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Article

A comparison of use of the mobile electronic health record by medical providers based on clinical setting

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SUMMARY

Technology can help streamline processes and improve communication between healthcare providers and patients. The electronic health record (EHR), along with its mobile application, have demonstrated the ability to improve the efficiency and accuracy of health care delivery. Given these capabilities, further research in technology adoption and utilization is warranted to determine best strategies for usage and deployment. By usage analysis one can ascertain if certain groups find mobile EHR (mEHR) tools more usable and useful than other groups. To determine if medical providers in different work settings at an academic pediatric hospital have similar or dissimilar frequencies of mEHR use, we categorized providers as inpatient, ambulatory, critical care, or emergency medicine according to their EHR profile departments. This study included data from 874 health care providers over a 12-month period regarding their usage of mobile phone (EPIC® Haiku) and tablet (EPIC® Canto) mEHR. Tablet mEHR use was relatively low compared to mobile phone EHR access, accounting for only 8% of total mEHR logins. Furthermore, ambulatory and inpatient care providers had the greatest usage levels over the 12-month period. Critical care providers do not utilize mEHR tools nearly as much as ambulatory or inpatient providers, likely due to workflow differences. Since clinical setting does affect usage levels of the mEHR, understanding of provider workflow can be helpful in maximizing the potential of these digital tools. Awareness of workflow allows for optimization of mEHR design and implementation, which should increase mEHR adoption and usage, leading to better health outcomes for patients.

INTRODUCTION

Federal agencies, health care industry groups, and patient-advocacy organizations have long advocated for the engagement of health information technology in the quest to advance efficiency, improve patient safety, and foster patient satisfaction. To this end, in the 1960s, the Mayo Clinic was one of the first major health systems to adopt an electronic health record (EHR) (1). An EHR is an electronic chart which stores data associated with each patient encounter, including demographic information, diagnoses, laboratory tests and results, prescriptions, radiological images, clinical notes, and patient messaging (2). EHRs improve the collection, organization, and storage of health information.While some EHRs originated on minicomputers, most were developed initially on large mainframe computers with limited storage, which required the use of disk packs and/or tape for data storage, nightly downtimes for database back-up, and dedicated, wired terminals (3). In the late 1980s and early 1990s, the use of personal computers, local area networks, the internet, and compact hardware provided faster and easier access to medical information and web-based EHRs (4). As inadequacies of the paper record became increasingly more apparent, the Institute of Medicine advocated a shift from a paper-based to an electronic medical record (5). In 2004, President George W. Bush created the Office of the National Coordinator for Health Information Technology, which described its roadmap to enable most Americans to have EHRs within 10 years (6). This directive increased the ability of healthcare providers to share information, improve healthcare quality, prevent medical errors, and reduce administrative inefficiencies. EHRs made medical information easier to read and widely available (3). By transitioning the format of health records from paper to electronic, the EHR revolutionized health care delivery.

In subsequent years, hospital adoption of EHR systems increased rapidly, in part due to the $35 billion in EHR adoption incentives for hospitals and physician practices provided by the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 (7). Adoption of EHRs grew from 10–20% in 2008 to over 75% adoption in 6 years (8). Adoption of Certified EHRs expanded to virtually every hospital and over 90% of ambulatory physicians (7).

While primarily designed for improving healthcare efficiency from an operational standpoint, the EHR has value in secondary use for clinical informatics applications. For example, the data contained in EHR systems has been used for a variety of tasks, including medical concept extraction, patient trajectory modeling, disease inference, and clinical decision support systems (9). Specifically, studies show that clinical decision support systems improve patient safety for medication prescribing (10,11). EHRs with decision support capabilities decrease rates of drug–drug interactions and medication errors. Automatic dosage calculators reduce

dosage errors, and the medication administration record alerts to improve medication adherence while reducing medication overuse (12). A review addressing medication safety reported that multiple studies documented an increase in patient safety with the implementation of computer physician/provider order entry (CPOE) systems and an increased benefit with the implementation of clinical decision support (13). The EHR has evolved from a simple data storage tool to a platform for data analysis and decision-making tools.

