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## Research and Applications

# A mobile application to support bedside nurse documentation and care: a time and motion study

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### ABSTRACT

Documentation at the bedside is still often initiated on paper before being entered in electronic charts, even after implementing electronic health records (EHRs). This 2-step process is time-consuming, a potential source of error, and hinders the use of real-time information. We developed the “Bedside mobility” smartphone application to facilitate bedside documentation in the EHR.

**Objective:** This study aims to evaluate the impact of our app in 2 wards of a teaching hospital with a pre-post design.

**Materials and methods:** The duration and location of all documentation activities were recorded using a time motion study.

**Results:** Using the app significantly decreased the duration of EHR documentation per hour of observation by 4.10 min ( $P = 0.003$ ), while the time spent interacting with patient increased by 1.45 min although not significantly. Also, in the intervention period, the average duration of uninterrupted documentation episodes increased by 0.27 min ( $P = 0.16$ ) and the uninterrupted interaction with patient increased by 8.50 min ( $P = 0.027$ ).

**Discussion:** By reducing the fragmentation of documentation workflow, decreasing the overall EHR documentation time and allowing nurses to spend more time with their patients, app use led to potential higher quality of care and higher patient satisfaction and may help maintain a smoother workflow.

**Conclusion:** Our mobile app has the potential to positively impact bedside nurses’ clinical workflow and documentation, as well as patient–provider communication and relationship.

**Key words:** mHealth, nursing, time motion study

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## INTRODUCTION

Patient care by nursing teams is a key component for patient management in the hospital.<sup>1</sup> Nurses provide many types of care interventions, which range from administering medication, checking vital signs, changing bandages to providing patient support and education. While each healthcare system may have different practices, a daily list of nursing tasks is planned for each patient, based on the nurses’ care interventions and the doctors’ prescriptions.<sup>2</sup> The

current practice in our hospital is for nurses to print out the daily task list for each patient at each shift.

Although these paper-based supports help guide the bedside activities, they also raise some concerns. These print-outs are snapshots of patient interventions at a given point of time: any tasks added after printing is written in by hand, and may be missed. After completing the interventions, nurses log into the patients’ electronic health records (EHRs) to document their actions and observations.

### LAY SUMMARY

In hospitals, documentation at the bedside is still often initiated by nurses on paper before being entered in electronic charts. This 2-step process is time-consuming, a potential source of error, and hinders the use of real-time information. We developed the “Bedside mobility” smartphone application to facilitate bedside documentation. This study aims to evaluate the impact of our app in terms of documentation duration. To this end, observations were conducted in 2 wards of a teaching hospital before and after the introduction of the app. Results show that using the app significantly decreased the time spent by care-providers on documentation by 4.10 min per hour of observation. Also, the time spent interacting with patients increased by 1.45 min. After implementing the app, the duration of uninterrupted documentation episodes increase of 0.27 min as well as the uninterrupted interactions with patient by 8.50 min, suggesting that the app may help maintain a smoother workflow. By reducing the fragmentation of the documentation process, decreasing the overall EHR documentation time and allowing nurses to spend more time with their patients, app use lead to a potentially higher quality of care and higher patient satisfaction, as well as improving patient-provider communication and relationship.

Paper-based supports are sometimes used to jot down quick notes of clinical data (ie, vital signs) before entering them into the EHR. Paper-based supports may therefore create an additional step in clinical documentation, and bear the risk of potential transcription errors. It also creates a delay in the availability of collected data within the EHR. Furthermore, print-outs do not provide an easy access to detailed patient information as they are limited in their searchability and presentation of information. In addition to all these concerns, the institution’s desire to be more environmentally friendly also motivated the development of alternative solutions to improve the bedside patient care process.

One viable solution is to implement a mobile application. Mobile devices provide many new opportunities and tools for patient care.<sup>3,4</sup> An EHR-connected application, for example, can provide the needed task list at timely moments, with real-time documentation. Also, entering data directly on the device could reduce potential transcriptions errors as well as delays in the availability of collected data.<sup>5</sup> Having access to elements in the EHR can help nurses respond to patient questions more readily, and could further empower patients by receiving timely and accurate information whenever needed. Therefore, we developed a mobile application for bedside nurses to decrease the amount of their time spent on chart updates and to increase the quality of care. The feasibility, acceptability, and satisfaction results for the app were positive and have been reported elsewhere in detail.<sup>6–11</sup>

### App description

Our team developed a mobile application (“the app” hereafter) for nurses connected to the local EHR using a participatory design approach.

