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A Usability Evaluation of a Touchscreen Workstation on Wheels in a Simulated Emergency Department Workflow

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ABSTRACT

Background: Touchscreens have become ubiquitous in our daily lives, offering a comfortable and natural human-technology interactive experience. There exists a gap in the literature regarding the usability and efficiency of a touchscreen workstation on wheels (WOW) within an emergency department (ED) workflow, specifically with electronic medical record (EMR) systems designed for keyboard and mouse. **Methods:** This was a randomized, controlled, 2-intervention-2-period crossover study comparing a touchscreen to a non-touchscreen WOW. Participants were asked to complete a series of seven tasks that are typically done in the ED followed by the completion of a post-study questionnaire. **Results:** A total of 24 people (12 attendings, 12 resident physicians) participated in the study. Results from the linear mixed model regression analyses showed no evidence to reject the hypothesis that the average time to complete each task and the average total time to complete all tasks combined were similar ($p>0.05$) between the touchscreen and non-touchscreen WOW. Results from the post-study questionnaire using a 7-point Likert scale (Figure 1) demonstrated that the majority (>50%) of participants agreed to most questions favoring intention to use (BU), ease of use (PEOU), perceived usefulness (PU), and attitude towards utilization (AU) of the touchscreen WOW. **Conclusion:** This study builds on previous work on touchscreen devices by specifically evaluating the usability and efficiency of touchscreen WOWs in a controlled, simulation-based setting, differentiating from prior studies on tablets at the bedside. Future studies, should evaluate the impact of touchscreen-friendly EMR designs on clinical workflows in the ED.

KEYWORDS

healthcare information technology, touchscreen, workflow efficiency, emergency department, electronic medical records

1 | INTRODUCTION

Emergency Departments (EDs) serve as crucial entry points to hospitals, providing immediate care to patients with diverse medical needs. However, the high patient volume often leads to overcrowding, resulting in delayed care and emergency access blocks, the number one safety concern in first-world EDs (1–3). Timely care in the ED is essential for improving patient outcomes and reducing mortality rates (4–8). A recent study conducted in 2019 that analyzed ED data from 25 Canadian hospitals found that improvements that can increasing tasks performed at the bedside and reducing tasks at the stationary workstation have been observed to reduce workflow interruptions, decrease errors of omission, and increase time with patients and their families, which improved patient satisfaction and thus optimized provider service (9). Though technological innovations and information technology (IT) solutions have the potential to improve healthcare delivery, limited research exists on the specific mechanisms by which these solutions impact ED operations.

Touchscreens have become ubiquitous in our daily lives, offering a comfortable and natural human-technology interactive experience (10,11). A prospective pilot study conducted in a large level 1 ED introduced touchscreen tablet computers at the bedside, reducing physicians' time away from patients by 38 minutes per shift (12). Physicians reported positive perceptions of these devices, considering them clinically useful, efficient, easily portable, easy to disinfect, and improved overall patient care. While portable tablets show promise, their adoption can be limited regarding universal accessibility, operational capacity, security, fragility, interface quality, and compatibility with EMRs and associated software. Furthermore, the specific aspects of these interventions, such as portability or touchscreen functionality, that contribute to improved workflow efficiency require further investigation.

Our study aims to assess workflow efficiency and perceived usability of a touchscreen interface compared to a mouse-based interface on a standard workstation on wheel (WOW) with common tasks performed on two existing electronic medical record (EMR) systems in the emergency department (ED).

