Impact of Health Information Technology Portfolio on Hospital Quality:
A National Study of U.S. Acute Care Facilities

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Research Objective: This study empirically examines the association of a portfolio of clinical health information technologies, compared to individual technologies, on quality in acute care hospitals.

Study Design: We analyze data from the 2006 annual survey of health information technologies (HIT) conducted by Dorenfest Institute-HIMSS Analytics and hospital quality performance data from the 2006 CMS Hospital Compare database. We consider the impact on quality of care of adopting a portfolio of five clinical health IT applications in U.S. acute care hospitals: clinical data repository (CDR), clinical decision support (CDS), computerized physician order entry (CPOE), enterprise electronic medical records (EMR), and electronic medication administration record (EMAR) systems. Hospital quality is measured using the eight CMS benchmark care indicators for acute myocardial infarction (AMI). Each AMI quality measure is regressed on the individual HIT applications, and on overall HIT portfolio size (controlling for bed size, profit status, academic status, and affiliation with integrated health delivery system). Since the quality measures are bounded within the interval $[0,1]$, we use a generalized linear model (GLM) regression with the logistic function as linking function. To account for potential spatial correlation of errors, we use state-level error clustering. Figure-1 shows our research model indicating all the dependent and independent variables included in the statistical analysis. Our approach examines the effect of both overall clinical HIT portfolio and constituent individual technologies compared to prior studies examining the relationship of individual HIT applications or HIT portfolio with quality.

Population Studied: 2,624 non-federal acute care hospitals with at least 100 beds. From the initial sample of 5081 hospitals (in HIMSS dataset) after matching with corresponding hospitals in CMS Hospital Compare database and eliminating hospitals with bed size smaller than 100 and for missing data, we construct a final sample of 2624 hospitals. Figure-2 shows comparative distribution of hospitals by states across U.S. from original HIMSS dataset and hospitals finally included in our sample. A qualitative comparison of these two sets suggests fair representation of sampled hospitals in each state. Among the in-sample hospitals, about 3.6% are academic and 18.3% are for-profit hospitals.

Principal Findings: Figure-3 shows distribution of five clinical IT systems as well the portfolio size. On the one hand, among the five technologies while CDR is the most diffused technology (adopted by 76% of hospitals), CPOE is least diffused technology (adopted by 21% of hospitals). On the other hand, at portfolio level, the average clinical HIT portfolio size is 2.5 (range 0-5). More particularly, about 11% of

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hospitals have not yet deployed any of the five clinical IT systems, 53% of hospitals have 3 or more technologies installed, and only 9% of hospitals have all five technologies installed. Table-1 shows summary statistics for AMI indicators grouped under two subsets – arrival related, and discharge related and other indicators. For example, at our sampled hospitals, on average 91% of eligible patients receive β-Blocker at arrival and 92% of eligible patients at discharge.

Table 2 and 3 shows summary of GLM regression runs for at arrival quality measures, and at discharge and other quality measures respectively with reference to both individual technologies and clinical HIT portfolio size. When analyzing at individual technologies, we find limited evidence of an association between individual HIT applications and AMI quality measures. Among the technologies considered, we observe CPOE and EMAR having significant association with most number of AMI indicators (3 and 4 respectively out of 8 measures). CPOE is positively associated with aspirin administration both at arrival (p-value: 10%) and discharge (p-value: 5%), and application of ACE inhibitor or ARB for left ventricular systolic dysfunction, LVSD (p-value: 10%). Likewise, EMAR is positively associated with PCI within 120 minutes of arrival (p-value: 1%), aspirin and β- blocker at discharge (p-value: 1% and 5% respectively), and application of ACE inhibitor or ARB for LVSD (p-value: 10%).

In the analysis of effect of overall HIT portfolio size, we find a positive association between HIT portfolio size and five of the eight AMI quality measures. Particularly, hospitals with a larger HIT portfolio are more likely to give patients smoking cessation advice (p-value: 1%), administer aspirin at discharge (p-value: 5%), give PCI intervention within 120 minutes of arrival (p-value: 5%), and administer β- blocker at arrivals (p-value: 10%) and at discharge (p-value: 10%). Meanwhile, for remaining three AMI indicators the Logit coefficient estimates are though positive (except for thrombolytic medication), they are statistically insignificant. Our findings suggest that the effects of HIT use should not be viewed by individual applications; instead a portfolio view may enable greater quality improvement.

**Conclusion:** We assessed the impact of overall HIT portfolio on the quality of AMI care provided in U.S. hospitals and found statistically significant effects that hospitals with larger HIT portfolios have better process quality measures. Additionally, use of CPOE and EMAR appear to matter more in improving AMI quality measures compared to other technologies.

**Implications for Policy, Delivery or Practice:** HIT adoption has become a priority for U.S. policymakers, especially in light of the increasing focus on healthcare cost and quality. Our findings suggest that adoption of a portfolio of key clinical technologies does have a positive impact on quality of care. Developing appropriate policy measures and incentives to enhance the wide-spread diffusion of healthcare technologies, particularly CDR, CDS, CPOE, EMR, and EMAR systems will be critical to realize ulterior goals of improving care quality for all Americans.
Health IT Portfolio
- Clinical Data Repository (CDR)
- Clinical Decision Support (CDS)
- Computerized Physician Order Entry (CPOE)
- Enterprise Electronic Medical Records (eEMR)
- Electronic Medication Administration Record (EMAR)

Process Quality Measure: Acute Myocardial Infarction

Arrival Related
- Aspirin at Arrival
- β-Blocker at Arrival
- Thrombolytic Medication Within 30 Min Of Arrival
- PCI Within 120 Minutes Of Arrival

Discharge Related and Others
- Aspirin at Discharge
- β-Blocker at Discharge
- ACE Inhibitor or ARB for Left Ventricular Systolic Dysfunction
- Smoking Cessation Advice

Control Variables
- Academic Status
- Profit Status
- Health System Affiliation
- Bed Size

Figure 1: Research model

Figure 2: Distribution of hospitals in HIMSS’ dataset and our in-sample dataset across U.S.

