR adoption

Among the 11 measures of patient experience, only two measures (“cleanliness” and “doctor communication”) saw subtly but non-significantly lower scores in hospitals with certified EHR, whereas all other measures scored slightly higher in univariate analyses. Hospitals with certified EHR had significantly higher average scores in three measures of “recommend hospital” (Mean difference = 1.05; $t = 4.0, p < 0.001$), “overall hospital rating” (Mean difference = 0.46; $t = 2.5, p = 0.013$), and “care transition” (Mean difference = 0.38; $t = 3.1, p = 0.002$) (Table 1).

In addition, Pearson’s correlation analysis showed associations between certified EHR adoption and measures of patient experience including “care transition”, “discharge information”, “responsiveness of hospital staff”, “overall hospital rating” and “recommendation” (Table 2).

Table 3 presents the results from multiple linear regression that test the association between patient experience and certified EHR adoption. Controlled for hospital organizational

### Table 1. Hospital characteristics by EHR status.

| Dependent variables, Mean(SD) ** | All (n = 1,006) | Certified EHR (n = 564) | Paper-based/Non-Certified EHR (n = 442) | p-value |
|----------------------------------|-----------------|------------------------|---------------------------------------|---------|
| Responsiveness of hospital staff | 84.0(3.8)       | 84.0(3.6)              | 83.9(4.0)                             | 0.561   |
| Discharge information            | 86.7(3.4)       | 86.9(3.2)              | 86.5(3.6)                             | 0.084   |
| Care transition                  | 80.7(2.5)       | 81.0(2.4)              | 80.4(2.6)                             | 0.002   |
| Overall hospital rating          | 88.1(2.9)       | 88.3(2.8)              | 87.8(3.0)                             | 0.013   |
| Recommend hospital               | 87.2(4.1)       | 87.7(4.1)              | 86.6(4.2)                             | <0.001  |

### Independent variables, N(%)*

| Ownership* | Government | 157(21.5) | 88(15.6) | 69(15.7) | 0.043 |
|------------|------------|-----------|----------|----------|-------|
|            | Non-profit | 637(51.4) | 374(66.3) | 263(59.9) |       |
|            | For profit  | 209(27.1) | 102(18.1) | 107(24.4) |       |
| Teaching status | No | 385(38.3) | 190(33.7) | 195(44.1) | 0.001 |
|            | Yes        | 621(61.7) | 374(66.3) | 247(55.9) |       |
| System affiliation | No | 289(28.7) | 144(25.5) | 145(32.8) | 0.011 |
|            | Yes        | 717(71.3) | 420(74.5) | 297(67.2) |       |
| Location* | Rural      | 223(22.2) | 106(18.8) | 117(26.7) | 0.003 |
|            | Urban      | 780(77.8) | 458(81.2) | 322(73.3) |       |
| Bed size* | Small      | 415(41.4) | 203(36.0) | 212(48.3) | <0.001 |
|            | Medium     | 328(32.7) | 184(32.6) | 144(32.8) |       |
|            | Large      | 260(25.9) | 177(31.4) | 83(18.9)   |       |

Abbreviations: EHR, electronic health records.

* Pearson χ² tests for categorical variables.

** Independent-samples t tests were conducted to compare the difference in means of measures for patient perception of interoperability.

* Missing values

Notes: Results related to 6 variables, including communication with nurses, communication with doctors, pain management, communication about medicines, cleanliness of hospital environment and quietness of hospital environment, were not presented in this paper because no significant associations had been found between them and certified EHR adoption.

https://doi.org/10.1371/journal.pone.0234607.t001
characteristics, results from the linear regression analysis indicated that there was a significant association between certified EHR adoption and five satisfaction measures: "discharge information" ($\beta = 0.45$, 95% CI = [0.03, 0.86]; $t = 2.09$, $p = 0.037$), "care transition" ($\beta = 0.44$, 95% CI = [0.14, 0.75]; $t = 2.84$, $p = 0.005$), "responsiveness of hospital staff" ($\beta = 0.47$, 95% CI = [0.04, 0.90]; $t = 2.13$, $p = 0.033$), "recommend hospital" ($\beta = 0.66$, 95% CI = [0.16,1.16]; $t = 2.13$, $p = 0.033$), and "overall hospital rating" ($\beta = 0.39$, 95% CI = [0.03, 0.75]; $t = 2.09$, $p = 0.037$).