2 | METHODS

2.1 | Study Design

We performed a randomized, controlled, single-center, 2-intervention-2-period crossover study. The study subjects included a convenience sample of 12 resident physicians and 12 staff emergency physicians of the McGill University Health Center (MUHC), a large tertiary and quaternary academic teaching center in Montreal, Canada, who regularly use the existing MedUrge and Oacis EMRs for clinical care. The study involved the completion of the following EMR tasks in tandem with a ten-minute break in between interventions:

Task 1: Open a triage note and identify blood pressure via MedUrge
Task 2: Open most recent patient chart via Oacis
Task 3: Order CBC and CHEM7 bloodwork via Oacis
Task 4: Order chest x-ray imaging via Oacis
Task 5: Order acetaminophen medication via MedUrge
Task 6: Request a cardiology consult via MedUrge
Task 7: Discharge patient home via MedUrge

In keeping with a crossover design, all participants were evaluated for the completion of the same tasks using each of the two interventions. One intervention (A) involved completing the tasks with a non-touchscreen WOW (non-touchscreen monitor, keyboard, mouse) whereas the other intervention (B) involved completing the tasks with a touchscreen WOW (touchscreen monitor, keyboard, no mouse). Twelve subjects were randomly selected to perform the tasks in intervention A and then the tasks in intervention B (sequence AB), while the other twelve subjects completed the tasks in the opposite order (sequence BA). No washout period between interventions was introduced given that these are commonly performed EMR tasks and we assumed minimal to no carry-over effect (i.e., that the effect on

time to perform the tasks of the intervention used in the first period did not alter the effect on time to perform the tasks of the intervention used in the second period).

2.2 | User Interface

While both the touchscreen-based and non-touchscreen-based WOWs use the same EMRs user interface, differences exist in their interactions. The EMRs were designed more than a decade ago with the mouse and keyboard in mind, and thus, did not have user interface design considerations for touchscreens. Interaction difference between the mouse action versus touch actions include: 1) dragging of mouse vs movement of finger to find interface of interest, 2) mouse double left-click vs double touch to confirm specific selected options, 3) mouse right-click vs touch and hold to open patient care menus. Other differences may exist between interactions and the EMRs user interfaces but were not observed nor tested in the tasks assigned to participants. It is important to note that in this simulated environment, we did not have the opportunity to modify the design of EMRs user interface.

2.3 | Data Collection and Processing

An asynchronous observation study design was used to collect data during testing; asynchronous in that the interventions were video recorded and analyzed at a later point in time. Research assistants were present before and after the interventions to collect pre- and post-intervention surveys for participant demographic characterization and to assess perceptions of physician users, respectively. Pre- and post-intervention surveys were electronically collected using the Google Forms. To ensure survey completion, the survey responses were confidential although not anonymous.

2.4 | Outcome Measures

The primary outcome of this study was the combined time to complete all tasks sequentially for each of the interventions. Secondary outcomes include the time to complete each individual task as well as all participant's perceptions of touchscreen utility, efficiency, portability, reliability, capacity to improve care, satisfaction, and ease of use.

2.5 | Primary Data Analysis

Descriptive statistics are reported as counts and percentages for categorical variables. For continuous variables, we reported means and standard deviation (SD) if there was evidence that the distribution of values followed a normal distribution, and median and interquartile range otherwise.

Intervention effect was investigated by comparing the average time to complete each task and the average total time to complete all tasks with the touchscreen and the non-touchscreen WOWs. Data was analyzed using standard methods for a 2-treatment, 2-period crossover design for continuous data (15,16). For each comparison, we used a mixed linear regression model with the type of intervention as the main independent variable, adjusting for period of measurement and the sequence of intervention, as fixed effects, and subject level variability as a random effect, to consider that subjects are observed under both types of intervention. We did not account for carry over effect as it was assumed to be negligible in our study design. Furthermore, the analysis adjusted for age, sex, level of training, experience with computers, touchscreen devices, touchscreen computers, Medurge and Oacis.

On each model, assumptions on the model errors (randomness, normality, and homogeneity of variances) and the presence of possible influential observations or outliers were assessed with diagnostic plots of the model residuals. Robust standard errors (SE) were used to adjust for violations of the homogeneity of variances assumption, if applicable. Statistical tests of hypothesis were two-sided and with a 5% level of significance. Results of the linear models are reported as estimated adjusted means and SE, as well as differences in adjusted means between interventions with 95% confidence interval (CI). (13) All analyses were conducted in R version

4 (R Core Team 2020).

