

6-15-2021

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### Repository Citation

Upadhyay, S., Opoku-Agyeman, W. (2021). Factors that Determine Comprehensive Categorical Classification of EHR Implementation Levels. *Health Services Insights*, 14 1-10.

<http://dx.doi.org/10.1177/11786329211024788>

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# Factors that Determine Comprehensive Categorical Classification of EHR Implementation Levels

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Health Services Insights  
Volume 14: 1–10  
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sagepub.com/journals-permissions  
DOI: 10.1177/11786329211024788



**ABSTRACT:** Electronic Health Records (EHRs) have the potential to alleviate patient safety mistakes. Of the various levels of EHR, advanced or higher-level functionalities of EHR are designed to improve patient safety. Certain organizational and environmental factors may pose as barriers toward implementing all of the functionalities, leaving certain hospitals intermediate between basic and comprehensive levels of implementation. This study identifies a comprehensive categorical classification that includes hospitals that have functionalities between basic and comprehensive levels of EHR and determines the organizational and environmental factors that may influence hospitals to implement one or more combinations of these categories. A longitudinal panel design was used. Ordinal logistic regression with random effects model was fitted with robust cluster standard errors. Our sample consisted of non-federal general acute care hospitals utilizing a panel design from 2010 to 2016 with 17 586 hospital-year observations (or an average of 2600 hospitals per year). Larger size hospitals, ones with higher total margin, metropolitan and urban hospitals, system affiliated hospitals, and those in higher managed care penetration areas have higher odds of belonging in one of the higher categories of EHR implementation. Hospitals that can access a greater amount of human resources and financial assets from their environments, may implement higher levels of EHR. Initial and maintenance costs of EHR, interoperability issues, and inability to distribute high costs of training across facilities may stymie implementation of higher EHR functionalities. Policymaking to encourage competition among vendors may possibly lower the implementation price for hospitals with limited resources.

**KEYWORDS:** EHR implementation, hospitals, comprehensive EHR, RDT

**RECEIVED:** February 3, 2021. **ACCEPTED:** May 21, 2021.

**TYPE:** Original Research

**FUNDING:** The author(s) received no financial support for the research, authorship, and/or publication of this article.

**DECLARATION OF CONFLICTING INTERESTS:** The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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## Introduction

Patient safety mistakes and medical errors lead to approximately 98 000 deaths in the U.S. every year, according to the 1999 Institute of Medicine report *To Err is Human*.<sup>1</sup> More recent estimates show that at least 210 000 deaths per year may be associated with preventable harm.<sup>2</sup> Studies show that patient safety mistakes can be alleviated by harnessing the potential of health information technology. Electronic Health Records (EHRs), besides having a role in improving the efficiency and quality of healthcare delivery, are essential to improving patient safety.<sup>3</sup> EHRs have been implemented rapidly in the wake of the American Recovery and Reinvestment Act of 2009, by hospitals and healthcare providers.

Of the various levels of EHR, advanced or higher-level functionalities of EHR are designed to improve patient safety in the delivery of healthcare.<sup>4</sup> Comprehensive EHR systems that have higher level functionalities allow for decision support, barcoding, and interfaces with other systems, which are features that help streamline the safety and quality processes.<sup>5</sup> While hospitals may have invested necessary efforts toward implementation, specific barriers may prevent them from implementing all of the functionalities, leaving them intermediate between basic and comprehensive levels of implementation.

Barriers can be in the form of organizational and environmental factors, for instance, hospital characteristics, expenses,

and economics of the population that the hospital serves. Studies in the past have analyzed factors related with general EHR adoption<sup>6</sup> but not explored the factors associated with lower levels of EHR implementation as compared to higher levels. Our study attempts to shed light on these organizational and environmental factors, which would provide a deeper understanding to influence EHR implementation at higher levels and possibly positively impact patient safety. In doing so, our study also makes an effort to update the extant definitions of EHR categories<sup>7,8</sup> and provide a more comprehensive classification of EHR implementation that includes hospitals that have intermediate EHR.

Therefore, the purpose of this study is 2-fold: (1) to identify a comprehensive categorical classification that includes hospitals that have functionalities between basic and comprehensive functionalities of EHR, and (2) to determine the organizational and environmental factors that may influence hospitals in implementing one or more combination of these categories. Our paper highlights the intermediate category of EHR implementation, which is more than basic EHR implementation and less than comprehensive EHR implementation. It is essential to consider this category so that policies can be incentivized not merely for EHR adoption but to implement higher functionalities of EHR so that they can be meaningfully used to impact quality and patient safety. For providers and practitioners, recognizing the factors that affect various levels of



EHR implementation, may assist them in determining the allocation of resources while meeting other organizational needs.