### Table 2. Correlations between Hospital characteristics and EHR status.

| Independent variable | Care transition, Coef. (95% CIs) | Discharge information, Coef. (95% CIs) | Responsiveness of hospital staff, Coef. (95% CIs) | Recommendation, Coef. (95% CIs) | Overall hospital rating, Coef. (95% CIs) |
|----------------------|---------------------------------|----------------------------------------|-----------------------------------------------|-------------------------------|----------------------------------------|
| Certified EHR *      | 0.44(0.14--0.75)                | 0.46(0.03--0.86)                       | 0.47(0.03--0.86)                              | 0.66(0.16--1.16)              | 0.39(0.03--0.75)                       |
| System affiliation b | 0.04(-0.33--0.40)               | 0.00(-0.50--0.50)                      | 0.04(-0.50--0.50)                             | 0.16(-0.43--0.75)             | 0.15(-0.28--0.58)                      |
| Location-urban c     | -0.56(-0.98--0.14)              | -0.97(-1.55--0.40)                     | -1.94(-1.55--0.40)                            | 0.24(-0.45--0.93)             | -0.53(-1.03--0.03)                     |
| Teaching status d    | -0.25(-0.63--0.12)              | -0.42(-0.93--0.10)                     | -0.90(-0.93--0.10)                            | -0.07(-0.69--0.54)            | -0.42(-0.87--0.03)                     |
| Bedsize-middle e     | -0.03(-0.42--0.37)              | -0.31(-0.84--0.23)                     | -0.97(-0.84--0.23)                            | 0.68(0.04--1.32)              | 0.17(-0.30--0.63)                      |
| Bedsize-large f      | 0.04(-0.42--0.50)               | -0.46(-1.09--0.17)                     | -1.65(-1.09--0.17)                            | 1.41(0.66--2.17)              | 0.44(-0.11--0.99)                      |
| Ownership-non-profit g | 0.40(-0.38--0.83)               | 1.06(0.46--1.66)                       | 1.10(0.46--1.66)                              | 0.47(-0.24--1.19)             | 0.30(-0.22--0.82)                      |
| Ownership-profit h   | -1.68(-2.23--1.14)              | -0.48(-1.23--0.27)                     | -0.95(-1.23--0.27)                            | -2.19(-3.1--1.29)             | -1.03(-1.68--0.38)                     |

- *P value $<0.05$
- **P value $<0.001$

a: reference group is Paper-based/Non-Certified EHR
b: reference group is Non-system affiliation
c: reference group is Location-rural
d: reference group is Non-teaching status
e, f: reference group is Bedsize-small
g, h: reference group is Ownership-government.

### Table 3. Regression results of patient experience measures.

| Independent variable | Care transition, Coef. (95% CIs) | Discharge information, Coef. (95% CIs) | Responsiveness of hospital staff, Coef. (95% CIs) | Recommendation, Coef. (95% CIs) | Overall hospital rating, Coef. (95% CIs) |
|----------------------|---------------------------------|----------------------------------------|-----------------------------------------------|-------------------------------|----------------------------------------|
| Certified EHR *      | 0.44(0.14--0.75)                | 0.46(0.03--0.86)                       | 0.47(0.03--0.86)                              | 0.66(0.16--1.16)              | 0.39(0.03--0.75)                       |
| System affiliation b | 0.04(-0.33--0.40)               | 0.00(-0.50--0.50)                      | 0.04(-0.50--0.50)                             | 0.16(-0.43--0.75)             | 0.15(-0.28--0.58)                      |
| Location-urban c     | -0.56(-0.98--0.14)              | -0.97(-1.55--0.40)                     | -1.94(-1.55--0.40)                            | 0.24(-0.45--0.93)             | -0.53(-1.03--0.03)                     |
| Teaching status d    | -0.25(-0.63--0.12)              | -0.42(-0.93--0.10)                     | -0.90(-0.93--0.10)                            | -0.07(-0.69--0.54)            | -0.42(-0.87--0.03)                     |
| Bedsize-middle e     | -0.03(-0.42--0.37)              | -0.31(-0.84--0.23)                     | -0.97(-0.84--0.23)                            | 0.68(0.04--1.32)              | 0.17(-0.30--0.63)                      |
| Bedsize-large f      | 0.04(-0.42--0.50)               | -0.46(-1.09--0.17)                     | -1.65(-1.09--0.17)                            | 1.41(0.66--2.17)              | 0.44(-0.11--0.99)                      |
| Ownership-non-profit g | 0.40(-0.38--0.83)               | 1.06(0.46--1.66)                       | 1.10(0.46--1.66)                              | 0.47(-0.24--1.19)             | 0.30(-0.22--0.82)                      |
| Ownership-profit h   | -1.68(-2.23--1.14)              | -0.48(-1.23--0.27)                     | -0.95(-1.23--0.27)                            | -2.19(-3.1--1.29)             | -1.03(-1.68--0.38)                     |