Functionalities were chosen from an initial needs assessment and were designed with iterative testing by nursing staff. These are:

- A rapid access to patient charts by scanning a QR code on the patients’ hospital bracelets in accordance with our hospital’s patient safety policy.
- Presentation of administrative data (identity, age, length of hospital stay) and clinical data from the current hospitalization, such as comorbidities and daily nursing objectives. These components provide support for the handoff process.
- Nursing tasks that are sorted in chronological order for each patient, starting at the current time of app use. Similar activities (multiple medications, for example) are grouped together for easier readability.

- Tasks that are validated with a single swipe motion, and that can be modified, delayed or repeated. These functions are often used during documentation in the EHR.
- Vital signs and clinical scores that are visualized in different sections of the app. Nurses can spontaneously add results to these sections, even when they are not previously planned activities (eg, pain level gathered outside of scheduled pain assessments).
- Pro re nata use (PRN, or “as needed”) medications list readily available and the administered doses during the last 24 h.

Careful consideration was given to the design of the app to increase efficiency, such as offering the range of frequent tasks used in clinical documentation from a computer-based EHR. A usability test with 10 nurses was conducted prior to implementing the app in the study and is reported elsewhere.<sup>8</sup>

### Modification of documentation process

We use the term “clinical documentation” to include all data entry in the EHR. The current documentation process occurs throughout the day on the computers on wheels (COWs), or on the desktop computers, often with written notes and subsequent transcription in the EHR. Some elements are entered into the EHR throughout the day, such as vital signs, while others tend to be entered at the end of a shift, such as nursing progress notes. [Table 1](#) provides further detail of clinical documentation of different EHR sections in terms of content and process with and without the bedside application ([Table 1](#)).

We hypothesized that with the app, nursing staff would spend more time at the bedside. We also hypothesized that the use of the app would affect the documentation pattern (total duration per observation, continuous time per task).

### Objectives

Our objective focused on quantifying the impact of the app on the time spent on clinical documentation as well as on direct interaction with the patients.

### METHODS

To test our hypotheses, we relied on a time motion study (TMS) methodology to report the amount of time spent on clinical documentation.<sup>12</sup> A TMS allows us to collect detailed descriptive data of the documentation process at the bedside.<sup>14</sup> Such data include time-stamps, task types, mean of documentation, and location. In our

**Table 1.** EMR sections for clinical documentation, and comparison with app functions

EHR section	Baseline condition	Intervention with bedside app	Observable EHR task
Task list	Printed out for bedside use. Validation of tasks and annotations on COWs or paper (later transcribed)	Full list available on app with 1-swipe validation and features to rapidly annotate, duplicate, and postpone a task	Task validation
Vital signs	Available on COWs or desktop	Data entry and visualization are available in the app	Charting
Ins and outs	Handwritten notes at the bedside/waste disposal, data entry on desktop	Possible data entry in app	Charting
Clinical score (VAS, CIWA, etc.)	Available in a specific tab in the EHR	Certain scores that are assessed at the bedside have been included in the app, with a summary of previous results during the current hospitalization	Clinical score assessment
Nursing notes	Daily goals for nursing care and nursing notes often completed after handoff. Keywords often annotated on personal notes to remember the items	Free text annotations and tag function available in app to support detailed nursing notes at a later time	Nursing note documentation
Use of PRN medication	Prescription available on intervention list, annotations on the print-out if needed, need to access EHR for further information	Immediate view of the number of doses given in the last day, with summary of the doses administered during this period	Charting
Administrative patient information	All patient information in EHR available on desktop or COWs	Name, age, birthdate, contact information (patient cell number) and contact person information, duration of stay in the ward are available on the app	Dashboard viewing
Labs, medical reports (ie, admission and progress notes), radiology reports	Available on EHR on desktop or COWs	Reason of admission, type, and date of event are available on the app	Dashboard viewing
Computerized prescription	Physicians prescribe medical orders, which are acknowledged and planned by nursing staff	Tasks related to prescriptions are included in the task list	Task planning

case, direct human observation of nursing shifts was the most accurate way to study nurses' interactions with patients and location of EHR use.