## Background for Study Aim 1

### *Previous classifications of EHR implementation in the literature*

In the current literature, a hospital was categorized as having a basic EHR if it reported full implementation of the following ten specific functionalities in at least 1 clinical unit of the hospital: (1) electronically maintaining patient demographic information, (2) physician notes, (3) nursing assessments, (4) patient problem lists, (5) patient medication lists, and discharge summaries; (6) electronically viewing laboratory reports, (7) radiologic reports, and diagnostic test results; (8) electronically ordering medications, (9) physicians' notes, and (10) nursing assessments. Furthermore, a hospital was defined as having a comprehensive EHR if it reported the above 10 basic functions and 14 additional functions (see Appendix 1), fully implemented in all major clinical units. Based on the above 2 definitions, hospitals that had all of the basic EHR functionalities and some but not all of the comprehensive EHR functionalities implemented in all clinical units were included in the basic or comprehensive EHR groupings.<sup>7,8</sup> Then, a continuous measure of EHR was constructed by Adler-Milstein et al<sup>9</sup> to reflect the gap between basic and comprehensive EHR categories. However, besides the continuous measure, there is no other method of defining the hospitals that have more than 10 functionalities implemented in at least 1 unit but do not have all 24 comprehensive functionalities.

## Conceptual Framework for Study Aim 2

For study aim #2, we use underpinnings of Resource Dependence Theory (RDT) to develop the conceptual framework of the relationship between organizational and environmental resources and various levels of EHR implementation. A prime tenet of the RDT is that organizations depend on resources for their survival and to avoid uncertainties that arise from exogenous changes, organizations devise strategies to reduce their dependence on external resources.<sup>10</sup> A hospital's decision to implement one or more levels of EHR is a rational adaptation toward changes in the environment. For example, a hospital management's choice of implementing the type and number of functionalities is an adaptive response to the dynamic environmental landscape.

Furthermore, this theory posits that organizations adapt by making specific choices in the face of constraints.<sup>11</sup> However, if they fail to demonstrate such use, after a few years, they would be penalized. Regulations increase the pressure on hospitals to use EHR meaningfully leading them to implement the basic functionalities that would assist in fulfilling meaningful requirements. For instance, a meaningful use objective for hospitals is to record all of the following patient demographics:

preferred language, sex, race, ethnicity, date of birth, date, and preliminary cause of death in the event of mortality in the eligible hospital or Critical Access Hospital. A functionality that falls under the basic category is Clinical Documentation-demographic characteristics of patients.<sup>7</sup> To meet this meaningful use objective under the HITECH regulation, hospitals must implement the basic functionality that enables them to collect patient demographics.

This theory further propounds that organizations' resources determine the degree of strategic managerial decisions.<sup>12</sup> Hospitals face the challenge of choosing among various strategies of EHR implementation, such as single vendor strategy, best of suite strategy, etc. Using strategic managerial decisions, hospitals may deal with challenges posed on their Health Information Technology flexibility and management capacity to meet organizational and regulatory demands. For instance, hospitals that employ strategic partnerships with several software vendors by maximizing their resources may be able to implement more advanced functionalities of EHR as compared to not having EHR.<sup>13</sup>

RDT assumes that the key to organizational survival is the ability to acquire and maintain resources.<sup>14</sup> To this effect, there are specific dimensions of the external environment: munificence, dynamism, and complexity, that influence organizations' capability to transact with other elements in the environment to acquire needed resources.<sup>15,16</sup> Evidence suggests that more munificent environments can help organizations engage in various activities to accomplish goals and innovate as compared to less munificent environments. For instance, adoption of technology, quality management programs, and diversifying services are adopted by more munificent hospitals.<sup>17,18</sup>

The cost of EHR implementation and maintenance is a significant barrier for hospitals that would like to adopt EHR.<sup>19</sup> Hospitals that have higher financial and human resources because of being large or being more profitable may be more likely to obtain the necessary inputs for higher levels of EHR implementation. Hospitals that are large and have higher profit margins may also be better able to develop, implement, evaluate, and maintain sophisticated IT systems.<sup>20,21</sup> Hospitals that have lower profit margins have been found to have worse processes of care and readmission rates.<sup>22</sup> In prior studies, EHR has often been associated with improving process quality of care.<sup>23</sup> It may be the case that hospitals that have low-profit margins are not able to prioritize quality as an initiative due to lack of resources, which may be limiting the gains brought by implementing higher levels of EHR. Larger and profitable hospitals that have more significant resources are more likely to purchase expensive EHR systems and implement higher levels of EHR.