- *P value $<0.05$
- **P value $<0.001$
t = 2.68, p = 0.010), and “overall hospital rating” (β = 0.39, 95% CI = [0.03,0.75]; t = 2.11, p = 0.035). These results almost remained consistent with those from univariate analysis.

The adjusted R² values in all the five regression models indicated that those regression models had explained 4% to 22% of variance in each patient experience measure respectively (Table 3). In multivariate analysis, all multiple linear regression models had significant F tests, indicating the overall significance of the models.

Discussion

There is widespread agreement that the certified EHR is a lever to the care quality among hospitals which theoretically is helpful to improve service process and result in better patient experience. [9, 41] Empirical evidence is needed to testify about the implications of certified EHR use on the patient experience in psychiatric hospitals. This study sought to explore association between certified EHR adoption and patient experience in U.S. psychiatric hospitals by assessing the disparities in patient perception between psychiatric hospitals with and without certified EHR. Results in this study revealed that certified EHR adoption is positively and significantly associated with several categories of patient experience elements.

Our results reveal that a higher level of patient satisfaction with care transition was found in psychiatric hospitals which have adopted certified EHRs. According to the HCAHPS survey, highly scored satisfaction with care transition means that patients could understand better about their care when leaving hospitals, such as clearly understanding the purpose for taking each of their medications and their own responsibilities for managing their health. The implementation of certified EHR could lead to improvements in care information availability for patients and/or their families, [19, 42] which may be beneficial and helpful for patients to better manage their care. Certified EHR may also help mental health providers take patients’ preferences (and those of their families or caregivers) into account in deciding what patients’ health care needs would be when patients were discharged [25]. In addition, certified EHR advance the data interoperability and promote sharing of information among providers, which potentially improve service coordination across different settings. [8]

We also identified positive relationships between patient satisfaction with discharge information in hospitals adopting certified EHR. Compared to the information provided in a paper format, certified EHR adoption proved to be a more accurate, accessible and safer form of communication between patients and providers. It is critical for psychiatric patients and their families/caregivers to receive information about their health conditions and patient’s care plan at the discharge. Safety features of certified EHR, such as storability of data and spell check, may provide patients with easier access to the correct health information after discharge. [25] In contrast, patients may be likely to be worried about illegibility of handwriting and reading information correctly in paper health records. [25, 43, 44] Also, EHR systems can provide easy and quick access to patients’ data, such as test results and billings for multiple services and strategies, which is useful to improve availability of discharge information for patients.

Our study results showed that certified EHR adoption is positively related to the patient perception of the responsiveness of hospital staff. On the one hand, staff may be free from the manual task with digital technology and have more time for the attention to patient progress and subsequent problem solving; [45] on the other hand, certified EHR may assist mental health practitioners timely tracking the patient situation and behavior changes, manage risk with incident notification, and automatically remind staff of the upcoming events in the care plan [9]. All the efficient interaction between patients and mental health practitioners could potentially reduce their waiting time for services and thus improve their patient experience with responsiveness.
Furthermore, hospitals with certified EHR embraced higher overall patient experience and were more likely to be recommended by patients to their friends and family members. These two comprehensive measures, “recommend hospital” and “overall hospital rating”, were more robust to totally demonstrate the positive effect of certified EHR on the patient satisfaction than those individual measures above which showed consistent positive results.