We have estimated that 24 participants would be sufficient to detect a difference in the mean total time to complete both interventions in tandem by 30 seconds between the touchscreen WOW and the non-touchscreen WOW workflow with 80% power and a significant level of 5%. Considering there are no previous studies comparing similar workflows in the recent literature, we decided to use a pre-specific effect size of 0.8, which amounts to assuming a within-subject standard deviation for the total time to complete both interventions in tandem of 35 seconds. (14). We have computed the sample size using a standard formula for 2-treatment, 2-period cross-over trials. Post assessment, a technology acceptance model (TAMS) post-study survey (15) was administered to assess the subjects' perception of touchscreen utility, efficiency, portability, reliability, capacity to improve care, satisfaction, and ease of use (Table 1). Ad-hoc analysis assessing correlations between two variables was done using Spearman's correlation coefficients.

3 | RESULTS

3.1 | Demographics of Study Participants

A total of twenty-four practicing physicians from the MUHC volunteered to participate in this study (Table 2). Post-study questionnaire data was excluded for one participant due to insufficient time to complete the questionnaire.

Post-Survey Questions
Perceived Ease of Use (PEOU)
PEOU1: I find the WOW with touchscreen easy to use.
PEOU2: Interacting with the WOW with touchscreen does not require a lot of mental effort.
PEOU3: Switching from WOW without touchscreen to the WOW with touchscreen (or vice versa) is an easy transition for me.
PEOU4: It is easy to get the WOW with touchscreen to do what I want it to do.
PEOU5: It is easier to use the WOW with touchscreen than the WOW without touchscreen.
Perceived Usefulness (PU)
PU1: The WOW with touchscreen will make my work more efficient.
PU2: The WOW with touchscreen will be easy to disinfect.
PU3: The WOW with touchscreen will minimize errors.
PU4: The WOW with touchscreen will improve overall workflow.
PU5: The WOW with touchscreen will be more useful than the non-touch screen version.
Attitude Towards Utilization (AU)
AU1: I feel that implementation of the WOW with touchscreen is a good idea.
AU2: I feel that implementation of the WOW with touchscreen should be a priority.
AU3: Overall, I have positive feelings towards implementing the WOW with touchscreen.
AU4: I believe physicians should use the WOW with touchscreen instead of the WOW without touchscreen.
Behavioral Intention to Use (BU)
BU1: Assuming I have access, I intend on using the WOW with touchscreen.
BU2: If given the option to use either the WOW without touchscreen or the WOW with touchscreen, I would use the touchscreen version.

TABLE 1 Physician attitudes regarding use of touchscreen workstation on wheels

Variable		
Age (years), median (IQR)		34.5 (28.8–42.8)
Sex (Male), n (%)		19 (79.2%)
Training, n (%)	Attending	12 (50.0%)
	PGY1	4 (16.7%)
	PGY2	3 (12.5%)
	PGY3	1 (4.2%)
	PGY4	2 (8.3%)
	PGY5	2 (8.3%)
Dominant Hand (Right), n (%)		23 (95.8%)
Experience with computers, n (%)	Average	2 (8.3%)
	Slightly above average	3 (12.5%)
	Experienced	12 (50.0%)
	Very experienced	7 (29.2%)
Experience with touchscreen computers, n (%)	No experience	1 (4.2%)
	Somewhat experienced	2 (8.3%)
	Slightly below average	4 (16.7%)
	Average	6 (25.0%)
	Slightly above average	5 (20.8%)
	Experienced	4 (16.7%)
	Very experienced	2 (8.3%)
Experience with touchscreen devices, n (%)	Slightly above average	2 (8.3%)
	Experienced	9 (37.5%)
	Very experienced	13 (54.2%)
Experience using MedUrge (months), median (IQR)		36 (14–102)
Experience using Oacis (months), median (IQR)		49.5 (26–102)

TABLE 2 Physician demographics and experience (N=24).
IQR: 25th percentile–75th percentile. PGY: post-graduate year.