Hospital geographic location (rural, urban, or metro) tends to influence the adoption of information technology. Hospitals in rural locations as compared to those in urban and metro locations may have a lower volume of patients, and

lower rates of occupancy.<sup>24</sup> They may also be under financial constraints, and under social pressures to provide uncompensated care as compared to their counterparts.<sup>25</sup> Given the burden of limited resources in a less munificent environment in the case of rural hospitals, they may not be able to implement higher levels of EHR. On the contrary, hospitals located in urban and metro areas may have greater access to information technology vendors, companies that provide technological support, and funding agencies, enabling them to implement higher levels of EHR.

Additionally, urban hospitals are located in densely populated areas that provide them access to skilled technical workers. Some higher EHR functionalities may require wireless networks to be accessed on digital devices and urban locations may have a better network for wireless providers as compared to rural.<sup>26</sup>

Hospital ownership drives organizational strategy that may determine the use of EHR for accomplishing organizational goals and mission. Recent research reports based on the American Hospital Association's IT supplement data have investigated the average number of EHR data use processes that hospitals engage in and inform clinical practice and have found that most significant increase from 2015 to 2017 in EHR data use has been among for-profit hospitals. However, non-profit hospitals already had high EHR data use in 2015, as compared to for-profit hospitals and public hospitals.<sup>27,28</sup> Both non-profit and for-profit engage in diverse quality improvement activities and more advanced functionalities would support the activities better. Given the use of EHR data for organizational efficiency purposes, we expect that both non-profit hospitals and for-profit hospitals would have a higher likelihood of implementing intermediate and advanced categories of EHR.

Hospitals that belong to a system may be able to reduce uncertainty arisen due to the unavailability of external resources by engaging in alliances and collaborations.<sup>14</sup> To meet the demands of the external environmental pressures, hospital systems diffuse best practices and shared knowledge across hospitals belonging to the system.<sup>29</sup> Relevant to this study, hospitals in a system would share ways in which higher EHR functionalities such as decision support systems (clinical reminders, drug-allergy alerts) can improve the quality and safety of care delivered to patients. Integration into systems allows hospitals to benefit from shared resources that extensive network of hospitals would bring, for instance, the cost of implementation and maintenance of advanced EHR functionalities would spread over a large number of hospitals thus lowering the cost to an individual hospital belonging to a system as compared to a non-system hospital. Coordination of administrative processes related to higher levels of EHR implementation can be done in a centralized manner in system hospitals, and a group of hospitals would be able to better negotiate the purchase price of higher EHR functionalities.

An environmental resource, the number of people without health insurance in a county, represents the low affordability of healthcare for people residing in that area. Hospitals in such counties may be devoid of the financial resources. Besides, hospitals that serve a majority of uninsured people may have the burden of treating people with higher severity of illness, diverting internal resources into taking care of uninsured patients. Studies have shown that uninsured families have a lower health status, have greater unmet medical needs, and suffer from a higher number of chronic conditions as compared to families with health insurance.<sup>30,31</sup> Hospitals that serve a greater number of people without health insurance may be limited in their financial resources to implement higher functionalities of EHR.

Environmental complexity encompasses heterogeneity or variation, as well as the concentration of environmental elements.<sup>15</sup> Various attributes that are involved in making strategic decisions are shown in complexity,<sup>18</sup> for example, managed care penetration and market competition. Managed care penetration represents the pervasiveness of regulatory stringency in a particular area, which may lead to an increase in negotiations with managed care organizations for contracts.<sup>25</sup> Due to this, there would be an increase in dependency on managed care and a decrease in financial flexibility, thus constraining the resources in a complex external environment. As hospitals encounter more inter-organizational relationships, they may need to compete with others to gain necessary inputs despite limited resources.<sup>32</sup> A higher concentration of managed care may limit resources for hospitals to adopt advanced EHR functionalities. This may increase uncertainty and slow down or reduce the implementation of higher levels of EHR.

