

BRIEF REPORT

Integration of Mobile Devices to Facilitate Patient Care and Teaching During Family-Centered Rounds

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ABSTRACT

OBJECTIVES: The increasing prevalence of mobile devices in clinical settings has the potential to improve both patient care and education. The benefits are particularly promising in the context of family-centered rounds in inpatient pediatric settings. We aimed to increase mobile device usage by inpatient rounding teams by 50% in 6 months. We hoped to demonstrate that use of mobile devices would improve access to patient care and educational information and to determine if use would improve efficiency and perceptions of clinical teaching.

METHODS: We designed a mixed-methods study involving pre- and post-implementation surveys to residents, families, and faculty as well as direct observations of family-centered rounds. We conducted rapid cycles of continual quality improvement by using the Plan-Do-Study-Act framework involving 3 interventions.

RESULTS: Pre-intervention, the mobile computing cart was used for resident education on average 3.3 times per rounding session. After cycle 3, teaching through the use of mobile devices increased by ~79% to 5.9 times per rounding session. On the basis of survey data, we determined there was a statistically significant increase in residents' perception of feeling prepared for rounds, receiving teaching on clinical care, and ability to teach families. Additionally, average time spent per patient on rounds decreased after implementation of mobile devices.

CONCLUSIONS: Integration of mobile devices into a pediatric hospital medicine teaching service can facilitate patient care and perception of resident teaching by extending the utility of electronic medical records in care decisions and by improving access to knowledge resources.

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TABLE 1 Resident Survey Pre- and Post-implementation

Item	Pre (n = 11) ^a	Post (n = 11) ^a
	Mean (SD)	Mean (SD)
1. I feel prepared for rounds most days ^b	3.14 (0.45)	3.71 (0.42)
2. I feel confident in my ability to interpret laboratory values.	3.27 (0.52)	3.42 (0.50)
3. I feel confident in my ability to interpret chest radiographs.	3.23 (0.52)	3.52 (0.50)
4. Daily rounds are efficient.	2.82 (0.34)	2.96 (0.54)
5. I receive teaching on physical diagnosis skills and bedside manner during daily rounds.	2.91 (0.83)	3.02 (0.41)
6. I receive teaching on clinical care skills and pediatric hospital medicine during daily rounds. ^c	3.00 (0.45)	3.49 (0.50)
7. The work done during rounds improves my efficiency and the flow of patient care.	2.59 (0.80)	3.11 (0.66)
8. I use computer-based technology to obtain information regarding patients before rounds.	3.32 (0.72)	3.74 (0.40)
9. I use computer-based technology to obtain information regarding patients during rounds.	3.14 (0.64)	3.33 (0.61)
10. I am often distracted during rounds.	2.55 (1.13)	2.88 (0.86)
11. I am able to effectively teach families about their diagnosis and discharge instructions during rounds. ^d	2.86 (0.55)	3.29 (0.79)
12. I miss important clinical information because I am distracted by mobile devices during rounds.	2.91 (0.54)	2.47 (0.76)
13. I have witnessed another team member miss important clinical information because he/she was distracted by mobile devices during rounds.	2.09 (0.83)	2.10 (0.78)
14. I use mobile devices to respond to personal texts/e-mails during rounds.	2.64 (1.10)	3.05 (1.09)
15. Use of mobile devices improves my ability to access educational resources.	3.23 (0.68)	2.80 (0.87)
16. Use of mobile devices saves me time. ^e	3.23 (0.68)	2.42 (1.23)
17. Use of mobile devices allows me to become more engaged with my patients and their families.	2.55 (0.69)	2.50 (0.82)
18. Using mobile devices in front of families compromises my professionalism.	2.55 (0.93)	2.74 (0.84)
19. The presence of mobile devices on rounds improves the entire team's ability to learn.	2.91 (0.80)	2.83 (0.75)

^a Pre refers to pre-implementation of the handheld mobile device; Post refers to post-implementation of the handheld mobile device.