Despite of results mentioned above, patient experience with interpersonal care, including doctor and nurse communication were not found significant difference between with and without certified EHR. These results were consistent with previous works that there was no relationship between EHR adoption and patient perceptions about patient-doctor communication. [30, 46, 47] Some prior relevant work even found that patient-doctor communication may be negatively impacted by EHR adoption, possibly due to less experience and comfort of mental health practitioners incorporating EHR technology into patient care, [25, 31, 48] as well as distraction to patients and reduction in eye-contact. [32] Those neutral or negative results remind that interpersonal care should be a focus to reduce the unexpected adverse effects of certified EHR adoption in psychiatric hospitals [49] as communication skills and psychodynamic interpretations are arguably more highlighted in psychiatric hospitals than in non-psychiatric settings.

In all, positive findings in this paper should lessen the concerns of psychiatric hospitals over potentially patient dissatisfaction because of adoption of certified EHR. To our knowledge, this is the first study that provides empirical evidence at hospital level using national data to support that policy makers should advocate incentive programs in psychiatric hospitals. Federal and state governments should expand the incentive program to psychiatric providers for the certified EHR adoption and sponsor to update certified EHR to meet the requirements of psychiatric privacy laws. [50, 51]

There are limitations to our study that should be noticed. First, we excluded hospitals with missing values in key variables when merging the data from different data sources. This may create selection bias. There may also be selection bias in patients that chose to respond to the HCAHPS survey. [52] Second, as an observational study, it cannot identify the causal mechanisms underlying the relationships between patient perceptions and certified EHR adoption, although we adjusted for several potential confounders (e.g., teaching status, location, ownership). In addition, our findings may not be generalizable to non-psychiatric hospitals or outpatient settings. Finally, analysis of this study at hospital level did not consider patient demographic characteristics which were not available from the original data but may potentially inform patient experience and bring about bias.

Further study should apply longitudinal national data to testify about the causal association between certified EHR and patient experience, with considering more potential confounders like patient characteristics. Also, intrinsic mechanism should be examined to explain how certified EHR adoption is able to improve overall patient evaluation in psychiatric hospitals.

**Summary**

In conclusion, we found marked variation in patient experience between hospitals with and without certified EHR across U.S. psychiatric hospitals. Psychiatric hospitals with certified EHR are more likely to get higher level of patient experience. While results of this study do not imply causality between patient experience and certified EHR adoption, they suggest the positive association between certified EHR adoption and patient experience.

**Acknowledgments**

We are also grateful to Dr. Christy Harris Lemark (Department of Health Services Administration, University of Alabama at Birmingham) who offered a precious chance to authors to conduct this research in the Department of Health Services Administration.
Author Contributions

Conceptualization: Xuejun Hu, Haiyan Qu, Shannon H. Houser, Min Yu.
Data curation: Xuejun Hu, Jingmei Ding.
Formal analysis: Xuejun Hu, Huoliang Chen.
Funding acquisition: Xuejun Hu, Xianzhi Zhang, Min Yu.
Methodology: Xuejun Hu, Xianzhi Zhang.
Resources: Huoliang Chen, Xianzhi Zhang.
Software: Jingmei Ding.
Supervision: Haiyan Qu, Shannon H. Houser, Min Yu.
Validation: Shannon H. Houser, Min Yu.
Writing – original draft: Xuejun Hu.
Writing – review & editing: Xuejun Hu, Haiyan Qu, Shannon H. Houser, Jingmei Ding, Huoliang Chen, Xianzhi Zhang, Min Yu.