## Methods

### *Data and sample*

Our study utilized data from 4 secondary data sources, including American Hospital Association (AHA) Annual Survey, AHA annual Information Technology (IT) survey, the Area Health Resource File (AHRF), and the Healthcare Cost Report Information System (HCRIS). The different datasets were linked using a hospital identification number of HCRIS and Federal Information Processing Standard Codes (FIPS codes). Our national sample consisted of non-federal general acute care hospitals utilizing an unbalanced panel design from 2010 to 2016 with 17 586 hospital-year observation (or an average of 2600 hospitals per year). Only data from 2010 to 2016 was available across all the above datasets as at the development of this study.

### *Measures*

*Dependent variable.* Following the methods of Adler-Milstein et al, and Jha et al, in creating a categorical grouping of hospitals as having either basic or comprehensive EHR, we created

our dependent variable (Levels of EHR Implementation) that explores other categories of EHR implemented at hospital that included hospitals that had all of the basic EHR functionalities and some but not all of the comprehensive EHR functionalities implemented in at least 1 clinical units. By this approach, we now identified hospitals that previous studies failed to categorize. These hospitals we identified as having some organizational and environmental factors that may hinder their levels of adopts and we wanted to know why. Specifically, for every EHR functionality that was partially implemented, a hospital received 1 points, and received 2 points when fully implemented cross multiple units while enforcing that all 10 basic functionalities have been met. Thus, we created the additional categories to fill the gap between basic and comprehensive categories. In our study, we include the following categories and their definitions: (1) Less than basic EHR—A hospital is termed as having less than basic EHR if it has less than 10 of the basic functionalities identified by prior researchers.<sup>7,8</sup> (2) Basic EHR—A hospital is termed as having basic EHR if 10 specific functionalities have been implemented in at least 1 clinical unit. This means that hospitals that have a partial implementation of those 10 functionalities would qualify as having basic EHR. (3) Intermediate EHR—A hospital is termed as having intermediate EHR if more than 10 functionalities are implemented in at least 1 clinical unit. (4) Intermediate-Basic EHR—A hospital is termed as having intermediate-basic EHR if more than ten specific functionalities are at least partially implemented. (5) Comprehensive EHR—A hospital is termed as having comprehensive EHR if all 24 functionalities are fully implemented across all units. All hospitals that were comprehensive EHR would have the 10 specific functionalities that are required under basic EHR category. Based on the above definitions, we created a set of ordered categories, in which, (i) hospitals that had less than basic EHR functionalities were classified as 0, (ii) hospitals that had basic EHR were classified as 1, (iii) hospitals that had intermediate only were classified as 2, (iv) hospitals that had basic and intermediate were classified as 3, and (v) hospitals that had basic and comprehensive were classified as 4.

*Independent variables.* The following organizational factors were used as independent variables: Hospital size (measured as total number of beds per 100), total margin (measured as total revenue less total expenses divided by total revenue multiplied by 100), hospital location (measured as urban, metropolitan, and rural-based on the Rural-Urban Continuum Code [RUCC] for the county where the hospital is located), hospital ownership (measured as public, not-for-profit, and for-profit), system membership (measured as “yes” if system affiliated, or “no” if not affiliated with a system), percent of population without health insurance (measured as total percentage of resident population without health insurance in a county), Medicare managed care penetration rate (measured as the ratio of Medicare advantage plan enrollees over eligible Medicare individuals multiplied by 100).

*Control variables.* We included several organizational and market-level control variables that could vary over time and confound the level of EHR implementation: payer mix (measured as share of total inpatient discharge by payer); teaching status (measured with a dummy variable; 0 = not a teaching hospital; 1 = teaching hospital). Hospitals were classified as a teaching hospital if they met any of the following criteria: (1) have residency training approved by the Accreditation Council for Graduate Medical Education; (2) medical school affiliation reported to the American Medical Association, (3) member of Council of Teaching Hospital of the Association of American Medical Colleges (COH), or residency approved by American Osteopathic Association. We also controlled for per capita income (measured as the total personal income of the residents in a given area divided by the resident population in HSA per 1000), and percent of population 65 years or older (measured as a percentage of the total resident population aged 65 years or older with a county). Market competition (measured by the Hirschman-Herfindahl Index (HHI), that represents the sum of the squared market shares in a market, with market share based on the system level share of hospital inpatients days in a Health Service Area, was included.