### Study design and outcomes

The study design is a pre–post comparison of documentation time after app implementation in a medical ward and a surgical ward. This design allows us to minimize the variability between the control (pre) and intervention group (post). Indeed, nursing teams adopt workflows and practices that may differ in each ward; we also expected most participants to be the same in the pre- and post-periods. The primary outcome was the average duration of clinical documentation activities in the EHR as well as time spend with patients by nursing team per hour of observation before and after implementing the bedside nursing app. The secondary outcomes of our study included the average length of uninterrupted documentation activities.

### Clinical setting

The study was conducted in an academic medical center in Geneva, Switzerland. It included 2 nurses' teams: a surgical nursing team (orthopedic ward) of 20 nurses and 11 nursing assistants and a medical nursing team (medical ward) of 20 nurses and 12 nursing assistants. On average, each ward had 16–20 patients per day. Three nurses

were present during the morning shift, 2 nurses in the afternoon shift, and only 1 nurse at night. Nursing assistants were present day and night. Nurses had access to 3 desktop computers in the nursing stations and 2 portable computers on wheels (COWs) in each ward. These laptops had a barcode scanner to allow nurses to access patient charts at the bedside via the barcode on the patient's bracelets. For patients requiring protective isolation, the laptops were left outside in the corridor. Despite the availability of laptop, nurses currently printed the task lists for their patients at the start of their shift to have this information on hand during their shift.

### A priori power analysis

Our first outcome was the average duration of a documentation activity in the EHR. Based on an average documentation time accounting for 22.5% of the daily workload and a standard deviation of 10.7<sup>13</sup> and a paired *t*-test with an effect size of 10% (we consider a 10% reduction in documentation time significant) we obtained an *n* of 130. With an average of 18 patients per day on each ward, about 8 days of data were required to identify a significant difference: this resulted in 5 days of observation in each ward.

### Inclusion/exclusion criteria

Nurses and nursing aids who worked between 7 AM and 6 PM from Monday to Friday during the study period in the 2 selected wards

were included in the study. A total of 40 participants were recruited in the pre- and post-intervention.

### Study timeline

The study was carried out over 2 months in each ward. Indirect observations (EHR event logs) were conducted throughout the study period, while the direct observations (TMS) were conducted during the last week of the pre- and post-stage. As shown in Figure 1, the EHR log data were collected 4 weeks before and after the deployment of the app. The study was conducted between June and July of 2017 (orthopedic ward) and between July and August of 2017 (medical ward).

### Intervention

Participants received a brief training session for app use prior to its deployment. We provided 5 iPhones per ward with Wi-Fi connectivity. During the study, app use was limited from 7 AM to 6 PM from Monday to Friday, in order to provide the appropriate IT support. All data collected through the app was automatically integrated into the EHR. Participants were also asked to verify patient charts at the end of their shifts as an additional safety measure, to avoid any loss or corruption of clinical data.

### Data collection and analysis

Various data points were collected in the direct TMS observation as summarized in Table 2. For direct observations, the data were collected using a tablet-based application called “T&M data collector”.<sup>15</sup> A team of research collaborators, external to both wards, conducted 2 observation sessions (morning and afternoon) per day in each ward during 5 consecutive days (Monday to Friday) of the week prior to the intervention and during the fourth week with the app in each ward (Figure 1). Each observer followed a different nurse during shifts between 7 AM and 6 PM. They collected data on various work processes (eg, handoffs, rounds), all forms of clinical documentation, and nursing activities: tasks, phone calls, and interactions with patients. The TMS observed EHR-related tasks, as well as use of COWs and location of app use (nursing office, ward corridor, or patient room), which are not tracked in the EHR or app logs. A descriptive analysis of the documentation task durations in the TMS data is presented, and the differences between the baseline observations and those after 4 weeks of app use were explored using a univariate model to account for the non-parametric characteristic (Mann–Whitney *U* test).

## RESULTS

### Participants

Twelve of the 19 nurses from the surgical ward during the study period and all 14 nurses from the medical ward were observed during the TMS.

### TMS data analysis

A summary of the time motion data is presented in the following tables. Table 3 shows the duration of several documentation activi-

ties and interactions with patients per hour of observation and Table 4 shows the duration of uninterrupted documentation and interactions.

### Time spent on each activity per hour of observation

When looking at the median time spent for the different activities for each hour of observation, overall EHR documentation accounted for 12.35 min in the baseline period and diminished to 8.25 min during the intervention period (significant reduction of 4.10 min [ $P = 0.003$ ]). The time spent interacting with the patient increased by 1.45 min from baseline to intervention period going from 7.84 to 9.30 min ( $P = 0.25$ ).