^b Pre- versus post-ratings are statistically different via the Wilcoxon rank test ($P = .018$).

^c Pre- versus post-ratings are statistically different via the Wilcoxon rank test ($P = .017$).

^d Pre- versus post-ratings are statistically different via the Wilcoxon rank test ($P = .013$).

^e Pre- versus post-ratings are statistically different via the Wilcoxon rank test ($P = .042$).

millennial learners, teaching through innovative technology may improve efficiency and education.⁶ Recent studies of mobile device use are largely based on self-reported survey data, making them vulnerable to bias. There is need for greater specificity regarding how mobile devices improve efficiency and clinical teaching during FCR.

This brief report describes our efforts to integrate mobile devices into our pediatric hospital medicine teaching service. Our primary objective (Specific Aim 1) was to demonstrate that integration of mobile devices would improve access to point-of-care patient information and educational resources during FCR. We aimed to increase mobile device usage by 50% in 6 months. Our secondary objectives (Specific Aim 2) were to determine if increased use and access of mobile technology during rounds would improve efficiency and perceptions of clinical teaching.

METHODS

Context

Our setting is a 94-bed children's hospital within a hospital in a medium-sized city in the South. Our study population included pediatric hospitalists and physician assistants (ie, faculty) ($n = 7$), residents ($n = 33$), and a random selection of patients' parents and/or guardians ($n = 76$).

Design and Interventions

We conducted a quality improvement (QI) project between June 2015 and March 2016, incorporating observational and survey data collection before and after mobile device implementation during daily FCR. We conducted several Plan-Do-Study-Act (PDSA) QI cycles focused on mobile device usage during FCR.⁷

The first cycle involved the introduction of 2 Hewlett-Packard EliteBook Revolve devices to each rounding team. Before implementation, a mobile computer cart was used on FCR. The size of the mobile computer cart made it difficult to maneuver in small patient rooms, often limiting the accessibility of the computer during teaching and patient interactions.

The second cycle involved sending "To Show on the Go" e-mails to faculty and residents

Integration of tablets and smartphones into clinical care and medical education is a recent trend that continues to evolve rapidly.¹ Mobile device use among physicians improves productivity and efficiency,² especially for accessing electronic medical records.¹ Mobile devices have been integrated into resident workflow, averting patient delays and

possibly improving the continuity of care.³ Additionally, the incorporation of mobile devices into teaching improves the learners' perception of bedside teaching and patient care.⁴ Despite the documented benefits, the majority of pediatric hospitalists do not incorporate handheld devices into family-centered rounds (FCR).⁵ With resident duty hour restrictions and preferences of

TABLE 2 Faculty Survey Pre- and Post-implementation

Item	Pre (n = 5) ^a	Post (n = 5) ^a
	Mean (SD)	Mean (SD)
1. Residents are prepared for daily rounds.	3.2 (0.45)	3.0 (0)
2. Residents have all the necessary information regarding the patient during rounds.	2.4 (0.55)	2.9 (0.33)
3. Residents are often distracted during rounds. ^b	3.2 (0.45)	2.4 (0.36)
4. I am able to effectively teach residents about interpretation of laboratories and imaging during rounds. ^c	2.2 (0.45)	3.3 (0.33)
5. I am able to effectively teach families about their diagnosis and discharge instructions during rounds.	3.0 (0.71)	3.2 (0.14)
6. The use of mobile devices helped me teach bedside skills. ^d	—	3.2 (0.39)
7. Residents' use of mobile devices improves patient care on our service. ^d	—	3.2 (0.46)

—, not applicable.

^a Pre refers to pre-implementation of the handheld mobile device; Post refers to post-implementation of the handheld mobile device.

^b Pre- versus post-ratings are statistically different via the Wilcoxon rank test ($P = .043$).

^c Pre- versus post-ratings are statistically different via the Wilcoxon rank test ($P = .041$).