### *Analyses*

The unit of analysis was the hospital. Univariate and bivariate analyses provided descriptive statistics on the variables used. Multivariable confounders of the extent of EHR implementation along the 5 categories of EHR: 0 (Less than basic EHR), 1(basic), 2 (intermediate), 3 (intermediate and basic), and 4 (basic and comprehensive), were examined using panel ordinal logistic regression with random effects with less than basic EHR as the reference group. Robust standard errors were included to address correlation of repeated observations. Confounding variables were lagged by 1 year, given the effects of these variables on levels of EHR Implementation. We also tested for proportional odds assumption or parallel regression assumption using “omodel” and “brant” commands. All data were analyzed in Stata 15.

### **Results**

Overall, our sample size available for analysis in this study was 17 586 observation-years from 2010 to 2016. Year by year, changes in the proportion of each category of EHR implementation is presented in Figure 1. The proportions of hospitals with no EHR have gone down from 2010 (~45%) to 2016 (~3%). However, the proportion of hospitals with basic EHR had considerably stayed the same over the study period (~1%). The proportions of hospitals with only intermediate EHR have steadily gone down while hospitals with intermediate-basic had increased in proportions from 2010 (~12%) to 2016(~34%). Likewise, the proportions of hospitals with comprehensive-basic EHR increased over time. Specifically, approximately 4% of hospitals had comprehensive-basic EHR in 2010, which increased to about 52% in 2016.

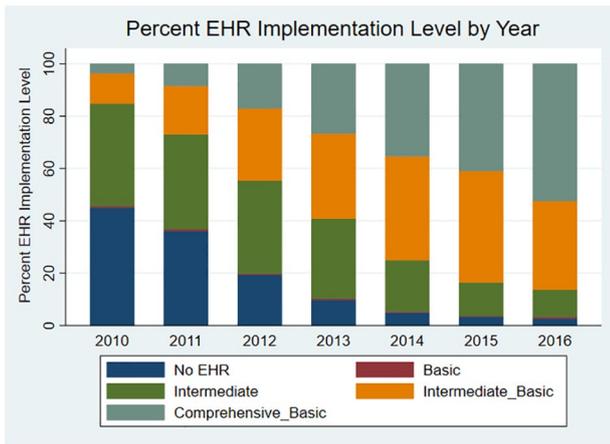


Figure 1. Percent EHR implementation level 2010 to 2016.

General descriptive characteristics of the hospitals in this study in 2010 and 2016 are presented in Table 1. On average, hospitals had a bed size of about 1.82 in 2010 and 1.88 in 2016. The total margin in 2010 and 2016 were 4.75 (SD = 8.14) and 4.72 (SD = 9.61) respectively. Majority of the hospitals in our sample, both in 2010 and 2016 were located in metropolitan areas (56% and 61% respectively), followed by urban area (36% and 33% respectively). The proportions of investor-owned for-profit hospitals increased from approximately 11% in 2010 to 13% in 2016. However, the percentage of public-nonfederal hospitals decreased from 25% in 2010 to 20% in 2016. About 52% of hospitals belong to a hospital system in 2010 and 63% in 2016. The percentage of people without health insurance saw a decline from 2010 (6%) to 2016 (5%).

Medicare managed care penetration saw an increase from 20% in 2010 to 28% in 2016. Among market level characteristics of markets in which hospitals operate, market competition (HHI) remained fairly unchanged with values of 0.78 (SD = 0.32) and 0.79 (SD = 0.30) in 2010 and 2016 respectively. Medicare and Medicaid payer mix stayed fairly the same. Specifically, Medicare payer mix slightly increased from an average of 50.34 (SD = 18.27) in 2010 to an average of 52.62 (SD = 18.11) in 2016. Likewise, Medicaid payer mix on average slightly increased from 19.85 (SD = 15.62) in 2010 to 20.24 (SD = 14.75) in 2016. The proportions of hospitals with teaching status had increased from 30% in 2010 to 41% in 2016. The average per capita income increased from approximately \$37 per 1000 (SD = 9.858) in 2010 to \$45 per 1000 (SD = 13.631) in 2016. The population of people older than 65 years for hospitals in these counties also saw an increase with the average population increased to approximately 88 000 (SD = 191 231.9) in 2016.