3.2 | Primary Results

Results from the mixed model regression analysis showed that, after adjusting for period, sequence of intervention, and the covariates of interest, there was no significant evidence to reject the hypothesis that the mean total times to complete all tasks in tandem were the same between the two interventions (p=0.08, Table 3). The adjusted total time to complete intervention means were 89.7 (SE 10.6) and 96.5 (SE 10.6) seconds. For the mouse WOW and touchscreen WOW, respectively, with a two-sided 95% CI of (-0.9, 14.5). Similar results were obtained for each task separately (Figure 1).

Results from the post-study questionnaire assessed along a 7-point Likert scale (Figure 1) demonstrated that the majority (>50%) of the participants agreed on all questions regarding attitude towards utilization (AU), behavioral intention to use (BU), perceived ease of use (PEOU), and perceived usefulness (PU) of the touchscreen WOW, except question PEOU5 and PU3. The Spearman's correlation coefficient between experience using touchscreen computers and ease of use of a touch-

Task Sequence	Time to Complete Intervention (seconds), Adjusted Mean (SE)			
	Mouse	Touchscreen	95% CI	p-value
Task 1. Open a triage note and identify blood pressure via MedUrge	3.1 (1.4)	3.5 (1.4)	0.4 (-0.3, 1.2)	0.35
Task 2. Open most recent patient chart via Oacis	6.2 (1.1)	5.7 (1.1)	-0.5 (-1.5, 0.4)	0.23
Task 3. Order CBC and CHEM7 bloodwork via Oacis	13.5 (4.8)	15.3 (4.8)	1.9 (-2.0, 5.8)	0.33
Task 4. Order chest x-ray imaging via Oacis	18.2 (3.0)	20.1 (3.0)	1.9 (-0.4, 4.2)	0.10
Task 5. Order acetaminophen medication via MedUrge	28.3 (5.4)	30.0 (5.4)	1.7 (-2.1, 5.6)	0.36
Task 6. Request coronary care unit consult via MedUrge	13.9 (2.6)	15.1 (2.6)	1.2 (-1.4, 3.9)	0.34
Task 7. Discharge patient home via MedUrge	6.7 (1.8)	6.8 (1.8)	0.1 (-0.7, 0.9)	0.76
Total Time	89.7 (10.6)	96.5 (10.6)	6.8 (-0.9, 14.5)	0.08

TABLE 3 Adjusted mean time elapsed to complete interventions.

screen WOW was found to be 0.6 (95% CI (0.2, 0.8)). The correlation between experience using Oacis and perceived usefulness of the touchscreen with WOW was -0.4 (95%CI (-0.7, -0.01)).

4 | DISCUSSION

To our knowledge, this is the first study to evaluate the impact of a touchscreen interface on workflow efficiency and perceived usability using a WOW and existing EMRs designed for non-touchscreens, mouse and keyboard interactions. Our study showed that in an environment simulating 7 commonly performed EMR tasks in the ED, there was no evidence to suggest a difference between the non-touchscreen and touchscreen WOW in terms of time to complete each task or all the tasks combined, while demonstrating an overall positive perceived benefit. On average, participants completed all the tasks (combined) faster the second time they performed them regardless of which apparatus was tested first. This is likely explained by participants' ability to become accustomed to the apparatus and perform tasks more efficiently in the subsequent trial. Indeed, despite having an average of approximately 5 years of experience using the EMRs through the standard, non-touchscreen WOW apparatus, the workflow efficiency of participants, ranging from year 1-5 resident and attending physicians, was not significantly impacted by switching from the standard to the touchscreen WOW. This suggests that if a touchscreen WOW is implemented in the ED, there likely will not be a meaningful obstacle of adjusting to the touchscreen. This can also be influenced by the carry-over effect, where exposure to the tasks during the first trial may facilitate the subsequent trial. Despite this effect, participants demonstrated consistent task completion rates across both methods by their second exposure. This study builds on previous work on touchscreen devices by specifically evaluating the usability and efficiency of touchscreen WOWs in a controlled, simulation-based setting, differentiating from prior studies on tablets at the bedside.