### Duration of uninterrupted activities

Table 4 reports the median durations of uninterrupted clinical documentation episodes in EHR (time spent on a single task before switching to another task). The results show that the median duration of an uninterrupted single continuous EHR documentation episode was 0.49 min shorter in the intervention period in the Surgical Ward ( $P = 0.0299$ ) but 0.83 min longer in the Medical Ward ( $P = 0.0039$ ). Examining the pattern in EHR documentation with and without vital signs, the significant decrease in Surgical Ward was attributed to the EHR documentation without vital signs, while the significant increase in Medical Ward was attributed to vital signs.

During the intervention period, participants spent longer uninterrupted episodes by more than 8 min (163.4% increase of medians,  $P = 0.027$ ) with their patients than in the pre-period, leading to potential higher care quality and higher patient satisfaction.

### Location of documentation

Finally, Figure 2 presents the percentage of time allocated to clinical documentation by location in both wards, by all users. The results show a significant drop in using computer and laptop in all settings. Use of desktop computers dropped in the office ( $P = 0.043$ ) and laptop computers in the corridors ( $P < 0.001$ ) for clinical documentation, and a significant decrease in laptop computer use in the patients’ rooms ( $P = 0.012$ ).

## DISCUSSION

Through participatory design, and iterations with bedside nursing staff, we designed this mobile app to facilitate the documentation process. Our results show that the use of the app was associated with a decrease of time spent on EHR documentation, whereas the time spent on patient interactions remained stable. Additionally, our results show that the use of the app led to a less fragmented documentation workflow, nurses spending significantly longer uninterrupted documentation and interaction episodes. The presence of longer documentation episodes suggests that nurses were less often interrupted during this task suggesting that the app may enable a smoother workflow but its effect may depend on the work environment. Some variability can be observed between the 2 wards. For instance, the length of continuous documentation episode increased

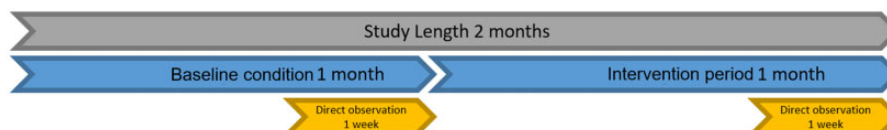


Figure 1. Study timeline.

**Table 2.** Types and sources of collected data during the pre and post observation weeks

Measure	Data source	Item monitored	Unit
Time spent during clinical activities	TMS data	Handoffs, rounds, measuring vital signs, clinical documentation	Minutes
Total active time	TMS data	All activity	Minutes
Time spent in location of EHR use	TMS data	Nursing office, corridor or bedside	Minutes
Time spent on different types of devices	TMS data	Laptop, smartphone, desktop	Minutes

**Table 3.** Time spent per hour of observation on documentation and interaction tasks for both wards and for each ward separately

Category	Ward	Baseline period		Intervention period		Diff (min/h)	P-value	change
		Session (observation) count	Median, IQR (min/h)	Session (observation) count	Median, IQR (min/h)			
Overall EHR documentation	Both	37 (509)	12.36 (9.36–18.53)	34 (383)	8.25 (5.42–10.97)	-4.10	0.0030*	↓
	Medical	18 (292)	13.34 (12.32–23.28)	16 (237)	11.16 (7.66–21.47)	-2.17	0.2188	↓
	Surgical	19 (217)	10.20 (8.67–13.41)	18 (146)	6.56 (4.74–8.58)	-3.64	0.0002*	↓
EHR documentation without vital signs	Both	35 (445)	10.55 (6.67–16.02)	32 (334)	7.26 (4.74–10.13)	-3.30	0.0119*	↓
	Medical	16 (256)	11.65 (9.99–21.09)	16 (209)	10.12 (6.41–18.36)	-1.53	0.2964	↓
Vital signs	Surgical	19 (189)	8.72 (6.22–11.31)	16 (125)	5.79 (3.94–7.86)	-2.93	0.0022*	↓
	Both	37 (64)	1.69 (0.83–2.59)	34 (49)	0.80 (0.42–1.81)	-0.90	0.0066*	↓
Interact with patients	Medical	18 (36)	1.76 (0.78–3.03)	16 (28)	1.28 (0.68–2.48)	-0.48	0.1414	↓
	Surgical	19 (28)	1.69 (1.05–1.91)	18 (21)	0.58 (0.38–0.95)	-1.12	0.0062*	↓
	Both	34 (72)	7.84 (3.88–15.53)	33 (67)	9.30 (5.74–14.42)	1.45	0.2511	↑
Interact with patients	Medical	18 (40)	9.15 (3.21–16.85)	16 (35)	10.89 (5.59–16.71)	1.74	0.3847	↑
	Surgical	16 (32)	7.16 (3.95–12.96)	17 (32)	8.76 (5.74–11.17)	1.60	0.2412	↑