Findings from the regression analyses are presented in Table 2. Our test for proportional odds assumption were non-significant ( $P = .248$ ). Results show that larger hospitals have higher odds of being in higher categories of EHR implementation as compared to smaller hospitals (OR = 1.176,  $P < .000$ ). As the total margin of hospitals increase, hospitals have

a slightly higher odds (OR = 1.011,  $P < .000$ ) of belonging to a higher category of EHR implementation. Compared to rural hospitals, metropolitan hospitals had a 2.246 times higher odds and urban hospitals had 0.361 times lower odds of belonging to the higher EHR categories ( $P < .000$ ). Public nonfederal-hospitals and investor-owned for-profit hospitals have a lower odds of being in a higher EHR category as compared to hospitals that are not-for-profit (OR = 0.779,  $P < .000$ ; OR = 0.364,  $P < .000$  respectively). Hospitals that were system affiliated had 1.632 times higher odds of belonging in one of the higher categories of EHR implementation ( $P < .000$ ). As the number of patients without health insurance increase in a county, hospitals serving in these counties, had a lower odds of being in any of the higher EHR categories (OR = 0.973,  $P < .000$ ). Similarly, hospitals that were located in areas with higher managed care penetration had slightly higher odds of belonging to one of the higher EHR categories (OR = 1.009,  $P < .000$ ). Market competition (HHI) was not found to be a significant factor related to levels of EHR implementation.

## Discussion

Hospital EHR implementation is an intended strategy based on external factors. It is essential to study the factors that influence various levels of EHR implementation from the RDT perspective because these factors may present barriers in more comprehensive implementations of EHR, putting some hospitals at risk for lagging on HIT use. Our study tested the association between organizational and market factors and levels of EHR implementation. Overall, our findings show that larger hospitals, not-for-profit, metropolitan hospitals, those that serve a smaller number of uninsured patients, hospitals in high managed care penetration areas, system affiliated hospitals, and those with higher total margins have a higher odds of implementing higher levels of EHR.

Environmental munificence, as shown by higher margins and larger size, may enable hospitals to access a greater amount of human resources and financial assets from their environments. Prior studies have found positive relationships between hospital size, infrastructure, and financial resources with clinical information systems that play a crucial role in clinical integration and providing seamless continuity of care to patients.<sup>17</sup> Recent studies and reports have found that small hospitals continue to lag in EHR adoption and have persistently lower adoption rates, which may be due to financial challenges.<sup>5,9</sup> Our study's findings were consistent with those of previous studies and call attention to addressing this challenge for small hospitals and ones with limited financial resources.

The availability of resources is related to organizational culture, structure, policies, and procedures, that may determine the readiness of hospitals for implementation of EHR. Rural hospitals have reported cultural and procedural barriers such as obtaining physician cooperation, as well as workflow and

**Table 1.** Descriptive statistics of variables (N = 17 586 hospital year observations).

VARIABLES	2010 (N = 2815)	2016 (N = 1688)
	M/F (%), M (SD)	
Dependent variable		
No her	1268 (45.04%)	45 (2.67%)
Basic	13 (0.46%)	11 (0.65%)
Intermediate	1106 (39.29%)	174 (10.31%)
Intermediate and basic	324 (11.51%)	572 (33.89%)
Comprehensive and basic	104 (3.69%)	886 (52.49%)
Independent variables		
Hospital size	1.822 (2.03)	1.8784 (2.31)
Total margin	4.75 (8.14)	4.72 (9.61)
Location		
Metropolitan	1570 (55.95%)	1022 (61.16%)
Urban	1009 (35.96%)	544 (32.56%)
Rural	227 (8.09%)	105 (6.28%)
Ownership		
Government, nonfederal	706 (25.08%)	344 (20.38%)
Investor-owned, for-profit	309 (10.98%)	222 (13.15%)
Not-for-profit	1800 (63.94%)	1122 (66.47%)
System membership		
Yes	1452 (51.58%)	1070 (63.39%)
No	1363 (48.42%)	618 (36.61%)
Persons without health insurance (county)	17.28 (5.80)	11.06 (4.91)
Medicare managed care penetration	20.20 (13.64)	27.93 (14.89)
Control variables		
Medicaid payer mix	19.85 (15.62)	20.24 (14.75)
Medicare payer mix	50.34 (18.27)	52.62 (18.11)
Teaching		
Yes	832 (29.56%)	699 (41.41%)
No	1983 (70.44%)	989 (58.59%)
Per capita income	37.031 (9.858)	44.684 (13.631)
Total population 65 plus	65 371.79 (152 751.20)	88 132.25 (191 231.9)
Market competition (HHI)	0.78 (0.32)	0.79 (0.30)