While hospital systems have experienced many benefits with EHR use, there are some potential negative aspects to a digital health record. Firstly, there are costs associated with EHR adoption, implementation, and maintenance, including hardware and software expenses, as well as labor and training costs (14). The EHR may also have unintentionally changed workflow patterns whereby providers must dedicate more time to EHR data review and entry compared to paper charting. Another potential drawback of EHRs is the risk of patient privacy violations, especially given the increasing amount of health information exchanged electronically. With the advancement of technology, the frequency and extent of cyber-attacks have increased, which raises privacy concerns and increases the security demands of health information systems (15). Fortunately, several security techniques, such as firewall categories and cryptography methodologies, have been successful in mitigating risk to the privacy and security of the EHR and its protected health information (15). Lastly, EHR implementation creates an environment of overdependence on technology, wherein providers can become too reliant on computer tools (14). When there is a planned or unplanned downtime, users may be less prepared to function without the EHR platform. Although the use of a digital health record has been widely accepted, healthcare systems need to recognize the drawbacks as well. As mobile devices became more ubiquitous, EHR accessibility expanded to mobile device applications. The near universal use of mobile technology among healthcare providers presents the opportunity to augment traditional patient care with telemedicine, remote monitoring, and more efficient and comprehensive patient data capture. The adoption of mobile devices in health care practice has contributed to improvement in clinical workflow, timeliness of communication, and patient safety (16). These mobile EHR (mEHR) applications improve the efficiency and effectiveness of hospitals, while helping to reduce organizational costs (17). Mobile technology adoption combined with EHR systems can improve information access, communication, cost savings, time savings, and error reduction (18). The mEHR provides further enhancement to the efficacy and impact of electronic records in health care.

Physicians agree that mobile devices can streamline clinical workflow through optimized data and improve communication with patients and other providers (19). Of note, physician attitude toward novel technologies was associated with physicians' satisfaction with the devices and their motivation regarding further use. Research shows that frequent usage of the mEMR by a provider is associated with shorter provider response time to emergency department consultation requests (20). Mobile EHR communication offers an improvement over mobile text or phone calls as it eliminates redundant details and delivers correct patient information within the mEHR. The use of mobile devices, such as smartphones and tablets, can improve the delivery of healthcare by facilitating early, remote, and speedy exchange of professional opinions, thereby improving the accuracy and efficiency of medical decision-making (16). Access to information regarding patient status and conditions is crucial for decision making, such as during morning rounds. Mobile EHRs allow providers to maintain the continuity of their clinical information regardless of time and location constraints (21). The mEHR enhances the accessibility of clinical information for use in the decision-making process.

As mEHR systems have demonstrated the ability to improve the efficiency and accuracy of health care delivery, healthcare organizations have recognized the need to foster and refine these offerings. Given these capabilities, further research in technology adoption and utilization is warranted to determine the best strategies for usage and deployment. By comparison of usage according to provider work setting, one can determine if certain groups find mEHR tools more usable and useful than other groups. If usage patterns reveal differences, this would advance understanding and demonstrate a need for further research regarding the motivations for and obstacles to mEHR utilization. Understanding of usage patterns is pivotal to maximization of usability and utility across all provider groups.

In this study, we examined the adoption and use of mEHR applications for mobile phones and tablets among providers at a large, academic, pediatric hospital. The two mEHR applications were EPIC® Haiku, accessed via mobile phone, and EPIC® Canto, accessed via tablet. To conduct our analysis on provider utilization and adoption, we collected twelve months of mobile EHR application data at Lurie Children's Hospital (LCH). We characterized provider usage patterns to identify trends that may reveal areas for improvement and refinement in clinician utilization. Usage was compared amongst different provider groups classified as ambulatory, critical care, emergency medicine, and inpatient, to determine if there is a difference in mEHR usage which is dependent upon provider work locale within the hospital organization. Better understanding regarding the needs of providers in different settings should help to identify opportunities to improve utilization of the mEHR and its digital toolbox.

RESULTS

To investigate the usage of mEHR among different provider settings, we reviewed 12 months of mEHR login data for physicians and advanced nurse practitioners (January 1, 2021–December 31, 2021). We identified 1145 EPIC® Haiku (mobile phone) and Canto (tablet) users. We removed users

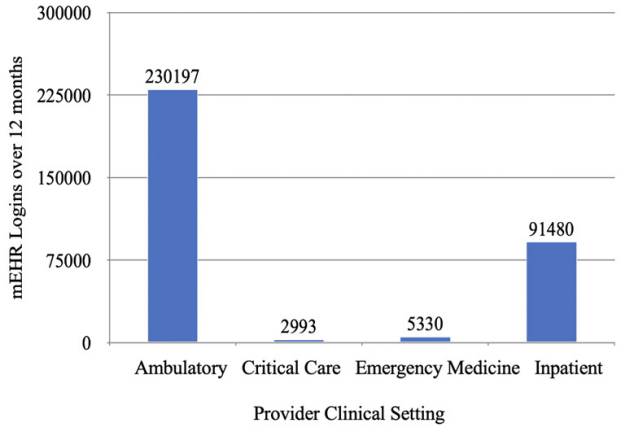

Figure 1. Total EHR logins (Epic® Haiku and Canto) by provider clinical category. Total mEHR logins over 12 months. The ambulatory, critical care, emergency medicine, and inpatient settings had 70%, 1%, 2%, 28%, respectively, of the total mEHR logins.