^d Items not asked at pretest.

consisting of predesigned teaching slides with highlights from literature and clinical care guidelines on topics frequently encountered in the inpatient setting. The slides were created by faculty and were designed to have a low threshold for participation while providing information that the team could quickly use during FCR. Links to slides were available on the residency's secure Web site platform and were also sent as weekly afternoon e-mails.

The third PDSA cycle involved the same "To Show on the Go" e-mail reminders that were now disseminated biweekly at 8 AM before FCR.

Our intervention team consisted of 2 pediatric hospitalists, the Medical Director of Quality and Patient Safety, and an education researcher. This study received approval from our institutional review board.

Observations of FCR

To assess Specific Aim 1, trained research assistants conducted observations of FCR and captured information on the frequency of device usage for teaching residents and families, and the number of times the device was used to refer to "supporting clinical education," which we operationally defined as the use of computing devices to access patient reports, clinical practice guidelines, reference material, and teaching slides.

Additional data were collected on resident distraction and length of FCR as balancing measures. To assess improved efficiency, we measured the length of rounds before and after mobile device integration.

Surveys

To assess Specific Aim 2, surveys were administered to residents and faculty pre-implementation and periodically post-implementation. Survey items were developed based on existing literature, targeted behaviors, and team member consensus. The resident survey included 19 items rated on a 4-point Likert scale in which 4 = Strongly Agree and 1 = Strongly Disagree (Table 1). The faculty survey used the same rating scale and presented 7 items (Table 2). Families were surveyed periodically after the third PDSA cycle. The family survey, which used the same 4-point Likert Scale and had a Flesch-Kincaid Readability score of Grade Level 6.2, included 5 items concerning how well team members explained issues related to the child and the degree to which the physicians' use of mobile devices interfered with communication.

Analysis

Annotated process control charts were used to describe the observation data

longitudinally, including the timing of interventions.⁷ The mean (center line) and upper and lower control limits were calculated and displayed as ± 3 SD of the mean. Chart analysis and center line adjustment were performed using standard rules to detect special cause variation.^{7,8} The Wilcoxon rank test was used to compare the linked pre- versus post-implementation responses of the residents and faculty.

RESULTS

Observation

Before integrating handheld devices, the mobile computing cart was used to support resident education on average 3.3 times per rounding session. The introduction of "To Show on the Go" e-mails produced nearly 6 educational mobile device uses per rounding session (Fig 1). Lastly, observations indicated that use of devices for family education increased from an average of 0.6 times to 1.1 times per rounding session.

Resident Surveys

A total of 11 residents completed surveys with unique identifiers that could be linked pre- and post-integration. Surveys were administered multiple times post-integration, and the mean response was used if there were multiple post-surveys for a particular resident (Table 1). By using the Wilcoxon rank test, there were statistically significant increases during the post-period of feeling prepared for rounds on most days (Item 1; z score = -2.36 , $P = .018$); receiving teaching on clinical care skills and pediatric hospital medicine during daily rounds (Item 6; z score = -2.93 , $P = .017$); and ability to effectively teach families about their diagnosis and discharge instructions during rounds (Item 11; z score = -2.49 , $P = .013$). There was a statistically significant decrease during the post-period for the belief that mobile devices save time (Item 16; z score = -2.03 , $P = .042$).

Faculty Surveys

By using the mean response if there were multiple post-surveys per faculty, we ran the Wilcoxon rank test on pre- and post-responses for 5 faculty with linked surveys. For the post-intervention, there was a statistically significant increase in faculty's