Abbreviation: HHI, Hirschman-Herfindahl index.

staffing challenges associated with maintaining EHR as reasons for slow implementation.<sup>33</sup> Also, initial and ongoing costs for the maintenance of EHR stymies the readiness of rural hospitals in progressing toward implementing higher EHR functionalities.<sup>9</sup> Rural hospitals generally are less ready to

implement higher levels of EHR, and have slower adoption rates even for Basic EHR.<sup>5,34</sup>

Organizations' dependence on environmental resources creates cultural and structural barriers regarding the acceptability of higher functionalities of EHR implementation, which

may vary according to ownership. Public hospitals may be averse to profit maximization, as their profits may be taken away by public owners and spent on other public goods.<sup>35</sup> Prior research has argued that for-profit hospitals strive for organizational efficiency more than non-profit hospitals and therefore are more likely to adopt EHR as compared to non-profit.<sup>24</sup> However, in our study, despite having slightly lower resources than for-profit, non-profit hospitals pursue organizational efficiency as much as for-profit hospitals. Leading not-profit hospitals such as Gundersen Lutheran, have adopted comprehensive EHR to improve quality, efficiency, and consistency.<sup>36</sup> EHR deployment efforts have shown that implementing higher functionalities such as decision support systems is central to achieving quality goals, but many EHRs do not currently include robust EHR functionalities and features.<sup>37</sup>

Similarly, structural barriers for hospitals that are not part of a system may include issues with interoperability, and a lack of opportunity to distribute the high costs of implementation and training across facilities. Prior studies have found that health system centralization increases the likelihood of EHR adoption.<sup>24</sup> Furthermore, system affiliated hospitals may have a central objective of improving quality and safety through EHR use. Given the HiTECH act, there has been a shift of policy focus from EHR implementation to EHR use, thereby emphasizing the need for having higher EHR functionalities, for example verifying patients through barcoding and identifying drug interactions through decision support systems. Aligning EHR use with quality objectives may be easier in system hospitals due to their centralized management.

Uninsured patients may present a financial burden for hospitals because patients without health insurance tend to have high severity of illness, higher expected risk of death, and high mortality rates as compared to their counterparts. They present to the hospital sicker, and more resources are expended on their care. Uninsured patients also account for the majority of uncompensated care at hospitals,<sup>38</sup> thereby being one of the limiting factors for financial resources that hospitals may have available. Diversion of funds from implementation of technology into taking care of uninsured patients may be a worthwhile strategic decision by hospitals.

Environmental complexity refers to the inter-organizational relationships, mainly the competition that organizations have to undergo to gain different inputs and to produce outputs given limited resources. In more complex markets, free resources may not be readily available. Managed care penetration and market competition were the 2 indicators of complexity considered in our study. Managed care penetration represents the pervasiveness of regulatory stringency in that particular area with a pressure to improve quality and maintain quality standards. Additionally, hospitals, where managed care patients make up a large percentage of their business, would be more willing to invest in higher levels of EHR to synchronize with plans operating in such markets, that have well developed

IT capabilities for their own contracting and analytical purposes.<sup>39</sup> Moreover, studies have shown that of the various insurance types, only managed care companies positively influence hospitals in the adoption of IT. It was observed that an additional IT application was adopted for every 2% increase in the percentage of hospital's managed care patients.<sup>40</sup> Our results imply that perhaps hospitals are responding more strategically to managed care penetration increases. In order to work more efficiently and timely, and to maximize profits, higher-level IT functionalities can help in improving clinical operations and assist hospitals in gaining revenues. Market competition not being associated with levels of EHR implementation shows that hospitals need to consider more factors when choosing to pursue strategic efforts such as EHR implementation. This may increase uncertainty and delay or impede EHR implementation.

Some limitations of our study are that we have used county-level data for managed care penetration, which may not accurately reflect the level of complexity faced by each hospital. Because prior research in this area has not considered intermediate level of EHR implementation, our method of operationalizing this construct has little guidance from previous literature. Future research should look at other possible ways of defining intermediate, intermediate and basic, and comprehensive and basic levels of EHR implementation. Additionally, future studies should consider including other potential confounders to control for, such as, the type of EHR, case mix index, and the cost of EHR implementation, and they should evaluate meaningful use functionalities, or Health Information Management Systems Survey (HIMSS) data to determine levels of EHR implementation based on EHR use.