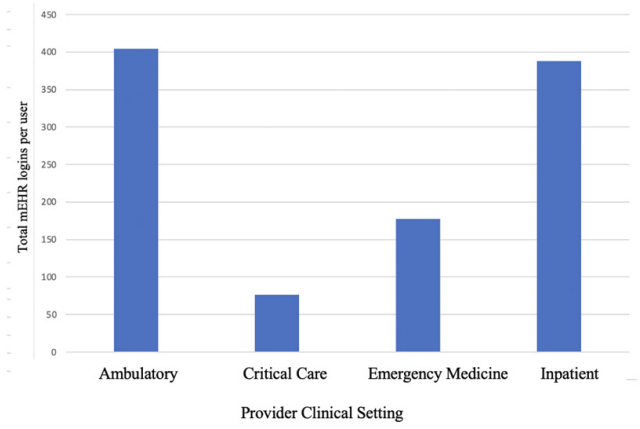

Figure 2. Total EHR logins (Epic® Haiku and Canto) by provider clinical category per user. Total mEHR logins per users over 12 months. The ambulatory, critical care, emergency medicine, and inpatient settings had 405, 76, 178, and 388 total mEHR logins per user, respectively.

from the data who did not fulfill study criteria. For example, a total of 58 users were removed because they were "INACTIVE" hospital status. In addition, ancillary health professionals, including 24 physical therapists, 8 occupational therapists, 1 art therapist, and 13 dietitians were excluded from the analysis. 73 registered nurses were also excluded. Providers for whom no department was reported were also removed from the data set.

Providers were classified according to primary work environment: inpatient, emergency medicine, ambulatory, and critical care (intensive care). The final analysis included 874 providers, with 326,946 EPIC® mobile phone (Haiku) logins and 3054 tablet (Canto) logins. Thus, providers accessed the mEHR much more frequently on a mobile phone than on a tablet, which only accounted for 8% of total usage. The ambulatory setting had the most, with 230,197 logins, followed by inpatient with 91,480, emergency medicine with 5,330, and critical care with 2,993 total mEHR logins **(Figure 1)**. However, the number of providers in each setting was different. Ambulatory, critical care, emergency medicine, and inpatient settings had 569, 39, 30, and 236 providers, respectively. When the total number of logins were analyzed per number of providers in the clinical setting, ambulatory had 405, inpatient had 388, emergency medicine had 178, and critical care had 76 total mEHR logins per user **(Figure 2).** Critical care providers did have significantly less mEHR mobile phone usage than providers of other settings **(Figure 3)**. Specifically, over 12 months, critical care providers had significantly less mEHR mobile phone usage than both ambulatory providers (p = 0.010) and inpatient providers (p = 0.023). The difference existed in the month 0-6 interval and the month 6-12 interval as well **(Figure 4)**. There was no difference between critical care providers and emergency medicine providers regarding frequency of mEHR use. Although critical care providers used Haiku less than outpatient and inpatient providers, there was no significant difference between critical care and emergency medicine providers over 0-6 months, 6-12 months, or 0-12 months. There was no significant difference found in mEHR mobile tablet (Canto) usage **(Figure 5)**. In sum, compared to critical care providers, ambulatory and inpatient providers demonstrated greater estimation of mEHR utility, as demonstrated by their increased degree of usage. Critical care providers accessed the mEHR much less than their ambulatory and inpatient counterparts. The mEHR was not as important to the workflow of the critical care provider as compared to that of the ambulatory or inpatient provider.