\*P-value < 0.05 (the session count refers to the total number of sessions in which a category of task was observed at least once; the observation count refers to the sum of all counts of a category observed in all sessions).

**Table 4.** Time spent on uninterrupted documentation and interaction tasks for both wards and for each ward separately

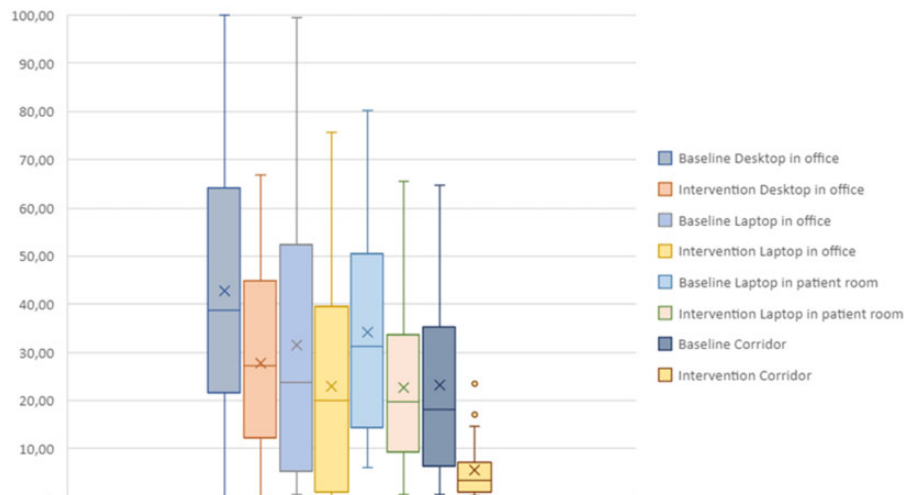
Category	Ward	Baseline period		Intervention period		Single observation difference		
		Session (observation) count	Median duration of single observation, IQR (min)	Session (observation) count	Median duration of single observation, IQR (s)	Diff (min)	P-value	Change
Overall EHR documentation	Both	37 (509)	1.45 (0.35–4.37)	34 (383)	1.72 (0.44–4.56)	0.27	0.1598	↑
	Medical	18 (292)	1.18 (0.23–3.62)	16 (237)	2.01 (0.45–5.41)	0.83	0.0039*	↑
	Surgical	19 (217)	1.75 (0.53–5.09)	18 (146)	1.26 (0.43–3.19)	-0.49	0.0299*	↓
EHR Documentation Without Vital Signs	Both	35 (445)	1.37 (0.27–4.33)	32 (334)	1.70 (0.39–4.59)	0.33	0.1027	↑
	Medical	16 (256)	1.11 (0.23–3.54)	16 (209)	1.91 (0.40–5.63)	0.80	0.0042*	↑
Vital Signs	Surgical	19 (189)	1.72 (0.50–4.98)	16 (125)	1.10 (0.39–3.25)	-0.62	0.0780	↓
	Both	37 (64)	2.53 (0.79–5.11)	34 (49)	2.10 (0.66–3.93)	-0.43	0.2336	↓
	Medical	18 (36)	1.80 (0.59–3.98)	16 (28)	2.54 (0.58–4.67)	0.74	0.3179	↑
Interact with Patients	Surgical	19 (28)	3.64 (1.23–6.22)	18 (21)	1.64 (0.87–2.81)	-1.99	0.0369*	↓
	Both	34 (72)	5.20 (0.63–20.14)	33 (67)	13.70 (3.46–29.84)	8.50	0.0270*	↑
	Medical	18 (40)	2.91 (0.38–21.61)	16 (35)	15.32 (3.57–31.85)	12.41	0.0276*	↑
Surgical	16 (32)	9.27 (2.02–20.14)	17 (32)	12.98 (3.61–28.64)	3.71	0.2446	↑	

\*P-value < 0.05 (the session count refers to the total number of sessions in which a category of task was observed at least once; the observation count refers to the sum of all counts of a category observed in all sessions).

when using the app in the medical ward, particularly when documenting the vital signs but not in the surgical ward.

