Supplementary Material A

Arch Collaborative Members endorsing this article:

Chris Longhurst and Brian Clay on behalf of UC San Diego
HC Eschenroeder Jr. on behalf of OrthoVirginia
Rachel Dunscombe on behalf of Salford Royal NHS Foundation Trust
Thomas Moran and Lacy Knight on behalf of Northwestern Medicine
David Graham on behalf of Memorial Health System
Jean Adam from Geisinger Health
Lynn McFarling and Amy Porwoll on behalf of CentraCare Health
Ken Koppenhaver on behalf of Mount Sinai Health System
Jordan Dale and Brian Patty on behalf of Rush University Medical Center
Melissa Jost and Scott MacDonald on behalf of University of California Davis Medical Center
Bryan Hinch and Alan Lasu on behalf of University of Toledo Medical Center
Andrew Neumann and Robert Korn on behalf of GoHealth Urgent Care
Kevin Gallagher on behalf of Glens Falls Hospital
Kayla Green on behalf of University of Chicago Medicine
Jeana O-Brien on behalf of Baylor Scott & White Health
David Kaelber and Jonathan Siff on behalf of The MetroHealth System (Cleveland, Ohio)
Mark Davis on behalf of Wasatch Pediatrics
Rob Schreiner on behalf of Wellstar Health System
Deane Morrison and Paul Clark on behalf of Concord Hospital
Steven Schlossberg on behalf of John Muir Health
Nicole Tremain on behalf of Sharp HealthCare
Spencer Erman on behalf of Hartford HealthCare
David Michael on behalf of Vidant Health
Shannon M. Dean and Jocelyn DeWitt on behalf of UW Health
Bruce Hayward on behalf of Steelemed
H.C. Eschenroeder Jr. on behalf of OrthoVirginia
Todd Craig on behalf of Mercy Health
Craig Joseph on behalf of El Camino Hospital
Lee Milligan on behalf of Asante Health
Jonathan Roskam on behalf of Franciscan Alliance, Inc.
Melissa Duncan on behalf of Indiana Regional Medical Center

John Gill on behalf of Heart of Texas Community Health Center
Angus Ritchie on behalf of Sydney Local Health District (Australia)

Supplementary Material B

Survey Methodology

Arch Collaborative EHR experience surveys are conducted in an economical and consistent manner. It is acknowledged that these surveys, collected through email invitations for feedback, are not statistically random, but the consistent approach makes comparisons appropriate. On average, the response rate per organization is 22%. While organizations have the option to include different questions in the survey, the core EHR survey can be viewed at https://klasresearch.com/arch-collaborative.

Surveys have been collected over the past 2 years, at varying times since EHR go-live. EHR go-lives have spanned from the late 1990s until 2018, with no significant correlation between go-live dates and the net experience score.

As part of the survey, respondents are asked about their satisfaction with the EHR’s ability to enable quality care, enable efficiency, enable patient-centered care and keep patients safe, and about their satisfaction with its availability, functionality, internal and external integration, response time, ease to learn, analytics, and reporting.

A key statistic used in the Arch Collaborative research is called the net EHR experience score (NEES), and it is calculated, on a per-respondent basis, by subtracting the percentage of satisfaction questions answered negatively from the percentage answered positively (a methodology somewhat similar to a net promoter score). Scores can range from −100 to 100. Actual scores achieved by the organizations in this research range from a low of −71 to a high of 73.

Because the common question set has evolved over time, not all questions in the current version of the survey have been asked by all organizations in the collaborative, and so sample sizes will vary depending on the questions included in the analysis. Please see full report: https://klasresearch.com/arch-collaborative.
Below is a list of the questions in the current survey:

<table>
<thead>
<tr>
<th>Question/variable</th>
<th>Question type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you agree that ongoing EHR training/education is helpful and effective?</td>
<td>Likert scale from strongly disagree to strongly agree</td>
</tr>
<tr>
<td>Do you agree that your initial training prepared you well?</td>
<td>Likert scale from strongly disagree to strongly agree</td>
</tr>
<tr>
<td>Organization</td>
<td>Categorical variable levels for each organization</td>
</tr>
<tr>
<td>EHR you are using</td>
<td>Categorical variable unlimited levels</td>
</tr>
<tr>
<td>Percentage of personalization options engaged</td>
<td>Percent of EHR personalization the user reports</td>
</tr>
<tr>
<td>Current EHR proficiency</td>
<td>Categorical variable with four levels: expert, advanced, intermediate, or struggling</td>
</tr>
<tr>
<td>Physician fulfillment</td>
<td>Likert scale from strongly disagree to strongly agree</td>
</tr>
<tr>
<td>Percentage of charting you are able to close out during inpatient rounds</td>
<td>Percent</td>
</tr>
<tr>
<td>Hours per week spent completing charting outside of your normal business hours</td>
<td>Categorical variable with options from 0 to 25+ hours</td>
</tr>
<tr>
<td>Hours you spend each year receiving follow-up training or other education on EHR functionality?</td>
<td>Categorical variable with options from 0 to 20+ hours</td>
</tr>
<tr>
<td>Years practicing medicine</td>
<td>Categorical variable with options from 0 to 25+ years</td>
</tr>
<tr>
<td>Percentage of charting you are able to close out during or immediately after ambulatory patient encounters</td>
<td>Percent</td>
</tr>
<tr>
<td>Clinical background</td>
<td>Categorical variable with options including physician, physician resident or fellow, nurse practitioner or physician assistant</td>
</tr>
<tr>
<td>Your specialty</td>
<td>Categorical variable</td>
</tr>
<tr>
<td>How do you document?</td>
<td>Categorical variable with options including direct entry (typing), voice recognition, scribe, and dictation/transcription</td>
</tr>
<tr>
<td>Enter own orders</td>
<td>Likert scale from “all the time” to “most of the time someone pens these orders for my signature”</td>
</tr>
<tr>
<td>Patient types</td>
<td>Categorical variable with options including adult, pediatric, or both</td>
</tr>
<tr>
<td>Use environment</td>
<td>Categorical variable with options including inpatient, ambulatory, or both</td>
</tr>
<tr>
<td>Are you employed by your health system?</td>
<td>Binary variable</td>
</tr>
<tr>
<td>Years using EHR</td>
<td>Categorical variable with options from 0 to 5+ years</td>
</tr>
</tbody>
</table>

**Description of Data Results**

The software platforms of Allscripts (Chicago, Illinois, United States), Athenahealth (Watertown, Massachusetts, United States), Cerner Millennium (Kansas City, Kansas, United States), Epic Systems (Verona, Wisconsin, United States), and MEDITECH (Westwood, Massachusetts, United States) are all included in this research. The ratings of each platform vary between the highest-satisfied and least-satisfied customers by an average of 69.4 points on a scale ranging from −100 to 100 (see Table 1), with the minimum spread being 95 points. These spreads in user satisfaction indicate wide variability in the success organizations achieve utilizing the same software (in some cases using SAS solutions such that the software version is exactly the same). Every vendor but one has a customer with a relatively high net EHR experience score, and all have a customer organization with a negative net EHR experience score. These findings indicate that multiple EHRs have been implemented in at least one organization, and all measured EHRs have been unsuccess-fully implemented at least once. This variation indicates that a singular focus on software, at today’s current technology levels, is unlikely to yield consistently successful EHR implementa-tions (see Table 1).

Understanding from where variation is coming from is critical to identifying solutions to current EHR failures. Within-group and between-group variation was measured for four nested groups: the EHR, organizations using that EHR, specialties within those organizations, and users within those specialties. We find that a majority of variation stems from individual users within a specialty (in the same organization using the same EHR) having very different EHR experiences. Since these physicians are of the same specialty and are using the exact same software, differences in their experiences stem from differences in their use of and knowledge about the EHR.

This research does not include any formal usability testing or human factor engineering, and we recognize that it...
would be important in understanding how much of the 19.8% of variation by EHR and the 15.1% of variation by organization could be explained by formal usability testing to better identify the roles that these important tools should have for health care provider organizations (Table 2).

In seeking to better understand the connection between the EHR training received and providers’ confidence that their EHR enables them to deliver high-quality care, we observe that providers are 3.9 times more likely to feel that their EHR hurts their ability to deliver quality care if they also report poor training (see Table 3).

It might be expected that scribes alleviate the need for high-quality education. However, even after controlling for the quality of training, providers who use scribes are more likely to disagree that their EHR enables the delivery of high-quality care (see Table 3).

We also notice that excellent training not only has to do with the quality of the training given but is also linked to the training expectations that organizations set for their provider users. Organizations that require more education from their users see significant improvements in satisfaction ($p < .01$) (Table 4).

One of the most powerful findings of this collaborative is that users need to expect to personalize their EHR in order for it to be highly attuned to their needs. Regardless of the specific EHR in use, users who take the time to personalize their EHR report significantly higher satisfaction (Table 5).

Very notable is the tight correlation between an organization’s average adoption of personalization features and that organization’s overall EHR satisfaction (Tables 5 and 6). Across organizations, this correlation is highly statistically significant ($p < 0.01$). Collaborative organizations are given the survey once a year, and as the collaborative completes its first year and organizations begin to be remeasured, we will gain even greater clarity into the causal/correlative nature of this relationship (Table 6).