References

1. Centers For Medicare Medicaid HHS. Medicare and Medicaid Programs; Electronic Health Record Incentive Program—Stage 3 and Modifications to Meaningful Use in 2015 Through 2017. Final rules with comment period. Fed Regist. 2015; 80(200):62761–62955. PMID: 26477064
2. Payne TH. The electronic health record as a catalyst for quality improvement in patient care. Heart. 2016; 102(22):1782–1787. https://doi.org/10.1136/heartjnl-2015-308724 PMID: 27504000
3. Jones SS, Rudin RS, Perry T, et al. Health information technology: an updated systematic review with a focus on meaningful use. Ann Intern Med. 2014; 160(1):48–54. https://doi.org/10.7326/M13-1531 PMID: 24573664
4. Bright TJ, Wong A, Dhurjati R, et al. Effect of clinical decision-support systems: a systematic review. Ann Intern Med. 2012; 157(1):29–43. https://doi.org/10.7326/0003-4819-157-1-201207030-00450 PMID: 22751758
5. Wolf L, Harvell J, Jha AK. Hospitals Ineligible For Federal Meaningful-Use Incentives Have Dismally Low Rates Of Adoption Of Electronic Health Records. Health Affairs. 2012; 31(3):505–513.
6. Walker D, Mora A, Demosthenidy MM, et al. Meaningful Use Of EHRs Among Hospitals Ineligible For Incentives Lags Behind That Of Other Hospitals, 2009–13. Health Affairs. 2016; 35(3):495–501. https://doi.org/10.1377/hlthaff.2015.0924 PMID: 26953305
7. Henry J, Pylypchuk Y, Searcy T, et al. Adoption of Electronic Health Record Systems among U.S. Non-Federal Acute Care Hospitals: 2008-2015.Onc Data Brief. 35:1–9. Washington DC: Office of the National Coordinator for Health Information Technology.
8. McGregor B, Mack D, Wrenn G, et al. Improving Service Coordination and Reducing Mental Health Disparities Through Adoption of Electronic Health Records. Psychiatr Serv. 2015; 66(9):985–987. https://doi.org/10.1176/appi.ps.201400095 PMID: 25975885
9. Bruns EJ, Hook AN, Parker EM, et al. Impact of a Web-Based Electronic Health Record on Behavioral Health Service Delivery for Children and Adolescents: Randomized Controlled Trial. J Med Internet Res. 2018; 20(8):e10197. https://doi.org/10.2196/10197 PMID: 29903701
10. West JC, Clarke DE, Duffy FF, et al. Are Psychiatrists Ready for Health Care Reform? Findings From the Study of Psychiatric Practice Under Health Care Reform. Psychiatr Serv. 2016; 67(12):1292–1299. https://doi.org/10.1176/appi.ps.201500536 PMID: 27524368
11. Salomon RM, Blackford JU, Rosenbloom ST, et al. Openness of patients’ reporting with use of electronic records: psychiatric clinicians’ views. Journal of the American Medical Informatics Association. 2010; 17(1):54–60. https://doi.org/10.1197/jamia.M3341 PMID: 20664802
12. Ser G, Robertson A, Sheik A. A qualitative exploration of workarounds related to the implementation of national electronic health records in early adopter mental health hospitals. PLoS One. 2014; 9(1): e77669. https://doi.org/10.1371/journal.pone.0077669 PMID: 24454678
13. Rumshisky A, Ghassemi M, Naumann T, et al. Predicting early psychiatric readmission with natural language processing of narrative discharge summaries. *Translational Psychiatry*. 2016; 6(10):e921. https://doi.org/10.1038/tp.2015.182 PMID: 27754482

14. Iqbal E, Mallah R, Jackson RG, et al. Identification of Adverse Drug Events from Free Text Electronic Patient Records and Information in a Large Mental Health Case Register. *PLoS One*. 2015; 10(8): e134208.

15. Kaufman KR, Hyler SE. Problems with the electronic medical record in clinical psychiatry: a hidden cost. *J Psychiatr Pract*. 2005; 11(3):200–204. https://doi.org/10.1097/00131746-200505000-00008 PMID: 15920394

16. Krishna R. The Impact of Health Information Technology on the Doctor-Patient Relationship in Child and Adolescent Psychiatry. *Child and Adolescent Psychiatric Clinics of North America*. 2017; 26(1):67–75. https://doi.org/10.1016/j.chc.2016.07.007 PMID: 27837943

17. Stewart RF, Kroth PJ, Schuyler M, et al. Do electronic health records affect the patient-psychiatrist relationship? A before & after study of psychiatric outpatients. *BMC Psychiatry*. 2010; 10:3.