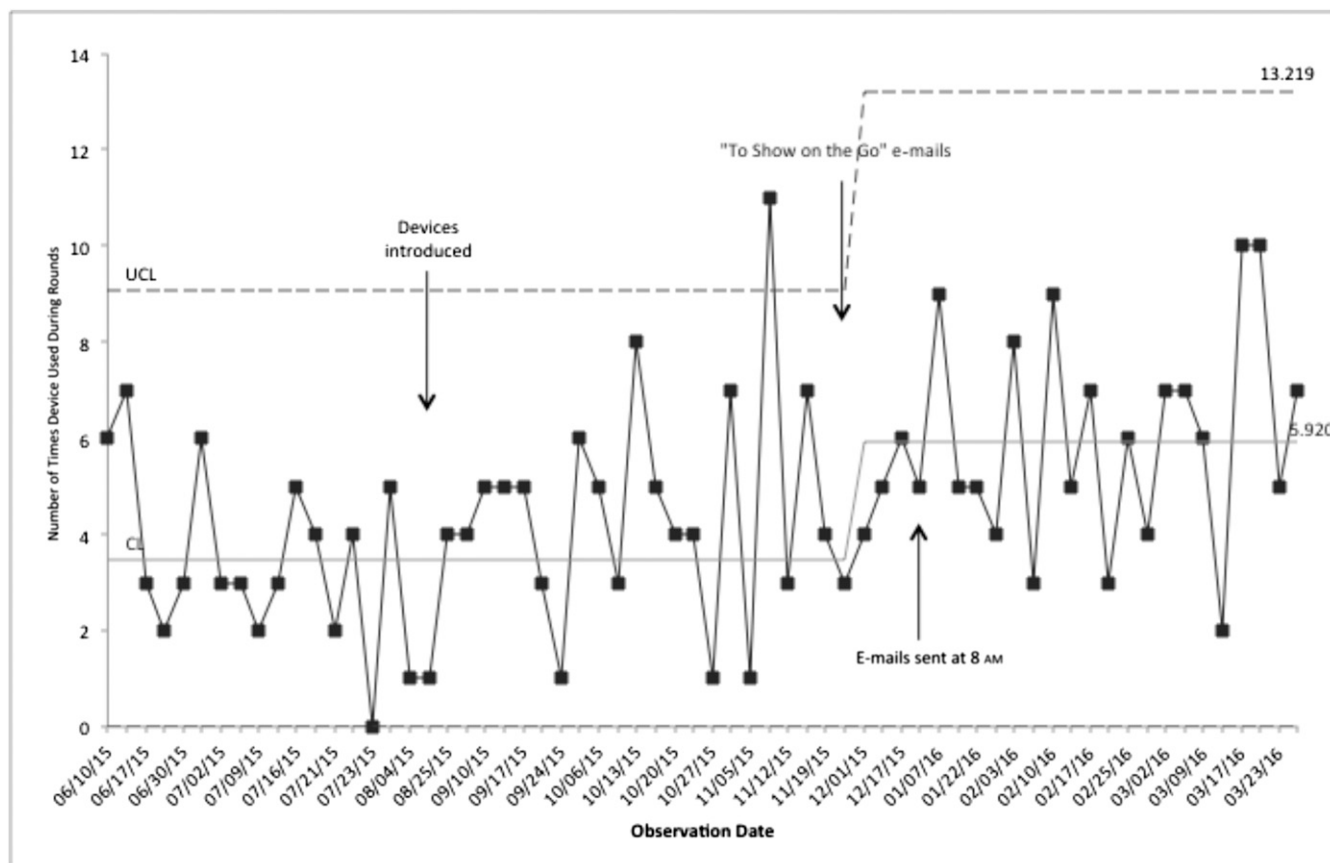


FIGURE 1 Mobile device use for resident education. CL, control limit; UCL, upper control limit.

belief that they were able to teach residents effectively how to interpret laboratory values and images during rounds (Item 4; z score = -2.04 , $P = .041$) and a statistically significant decrease in faculty beliefs that residents were often distracted during rounds (Item 3; z score = -2.0 , $P = .043$).

Parent Surveys

The vast majority of the 76 parents agreed or strongly agreed that physicians explained their child's situation (98.7%) and prepared them for discharge (73.7%). Only 30.3% of parents agreed that mobile devices were used to help them understand their child's diagnosis, and none indicated interference with physician communication because of the use of mobile devices.