DISCUSSION

In comparing each of the provider groups, we found that most of the provider settings had similar mEHR usage. Only one category, critical care, had a significantly different degree of mEHR usage compared to another category. Specifically, critical care providers had significantly less mEHR mobile phone (Haiku) usage than both outpatient and inpatient providers. The decreased use of mEHR via phone is likely related to differences in workflow. The fact that critical care

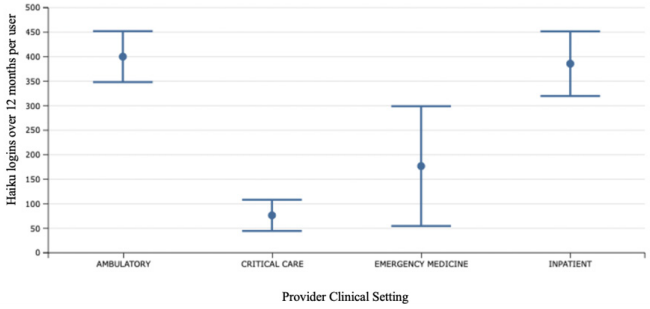

Figure 3. Average Haiku usage over 12 months by provider category. Average Haiku logins over 12 months with 95% CI. Critical care providers had significantly less Haiku usage than ambulatory or inpatient providers, p=0.002. Comparison was based on ANOVA testing with Scheffé multiple-comparison post hoc analysis.

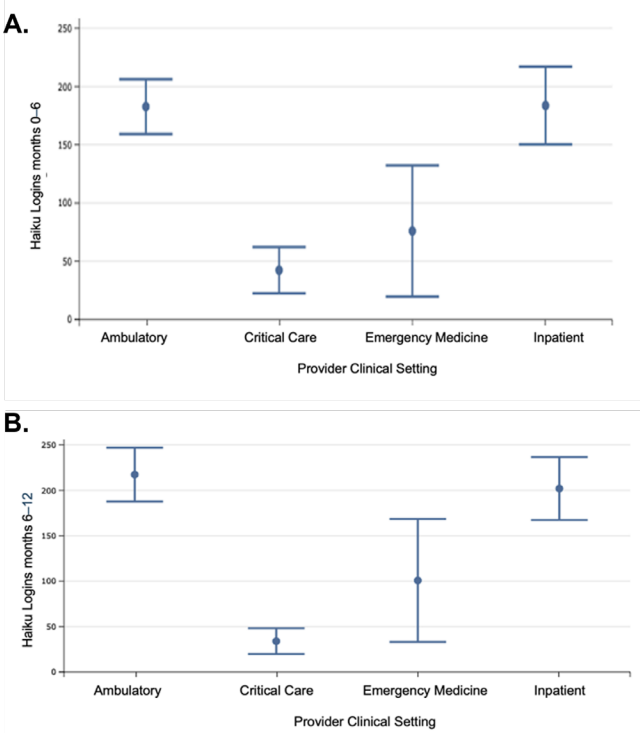

Figure 4. Haiku usage by provider category, months 0–6 and 6-12. For months 0–6, there is a significant difference between groups, with a *p*-value through ANOVA testing of p=0.003. For months 6–12, there is a significant difference between groups, with a *p* value through ANOVA testing of p=0.002. Critical care providers had significantly less Haiku usage than outpatient or inpatient providers. *p*-values were based on ANOVA testing with Scheffé multiple-comparison post hoc analysis.

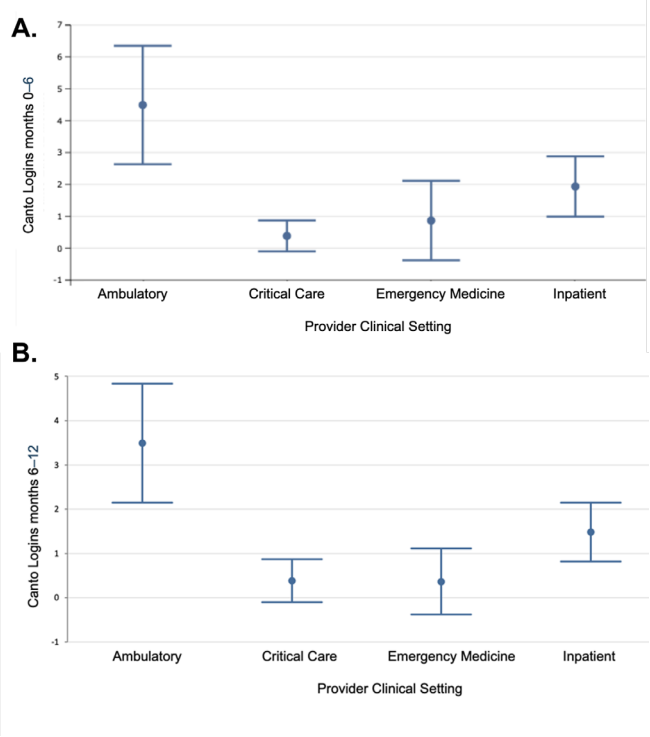

Figure 5. Canto usage by provider category, months 0–6 and 6-12. For months 0–6, there is not a significant difference between groups, with a *p*-value through ANOVA testing of p = 0.176. For months 6–12, there is not a significant difference between groups, with a *p*-value through ANOVA testing of p = 0.116. *p*-values were based on ANOVA testing with Scheffé multiple-comparison post hoc analysis.