18. Boyer L, Renaud MH, Baumstarck-Barrau K, et al. Establishment of an electronic medical record in a psychiatric hospital: evolution of professionals’ perceptions. *Encephale*. 2010; 36(3):236–241. https://doi.org/10.1016/j.encep.2009.05.004 PMID: 20620266

19. Boyer L, Samuelian JC, Fieschi M, et al. Implementing electronic medical records in a psychiatric hospital: A qualitative study. *Int J Psychiatry Clin Pract*. 2010; 14(3):223–227. https://doi.org/10.3109/13651501003717243 PMID: 24917324

20. Riahi S, Fischler I, Stuckey MI, et al. The Value of Electronic Medical Record Implementation in Mental Healthcare: A Case Study. *JMIR Medical Informatics*. 2017; 5(1):e1. https://doi.org/10.2196/medinform.6512 PMID: 28057607

21. Batbaatar E, Dorjdagva J, Luvussenyam A, et al. Determinants of patient satisfaction: a systematic review. *Perspectives in Public Health*. 2017; 137(2):89–101. https://doi.org/10.1177/17579196634136 PMID: 27004489

22. Kaziy AS, Diana ML, Ford EW, et al. Is electronic health record use associated with patient satisfaction in hospitals? *Health Care Management Review*. 2012; 37(1):23–30. https://doi.org/10.1097/HMR.0b013e3182307bd3 PMID: 21918464

23. Shield RR, Goldman RE, Anthony DA, et al. Gradual electronic health record implementation: new insights on physician and patient adaptation. *Ann Fam Med*. 2010; 8(4):316–326. https://doi.org/10.1370/afm.1136 PMID: 20644186

24. Irani JS, Middleton JL, Marfatia R, et al. The Use of Electronic Health Records in the Exam Room and Patient Satisfaction: A Systematic Review. *The Journal of the American Board of Family Medicine*. 2009; 22(5):553–562. https://doi.org/10.3122/jabfm.2009.05.080259 PMID: 19734402

25. Rose D, Richter LT, Kapustin J. Patient experiences with electronic medical records: lessons learned. *J Am Assoc Nurse Pract*. 2014; 26(12):674–680. https://doi.org/10.1002/2327-6924.12170 PMID: 25234112

26. Duarte JG, Azevedo RS. Electronic health record in the internal medicine clinic of a Brazilian university hospital: Expectations and satisfaction of physicians and patients. *International Journal of Medical Informatics*. 2017; 102:80–86. https://doi.org/10.1016/j.ijmedinf.2017.03.007 PMID: 28495351

27. Harle CA, Marlow NM, Schmidt SO, et al. The effect of EHR-integrated patient-reported outcomes on satisfaction with chronic pain care. *Am J Manag Care*. 2016; 22(12):e403–e408. PMID: 27982672

28. Hessel A, Flynn L, Cimiotti JP, et al. Impact of Health Information Technology on the Quality of Patient Care. *Online J Nurs Inform*. 2015; 19.

29. Jarvis B, Johnson T, Butler P, et al. Assessing the Impact of Electronic Health Records as an Enabler of Hospital Quality and Patient Satisfaction. *Academic Medicine*. 2013; 88(10):1471–1477. https://doi.org/10.1097/ACM.0b013e3182a36cab PMID: 23969372

30. Mitchell JP. Electronic Healthcare’s Relationship With Patient Satisfaction and Communication. *J Healthc Qual*. 2016; 38(5):296–303. https://doi.org/10.1097/01.JHQ.0000462678.02018.92 PMID: 26042753

31. Meyerhoefner CD, Sherer SA, Deily ME, et al. Provider and patient satisfaction with the integration of ambulatory and hospital EHR systems. *J Am Med Inform Assoc*. 2018.

32. Marmor R, Clay B, Millen M, et al. The Impact of Physician EHR Usage on Patient Satisfaction. *Applied Clinical Informatics*. 2018; 09(01):11–14.

33. Centers For Medicare And Medicaid Services. *Technical Notes for HCAHPS Star Ratings* (Revised for December 2017 Public Reporting). https://www.hcahpsonline.org/globalassets/hcahps/star-ratings/tech-notes/2017-10_star-ratings_tech-notes.pdf. Accessed August 21, 2018.
34. Tverdal C, Howe E, Røe C, et al. Traumatic brain injury: Patient experience and satisfaction with discharge from trauma hospital. *Journal of Rehabilitation Medicine*. 2018; 50(6):505–513. https://doi.org/10.2340/16501977-2332 PMID: 29620136

35. Ediyattungalam R, Shivaji. Relationships between Patient Satisfaction, Quality, Outcomes and Ownership Type in US Hospitals: an Empirical Study(dissertation). Fairfield, IA: Maharishi University, 2012.