The impact of digitalization on medical activity has been already reported in the literature.<sup>16,17</sup> A systematic review on the impact of EHR on time efficiency of physicians and nurses showed that EHR and computerized physician order entry (CPOE) systems can generate time savings in other activities, such as accessing a patient chart or maintaining patients' report forms. Another study assessing the impact of electronic medical record demonstrated that it may reduce documentation time after the adoption of CPOE. Concerning the

fragmentation of activities, it is known that interruptions of workflow significantly increase the cognitive load, stress and anxiety, inhibit decision-making performance and increase task errors.<sup>18,19</sup> Interruptions can cause an individual to forget items in their working memory, leading to errors such as failing to complete or initiate tasks, or repeating tasks.<sup>20</sup> On the other hand, longer episodes of time at the bedside allows nurses to show their interest for patients and deal with their needs when present at the bedside, which enhances patient-perceived nurse caring and leads to higher patient satisfaction.<sup>21</sup>



**Figure 2.** Percent of time allocated for clinical documentation in EHR in each location in baseline and intervention period for both wards and for all types of users.

The positive relationship between time spent and patient satisfaction is also evident in the outpatient setting: the amount of time that primary care physicians spend with their patients is the strongest predictor of patient satisfaction.<sup>22</sup> However, the use of digitalization can also be considered as a barrier for communication between patients and care-providers.<sup>23</sup>

The variability observed between the 2 wards may be a consequence of the high variability in work processes, types of health conditions, and overall patient status (age, comorbidities, need for nursing care, etc.) between medical and surgical patients.<sup>24</sup> Finally, there may also be differences in patient workload, in patient complexity and subsequent need for documentation, as well as in staffing of nurses during the 4 weeks (study during the summer vacation period).

This evaluation study has a few limitations. The downside of direct observations in the ward includes the high cost of recruiting observers, managing observation episodes, resulting in a limited number of observations per nurse. Therefore, our data may not be sufficiently powered to show a significant difference. Five days of observations may not represent the usual documentation time or time spent interacting with patients in a ward. Also, observations were limited, since observers could only observe 1 person at a time to collect the data with this level of detail. Second, as only 1 surgical ward and 1 medical ward participated in the study, generalizability of the results may be limited. The care team's level of interest in using a new tool was variable, decreasing if the workload was high. Time pressure and workload are barriers to testing new approaches, because of the learning curve. Furthermore, as the first EHR app in our institution, app users were asked to verify the EHR at the end of the shift to ensure correct entry of app-related data. It is likely that this required EHR use affected the measured outcomes negatively in this study, by increasing the total EHR use in the post group. Last but not least, the short duration of the study may not have allowed all team members to fully adopt the app, due to planned absences and night shifts.

## CONCLUSION

Clinical documentation is an unavoidable yet time-consuming and tedious process and can be a source of error (eg, transcription

errors). The ultimate goal of our project was to facilitate documentation for care-providers, and to improve patient safety for better quality of care. The current study explored the impact of a mobile app on the nurses' actual work processes using TMS data. Our findings suggest a potential improvement in terms of clinical documentation time and patient interaction with nursing staff in the individual ward data. The suggested benefits of this evaluation study have led us to pursue the implementation of this tool in other wards of our institution. Further user assessments have revealed a need for new functions, such as a camera (eg, wound assessment) to facilitate importing pictures into the patient's chart, and a team communication tool within the app to help coordinate and organize patient care. We will continue to improve the usability and functionality of the tool with assessments of its effectiveness in decreasing documentation time and work load, and improving workflow efficiency, care quality, and patient safety as well as user satisfaction.

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## AUTHOR CONTRIBUTIONS

All authors have substantially contributed to the conception, design of the work, acquisition, analysis, or interpretation of data for the work.

All authors have drafted the work or revised it critically for important intellectual content.

All authors have given their final approval of the version to be published.

All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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## CONFLICT OF INTEREST

The authors have no competing interests to declare.

## DATA AVAILABILITY

Data available on request.

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