providers spend much of their time in the physical space of the hospital and the intensive care unit may mean that they are more likely to use desktop EHR as opposed to mEHR for access to the medical chart. This study would benefit from supplementary information related to desktop EHR usage in addition to mEHR usage. A study analyzing mEMR usage times reported that mEMR use peaks early in the morning (6:00 am to 10:00 am), corresponding to morning rounds (21). Desktop or laptop availability could constrain access to necessary patient information at this time. Researchers saw a similar bump in mEHR usage from early evening (5:00 pm) to midnight (12:00 am), which was not seen with desktop EHR access (21). Thus, users opted to obtain patient information via the mEHR when accessing hospital-based desktops may not be convenient or feasible. The constraints of desktop access may isolate providers depending on the location of the desktop hardware. Mobile CPOE can supplement CPOE by allowing physicians to enter simple orders and order sets that they use most frequently, when desktop workstations are not conveniently accessible (22). As opposed to tethering themselves to a desktop before or after rounds to review the medical record, mEHR applications enable users to access current information without time and location constraints. In addition, mEHR offers an efficient option for tasks such as order entry and decision support. Given that the mEHR has been shown to optimize health care delivery, research is needed to identify usage deterrents as perceived by critical care providers.

Critical care physicians could improve their patient care by utilizing mEHR via Canto or Haiku at the bedside, especially during work rounds. Of note, critical care providers may be utilizing standard EHR access in a mobile capacity by utilizing the "laptop on a cart." During work rounds, this laptop cart can be wheeled from bedside to bedside, accessing the conventional EHR but using it in a mobile capacity. While this approach can be more cumbersome than utilizing an actual mEHR device, it may have perceived advantages in that the laptop cart devices are maintained by the hospital and remain tethered in the ICU. However, mEHR tablet devices cost significantly less than laptops and can be mounted and secured to rolling carts if desired. In fact, an entry level laptop is significantly more expensive than either a tablet or a desktop computer (23). Tablet devices offer more mobility and as such may be less disruptive to the patient encounter. Clinicians as well as patients report mostly positive perceptions of provider use of tablet computers in patient interactions (24). Tablets facilitate information sharing with patients, and patient communication while using a tablet as opposed to

a desktop computer may be easier given placement of the device (25). Tablets can also integrate more functions with mobile applications that may be helpful or relevant for medical practice (26). While our study found the usage of mEHR via tablet (Canto) between provider categories was not different, tablet use overall was much less than mEHR phone (Haiku) use. With 32,946 EPIC® Haiku logins and 3,054 Canto logins, mEHR accounted for only 8% of total mEHR (Haiku and Canto) usage. To increase Canto use, hospitals would need to provide the tablets, as tablet usage does not have near the universal ownership of mobile phones. For ICU physicians, who are frequently in the physical space of the intensive care unit, a dedicated mEHR tablet program may be more useful, efficient, and cost-effective than either phone mEHR access or laptop computer rolling carts.

Beyond just the frequency of access, providers of different departments are likely to access distinct types of information. An adult medicine study showed that mEHR usage by physicians in general medical departments is higher than in surgical departments, and that the type of information obtained through the mEHR often depends upon the provider department (21). The authors suggested that while physicians in surgical departments may use the mEHR only for key patient information, physicians in medical departments may need to review and share patient information more comprehensively. However, this phenomenon is not likely to explain the decreased mEHR frequency of the critical care providers in our study, as critical care providers need to have exhaustive knowledge of their patients' medical histories and conditions. More likely may be that critical care providers are obtaining their information through other means.

One limitation of our study is that although we can classify providers into 4 categories, there is not a quantitative record of the hospital environment in which each provider works. For example, although dermatology is an ambulatory subspecialty, undoubtedly there is some inpatient and critical care consultation, as well as the potential for emergency room consultation. In the subsequent phases of this study, demographics will be collected from the provider regarding actual time percentage spent in various areas of clinical care. A major strength of our study includes the large sample size, with automated collection of data via the EPIC® EHR system. However, this study was limited to data from a single pediatric academic center and did not include data from community hospitals within the LCH system.