Our study, which showed no isolated difference in the average time to complete the combined tasks, suggests that more tasks could be performed on a touchscreen WOW at the bedside, without losing the efficiency of standard mouse and keyboard workstations. Therefore, a touchscreen interface is feasible and does not hinder the workflow or usability. Currently, the MUHC sites, presumably along with other sites healthcare institutions, have touchscreen devices being used

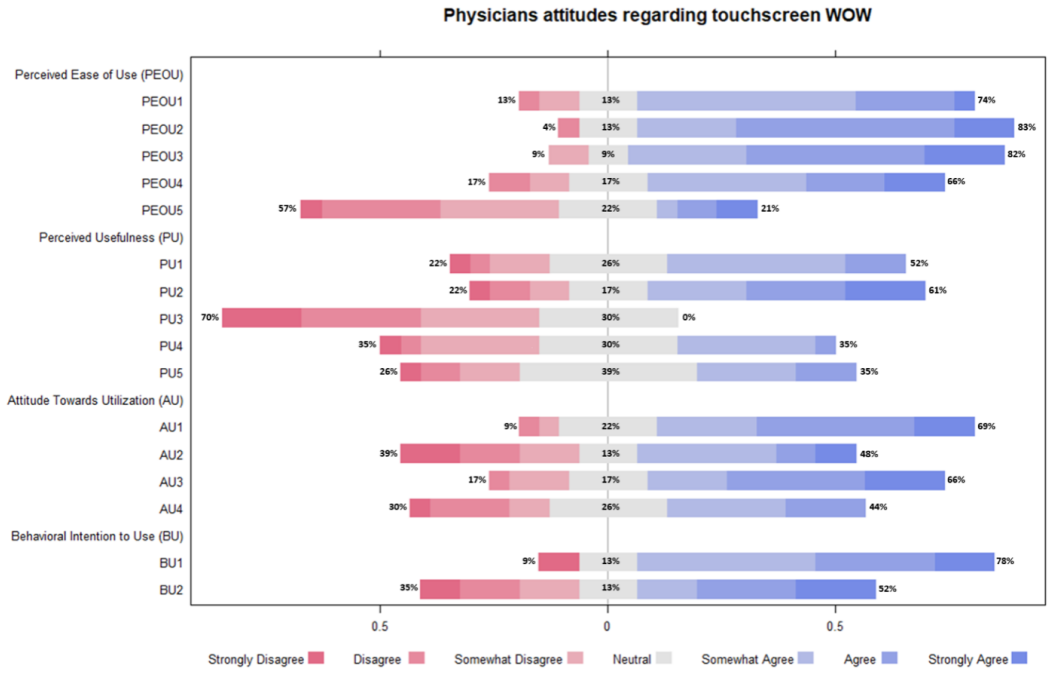

FIGURE 1 Physician attitudes regarding touchscreen WOW

with EMR systems designed for traditional input (keyboard and mouse). Indeed, touchscreen WOWs do not degrade or negatively impact physician performance, even though the EMR systems used were originally designed for use with a keyboard and mouse rather than a touchscreen.

Given that there were no differences in time to complete commonly performed ED tasks between the touchscreen and non-touchscreen WOW groups, further studies need to evaluate if touchscreen WOW may be an appropriate addition to facilitate ED workflow. In addition, allowing the users the option of using mouse, keyboard, and touchscreen could cater to individual preferences of which modality enables efficiency in the right context. Future studies could evaluate the impact on ED workflow of using all three modalities compared to the standard mouse and keyboard interactions. Perhaps customized interactions involving all three modalities may yield faster time to complete certain tasks in a simulated environment, or improve clinical efficiency.