36. Lehrman WG, Elliott MN, Goldstein E, et al. Characteristics of hospitals demonstrating superior performance in patient experience and clinical process measures of care. *Med Care Res Rev*. 2010; 67(1):38–55. https://doi.org/10.1177/1077558709341323 PMID: 29638640

37. Kazley AS, Ford EW, Diana M, et al. Market factors related to hospitals’ patient satisfaction ratings. *Journal of Hospital Administration*. 2015; 4(4):40–47.

38. Elliott MN, Lehrman WG, Goldstein EH, et al. Do hospitals rank differently on HCAHPS for different patient subgroups? *Med Care Res Rev*. 2010; 67(1):56–73. https://doi.org/10.1177/1077558709339066 PMID: 19605621

39. Elliott MN, Lehrman WG, Goldstein EH, et al. Hospital survey shows improvements in patient experience. *Health Aff (Millwood)*. 2010; 29(11):2061–2067.

40. Raleigh VS, Frosini F, Sizmur S, et al. Do some trusts deliver a consistently better experience for patients? An analysis of patient experience across acute care surveys in English NHS trusts. *BMJ Qual Saf*. 2012; 21(5):381–390. https://doi.org/10.1136/bmjqs-2011-000588 PMID: 22421913

41. Holmgren AJ, Adler-Milstein J. Health Information Exchange in US Hospitals: The Current Landscape and a Path to Improved Information Sharing. *J Hosp Med*. 2017; 12(3):193–198. https://doi.org/10.12788/jhm.2704 PMID: 28272599

42. Meyerhoefeder CD, Sherer SA, Deily ME, et al. Provider and patient satisfaction with the integration of ambulatory and hospital EHR systems. *J Am Med Inform Assoc*. 2018.

43. Dal Sasso GT, Barra DC, Paese F, et al. Computerized nursing process: methodology to establish associations between clinical assessment, diagnosis, interventions, and outcomes. *Rev Esc Enferm USP*. 2013; 47(1):242–249. https://doi.org/10.1590/s0080-62342013000100031 PMID: 23515827

44. Gerard M, Fossa A, Focarelli PH, et al. What Patients Value About Reading Visit Notes: A Qualitative Inquiry of Patient Experiences With Their Health Information. *J Med Internet Res*. 2017; 19(7):e237. https://doi.org/10.2196/jmir.7212 PMID: 28710055

45. Ying LT. The Use of Information Technology to Enhance Patient Safety and Nursing Efficiency. *Stud Health Technol Inform*. 2018; 250:192. PMID: 29857427

46. Alkureishi MA, Lee WW, Lyons M, et al. Impact of Electronic Medical Record Use on the Patient–Doctor Relationship and Communication: A Systematic Review. *Journal of General Internal Medicine*. 2016; 31(5):548–560. https://doi.org/10.1007/s11606-015-3582-1 PMID: 26786877

47. Farber NJ, Liu L, Chen Y, et al. EHR use and patient satisfaction: What we learned. *J Fam Pract*. 2015; 64(11):657–696. PMID: 26697540

48. Strudwick G, Eysu T. Electronic Health Record Use by Nurses in Mental Health Settings: A Literature Review. *Archives of Psychiatric Nursing*. 2015; 29(4):238–241. https://doi.org/10.1016/j.apnu.2015.03.007 PMID: 26165979

49. Carroll T, Tonges M, Ray J. Preparing for Electronic Medical Record Implementation. *JONA: The Journal of Nursing Administration*. 2017; 47(1):538–564. https://doi.org/10.1097/NNA.0000000000000543 PMID: 29065072

50. Busch AB, Bates DW, Rauch SL. Improving Adoption of EHRs in Psychiatric Care. *N Engl J Med*. 2018; 378(18):1665–1667. https://doi.org/10.1056/NEJMp1800465 PMID: 29719176

51. Peters TE. Transformational Impact of Health Information Technology on the Clinical Practice of Child and Adolescent Psychiatry. *Child and Adolescent Psychiatric Clinics of North America*. 2017; 26(1):55–66. https://doi.org/10.1016/j.chc.2016.07.003 PMID: 27837942

52. Tsai TC, Orav EJ, Jha AK. Patient Satisfaction and Quality of Surgical Care in US Hospitals. *Annals of Surgery*. 2015; 261(1):2–8. https://doi.org/10.1097/SLA.0000000000007685 PMID: 24887985