Balancing Measures

The average length of rounds increased from 90 to 102 minutes post-intervention. However, during the same time period, the average number of patients seen during rounds increased from 7.8 to 10.6 persons

per rounding session. Thus, the average number of minutes spent per patient decreased after integrating the mobile devices from 11.5 to 9.6 minutes. Also of note, the research assistants infrequently marked that team members were distracted during rounds.

DISCUSSION

Our primary aim of increasing mobile device usage by 50% in 6 months on an inpatient teaching team was accomplished, and residents and faculty reported a perceived improvement in their education during that time. We found that the use of mobile devices during FCR can increase access to patient information via the electronic medical record (EMR). We consider EMR access to be a critical component of teaching because role modeling of clinical reasoning is a well-documented teaching strategy that is valued by millennial learners.^{9,10} The authors of a recent systematic review found that

physicians' use of handheld computers facilitates patient care¹¹; in our report, we show that learners accessed resources more frequently on rounds, which may have, in turn, facilitated patient care. Additionally, survey responses suggest that both faculty and residents' perception of clinical teaching significantly improved after integration of mobile devices. This finding supports the well-described millennial learner's value of experiential and technology-based learning⁹ and demonstrates how mobile devices can be an effective teaching asset during FCR.

Although residents did not report that mobile devices saved time, direct observations of rounds suggested that efficiency might have been improved because the amount of time spent per patient decreased. Resident perception of lack of efficiency could be because of the fact that the intervention period occurred during busier high census months. Although these results do not conclusively reveal a

link between mobile devices and efficiency, we were encouraged that efficiency was not negatively impacted.

Overall learner response to the devices was positive. Some participants reported challenges related to the heaviness of the device itself and difficulty with the touch screen feature when in tablet mode. Others have noted similar findings; for example, problems with portability of devices and difficulties with typing within Citrix were reported obstacles to mobile device use at 1 institution.¹² To address these issues, we plan to change to a lighter device that is more compatible with our hospital EMR. We specifically chose the Hewlett-Packard EliteBook Revolve devices on the basis of their compatibility with our hospital's current technology infrastructure. This is significant because strong institutional support has been described as an important factor in successful use of mobile devices.²

The authors of several studies have discussed the potential for mobile devices to cause distraction with regards to both learning and patient care.^{1,13} Although we found relatively few notations of distraction (eg, a resident asking for information to be repeated) during direct observation of FCR, survey data revealed a trend toward increased perception of distraction by the residents (Table 1, question 10). Additional study is needed to investigate the extent of any negative outcomes related to patient safety and resident education as a result of distraction.

This single-center study offers important but narrow insight into the pragmatic utility of mobile devices in a clinical learning environment. Survey data are limited by the available number of paired responses; therefore, conclusions on resident perception may not truly reflect the perception of the entire group. Additional work is needed to examine the impact of more ubiquitous use of mobile devices on efficiency. Furthermore, we were unable to measure whether increased access to educational resources translated into measurable improvements in resident learning. Future studies should include resident knowledge assessments to

evaluate if improved point of care access correlates with improved medical knowledge and clinical reasoning.

Additionally, increase in family education was based on observation data alone because families did not complete surveys before the intervention. It is unclear if the minimal impact on family education was the result of interventions that focused more on resident rather than family education.

Another potential limitation was that observation of distractions caused by the mobile device, 1 of our balancing measures, may have been challenging for observers. It is possible that residents were indeed distracted by the devices but were skilled in disguising the distraction from observation. Resident survey data did not reveal a statistically significant change in perception of distraction, whereas faculty responses support the research assistants' observations of greater attentiveness. It is difficult to make conclusions regarding distraction based on these data.

CONCLUSIONS

Mobile device use on a pediatric hospital medicine teaching service was increased by >50% in 6 months, and the increase in device use was associated with the perception of increase in education by both residents and faculty. Integration of mobile devices can effectively extend the utility of EMR in care decisions and improve the ability of the team to efficiently access knowledge resources. This can be done without significantly lengthening rounds. Additional QI interventions need to focus on use of the devices specifically for patient education, and additional research is needed on the extent of distraction caused by the devices.

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