Figure 3: Distribution of health IT adoption status by year 2006
Table 1: Summary statistics of AMI quality measures across U.S. hospitals

<table>
<thead>
<tr>
<th></th>
<th>Arrival Related</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aspirin</td>
<td>β- Blocker</td>
<td>Thrombolytic</td>
<td>PCI</td>
<td>Aspirin</td>
<td>β- Blocker</td>
<td>ACE/ARB</td>
<td>Smoking</td>
</tr>
<tr>
<td>N</td>
<td>2,357</td>
<td>2,356</td>
<td>1,297</td>
<td>1,282</td>
<td>2,354</td>
<td>2,354</td>
<td>2,306</td>
<td>2,126</td>
</tr>
<tr>
<td>Mean</td>
<td>0.946</td>
<td>0.906</td>
<td>0.295</td>
<td>0.65</td>
<td>0.921</td>
<td>0.917</td>
<td>0.817</td>
<td>0.861</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>0.054</td>
<td>0.099</td>
<td>0.308</td>
<td>0.21</td>
<td>0.097</td>
<td>0.107</td>
<td>0.163</td>
<td>0.208</td>
</tr>
</tbody>
</table>

Table 2: Regression results of at arrival AMI quality measures

<table>
<thead>
<tr>
<th>Sample Size [N]</th>
<th>Aspirin</th>
<th>β - Blocker</th>
<th>Thrombolytic</th>
<th>PCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio Size</td>
<td>0.015</td>
<td>0.030 *</td>
<td>-0.032</td>
<td>0.054 **</td>
</tr>
<tr>
<td>Is Academic</td>
<td>0.278 *</td>
<td>-0.007</td>
<td>-0.079</td>
<td>-0.251 ***</td>
</tr>
<tr>
<td>Is Profit</td>
<td>-0.385 ***</td>
<td>-0.435 ***</td>
<td>-0.207</td>
<td>-0.430 ***</td>
</tr>
<tr>
<td>System Affiliation</td>
<td>0.255 ***</td>
<td>0.216 ***</td>
<td>-0.031</td>
<td>0.097 **</td>
</tr>
<tr>
<td>Stuffed Beds/100</td>
<td>0.171 ***</td>
<td>0.193 ***</td>
<td>-0.095 ***</td>
<td>-0.017</td>
</tr>
<tr>
<td>Constant</td>
<td>2.335 ***</td>
<td>1.690 ***</td>
<td>-0.489 ***</td>
<td>0.542 ***</td>
</tr>
</tbody>
</table>

For Effects of Individual Technologies: only the coefficient of respective technology is shown below.

CDR                    | -0.008 | 0.084 | -0.148 * | 0.074 |
CDS                    | 0.022  | 0.063 | -0.052 | 0.120 **|
CPOE                   | 0.102 * | 0.116 | -0.119 | 0.052 |
EMR                    | -0.007 | -0.021 | -0.010 | 0.062 |
EMAR                   | 0.063  | 0.071 | 0.006 | 0.153 ***|

Table 3: Regression results of at discharge and other AMI quality measures

<table>
<thead>
<tr>
<th>Sample Size [N]</th>
<th>Aspirin</th>
<th>β - Blocker</th>
<th>Thrombolytic</th>
<th>PCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio Size</td>
<td>0.054</td>
<td>0.046 *</td>
<td>0.031</td>
<td>0.085 ***</td>
</tr>
<tr>
<td>Is Academic</td>
<td>-0.025</td>
<td>-0.065</td>
<td>0.031</td>
<td>-0.164</td>
</tr>
<tr>
<td>Is Profit</td>
<td>-0.476 ***</td>
<td>-0.513 ***</td>
<td>-0.32 **</td>
<td>-0.073</td>
</tr>
<tr>
<td>System Affiliation</td>
<td>0.344 ***</td>
<td>0.276 ***</td>
<td>0.215 ***</td>
<td>0.362 ***</td>
</tr>
<tr>
<td>Stuffed Beds/100</td>
<td>0.311 ***</td>
<td>0.269 ***</td>
<td>0.064 ***</td>
<td>0.311 ***</td>
</tr>
<tr>
<td>Constant</td>
<td>1.521 ***</td>
<td>1.627 ***</td>
<td>1.177 ***</td>
<td>0.683 ***</td>
</tr>
</tbody>
</table>

For Effects of Individual Technologies: only the coefficient of respective technology is shown below.

CDR                    | 0.078  | 0.104 | 0.048 | 0.303 ***|
CDS                    | 0.079  | 0.076 | 0.01 | 0.111 |
CPOE                   | 0.184 ** | 0.082 | 0.127 * | 0.095 |
EMR                    | 0.024  | 0.009 | 0.038 | 0.146 |
EMAR                   | 0.204 *** | 0.161 ** | 0.092 * | 0.104 |

1: Each AMI quality measure was regressed on health IT portfolio size controlling for academic status, profit status, system affiliation, and bed size of hospital by using Generalized Linear Model method with Logit as linking function.

* p<0.10; ** p<0.05; *** p<0.01