Furthermore, our survey results demonstrated an overall perceived user benefit associated with the use of touchscreen WOWs based on the positive attitude towards utilization and intention to use the touchscreen WOW of resident and attending physicians. Interestingly, while the majority (>50%) of the participants agreed on the total perceived benefit of the touchscreen WOW, they did not find it is easier to use than the non-touchscreen WOW and did not feel that the touchscreen WOW would minimize errors. For all participants, this was their first interaction with the touchscreen WOW on EMRs they have been using with mouse and keyboard interactions for as long as 102 months (median MedUrge use = 36 months, median Oacis use = 50 months). Such an interaction, under a controlled, "testing" environment, can make participants more prone to errors.

The findings from the study were likely not influenced by participants' experience with touchscreen computers, as there was a balanced distribution of ex-

perience amongst participants. Though perhaps among cohorts with more experience with touchscreen computers, participants may complete tasks faster using a touchscreen than a non-touchscreen WOW. Furthermore, ad-hoc results suggest that users with more touchscreen experience are more likely to find the touchscreen addition to the standard WOW easier to use than those with less experience, evidenced by Spearman's correlation coefficient. We also found that users with more experience on a software (Oasis) traditionally designed for a non-touchscreen apparatus will be less likely to find the touchscreen addition useful. The correlation coefficient value (<0.60) suggests that there may be room for customization of the software to adapt to a touchscreen WOW, which perhaps over time, will enable users to perceive that the touchscreen WOW is indeed useful.

Our results add to the existing knowledge on touchscreen modalities in clinical practice. Results by Horng et al. (12) showed that the use of touchscreen tablet computers for direct patient care reduced physicians' time spent at the workstation by 38 minutes per shift, thereby potential increasing time by the bedside. However, their inferior operating capacity compared to computers limit their generalizability across powerful software such as EMRs, in addition to the EMRs lack of touchscreen design considerations (16). Further studies could investigate the workflow efficiency impact of tablet computers vs touchscreen WOWs in busy clinical environments such as the ED.

The existing EMRs user interface, developed more than a decade ago leveraged the design considerations that may seem intuitive with a mouse, but are not equally intuitive when using a touchscreen. Key design considerations include the size of clickable boxes, and radial buttons, both of which require larger target areas to facilitate touch screen interactions. Another key design issue is the use of the mouse left double click, and the mouse right click, which require a non-intuitive learning curve of using the double touch tap and the touch and hold, respectively to achieve the required interactions. These innate differences in user interface interactions of the touchscreen and mouse with the EMR (described in the methods section) likely contributed to outcomes from the study including participants' perceptions of ease of use and capacity to minimize errors of the touchscreen WOW. These specific differences in the functions between the touchscreen and mouse WOW were not tested and warrant further study to optimize user interactions with EMRs. In the current study, we were unable to change EMR user interfaces which were built for a mouse dominant, non-touchscreen WOW. However, the touchscreen interface interaction was found to be objectively similar to the standard non-touchscreen interface regarding workflow efficiency showing no significant differences in average time to complete tasks commonly done in the ED while demonstrating an overall positive perceived benefit. We recommend further studies to assess the impact of touchscreen WOW models on workflow efficiency and healthcare provider perceived benefit with modern EMRs who have interfaces that are designed to be touchscreen friendly.

We acknowledge some limitations of our study. The majority of the participants in the study were male, right-hand dominant, and had an average of 5 years of experience with Medurge and Oacis EMRs, likely making it relatively more challenging for experienced users accustomed to the use of the standard non-touchscreen WOW to operate a touchscreen WOW. This study was done in a simulated environment and does not reflect real clinical environment user experience. Although the testing environment used identical interfaces with different input methods (touchscreen versus non-touchscreen), this study uniquely isolates the impact of the touchscreen interface as implemented with existing EMR designs. While we did not track errors made by participants using each intervention, we encourage others to do so if essential.

5 | CONCLUSION

In this simulated ED environment, the use of a touchscreen WOW demonstrated adequate functionality. We were unable to find a significant difference between the non-touchscreen and touchscreen WOW in terms

of time to complete tasks, while showing an overall positive perceived benefit from resident and attending physicians in the ED. A touchscreen WOW may potentially replace a non-touchscreen WOW in the ED, but this requires more research with modern EMRs that have incorporated touchscreen user interface design considerations.

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