### Practice Implications

Managers need to recognize that hospitals may be more likely than others to implement higher levels of EHR functionalities based on environmental and organizational factors. For hospitals with barriers, they need to make strategic priorities in order to avail limited resources given these barriers. With quality and efficiency as one of the top strategic priorities, hospitals may decide to implement higher levels of EHR, such as barcoding and decision support systems. However, if environmental and financial resources are limited, hospitals may choose to implement basic and intermediate levels of EHR.

Sophisticated IT systems and their support personnel may be an expensive investment for hospitals, particularly the ones with resource constraints. Group purchasing by hospitals may assist in reducing the high cost of implementation of higher EHR functionalities. Perhaps in the future, forming coalitions of hospitals to create economies of scale of EHR implementation is a direction that hospitals need to seek. Hospitals that aspire to purchase higher levels of EHR, need to make decisions on leveraging essential resources into improving quality and efficiency, while diverting resources from other activities. Resource constraints also affect the organizational culture of

**Table 2.** Ordinal logistic regression analysis with the EHR implementation levels as dependent variable (N = 17 586 hospital year observations).

VARIABLES	ODDS RATIO	SE	P VALUE
Hospital size	1.176	0.025	.000***
Total margin	1.011	0.003	.000***
Location			
Metropolitan	2.246	0.292	.000***
Urban	0.361	0.033	.000***
Rural	<i>Ref</i>		
Ownership			
Government, nonfederal	0.779	0.057	.001***
Investor-owned, for-profit	0.364	0.034	.000***
Not-for-profit	<i>Ref</i>		
System membership			
Yes	1.632	0.100	.000***
No	<i>Ref</i>		
Persons without health insurance (county)	0.973	0.006	.000***
Medicare managed care penetration	1.009	0.002	.000***
Control variables			
Medicaid payer mix	0.991	0.002	.939
Medicare payer mix	0.992	0.002	.916
Teaching status			
Yes	1.012	0.069	.857
No	<i>Ref</i>		
Per capita income	1.002	0.003	.582
Total population 65 plus	1.000	0.000	.787
Market competition (HHI)	0.832	0.101	.128
Year			
2011	2.092	0.111	.000
2012	6.570	0.394	.000
2013	15.527	1.020	.000
2014	32.013	2.246	.000
2015	44.972	3.473	.000
2016	79.988	7.066	.000
2010	<i>Ref</i>		
EHR levels (cutoff) <sup>a</sup>			
Level 5	0.448	0.277	
Level 4	0.496	0.277	
Level 3	2.926	0.278	
Level 2	5.279	0.280	
Level 1	<i>Ref</i>		

Abbreviation: HHI, Hirschman-Herfindahl index.

<sup>a</sup>The individual intercept (constant) for each level of EHR implementation.

\*\*\* $P \leq .001$ .

hospitals, creating an organizational resistance to adopt higher EHR functionalities. Ensuring a champion advocate to provide constant encouragement and direction for the implementation of higher EHR functionalities may assist in overcoming that barrier.

Policies to incentivize implementation of higher EHR functionalities may target EHR vendors and encourage the creation of more EHR companies in the market, so that an increase in competition among vendors may possibly lower the implementation price for hospitals with limited resources.

### Author Contributions

Soumya Upadhyay conceptualized and wrote the introduction, background, conceptual framework, and discussion sections. William Opoku-Agyeman performed the data analysis and wrote the methods and results sections.

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**Appendix 1.** Functionalities required for basic and comprehensive Electronic Health Records.

FUNCTIONALITY	COMPREHENSIVE EHR	BASIC EHR
Clinical documentation		
Demographic characteristics of patients	X	X
Physician notes	X	X
Nursing assessments	X	X
Problem lists	X	X
Medication lists	X	X
Discharge summaries	X	X
Advanced directives	X	
Test and imaging results		
Laboratory reports	X	X
Radiological reports	X	X
Radiological images	X	
Diagnostic test results	X	X
Diagnostic test images	X	
Consultant reports	X	
Computerized provider-order entry		
Laboratory tests	X	
Radiology tests	X	
Medications	X	X
Consultation requests	X	
Nursing orders	X	
Decision support		
Clinical guidelines	X	
Clinical reminders	X	
Drug-allergy alerts	X	
Drug-drug interaction alerts	X	
Drug-laboratory interaction alerts (eg, digoxin and low level of serum potassium)	X	
Drug-dose support (eg, renal dose guidance)	X	