While we found that critical care providers used the mEHR the least, future studies should include collection of data regarding the motivations and obstacles. One study described "performance expectancy" of workflow improvement as a significant factor associated with mEHR usage (17). The authors reported that the motivations of healthcare professionals to use a mobile EHR system were associated with their positive or negative impressions of use and their opinions regarding system ability to help their work performance. Unless intensivists, or any provider for that matter, believe that the mEHR can improve their current workflows they will not be motivated to use it. Studies have shown that mEHR use improved physician-patient interaction and streamlined clinical workflow (17, 19, 27). However, even if they are motivated to use mEHR, they may need specific infrastructure, such as hospital supplied tablets, in place. Healthcare organizations should recognize the performance enhancements associated with mEMR systems and the potential for workflow improvement.

Mobile EHR tools have been shown to increase provider efficiency and accuracy. We found that critical care providers had significantly less mEHR mobile phone (Haiku) usage than outpatient or inpatient providers. The usage of mEHR via tablet (Canto) across clinical settings was not different, possibly related to decreased tablet usage in general. Regarding critical care providers, the decreased usage levels of the mEHR via mobile phone is likely related to differences in provider workflow. As critical care providers spend much of their time in the physical space of the intensive care unit, they may be more likely to use desktop EHR as opposed to mEHR to access the electronic record. If the hospital were to provide and support tablet usage for certain clinical settings such as the ICU, providers may be better able to realize the benefits of mEHR for clinical care. Future studies should explore rationale for use and nonuse to understand motivations and obstacles to mEHR usage. Clinical setting does affect usage levels of the mEHR, and this understanding of provider workflow can be helpful in maximizing the potential of these digital tools, with the end goal of improved patient health outcomes.

MATERIALS AND METHODS

The study parameters were submitted to the LCH Office of Research Integrity and Compliance, and after consideration the study was determined to be exempt from Institutional Review Board review, given the data and scope of the research. The mEHR reported data included all instances of physician or advanced nurse practitioner access to a Haiku or Canto LCH application activity from one calendar year (January 2021–December 2021). The dataset was scrubbed to include only access instances of providers as described. Providers with inactive status were removed, even if they had instances of mEHR access. In addition, speech therapists, physical therapists, and art occupational therapists were removed from the data set. Users without a listed department were also excluded. If a provider had a login for EPIC® Haiku and/or Canto but never accessed it with the mEHR system, they were included in the data set, albeit without any instances of access.

Using data available in EPIC®, physician providers and advanced nurse practitioners were categorized according to their department of record. Health care providers included 717 physicians and 157 advanced nurse practitioners. Of the 717 physicians, 120 of them were resident physicians. Inpatient providers were those who worked mainly in an inpatient setting, such as providers in the Division of Hospital-Based Medicine

and the Division of Pediatric Surgery. Ambulatory providers consisted of those who worked as physicians or advanced nurse practitioners in an outpatient capacity, including primary care pediatrics and outpatient subspecialties such as dermatology and allergy/immunology. Critical care providers consisted of those working in the LCH neonatal, pediatric, or cardiac intensive care units. Emergency medicine providers involved those working in the emergency room setting. During 2021, LCH, the city of Chicago, and the state of Illinois experienced several pandemic associated alterations in work patterns. As the study period was January 1, 2021–December 31, 2021, subdivisions were applied to ascertain if proximity to the global events affected mEHR use. Specifically, Haiku and Canto access was reported in time intervals of 0–12 months, with subdivision of 0–6 months and 6–12 months.

The usage patterns were analyzed using Analysis of Variance (ANOVA) according to the categorical variables of ambulatory, critical care, emergency medicine, and inpatient. The data were expressed as mean ± 95% confidence interval. One-way ANOVA with Scheffé multiple-comparison post hoc analysis was used to compare usage for phone mEHR between each pair of provider groups (ambulatory vs. critical care, ambulatory vs. emergency medicine, ambulatory vs. inpatient, critical care vs. emergency medicine, critical care vs. inpatient, and impatient vs. emergency medicine) for all three time intervals (0-12 month, 0-6 month, and 6-12 month. This process was repeated for tablet mEHR. p <0.05 was considered significant. Statplus software was used for statistical analysis.

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