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Evaluation of a proximity card authentication system for health care settings

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ABSTRACT

Background: Multiple users access computer workstations in busy clinical settings, requiring many logins throughout the day as users switch from one computer to another. This can lead to workflow inefficiencies as well as security concerns resulting from users sharing login sessions to save time. Proximity cards and readers have the potential to improve efficiency and security by allowing users to access clinical workstations simply by bringing the card near the reader, without the need for manual entry of a username and password.

Objectives: To assess the perceived impact of proximity cards and readers for rapid user authentication to clinical workstations in the setting of an existing electronic health record with single sign-on software already installed.

Methods: Questionnaires were administered to clinical faculty and staff five months before and three months after the installation of proximity card readers in an inpatient birthing center and an outpatient obstetrics clinic. Open-ended feedback was also collected and qualitatively analyzed.

Results: There were 71 and 33 responses to the pre- and post-implementation surveys, respectively. There was a significant increase in the perceived speed of login with the proximity cards, and a significant decrease in the self-reported occurrence of shared login sessions between users. Feedback regarding the system was mostly positive, although several caveats were noted, including minimal benefit when used with an obstetric application that did not support single sign-on.

Conclusions: Proximity cards and readers, along with single sign-on software, have the potential to enhance workflow efficiency by allowing for faster login times and diminish security concerns by reducing shared logins on clinical workstations. The positive feedback was used by our health system leadership to support the expanded implementation of the proximity card readers throughout the clinical setting.

1. Introduction

Electronic health record (EHR) adoption is continuing at a rapid pace, with nearly 60% of U.S. hospitals now having at least a basic EHR system installed [1]. To enable rapid and convenient access to EHRs for busy clinicians, workstations are becoming ubiquitous in both inpatient and outpatient settings [2–5]. The introduction of these computer systems, however, has led to concerns about both workflow efficiency and security [6–8]. The need for clinicians to repeatedly log in and out of various computers throughout the day, as well as forced logoffs due to system timeouts, can lead to both workflow interruptions and real or perceived productivity decreases [7,9–14]. These workstations are often shared by physicians, nurses, and other healthcare professionals, leading to concerns about clinicians sharing login sessions or passwords. Such sharing is a byproduct of a desire to save time when use of the workstation transitions from one clinician to another [7,9,15–18]. A recent survey of health professionals found that nearly a third (32%) had shared a password with someone else such as a coworker [19].

Using proximity cards to expedite login/authentication procedures could potentially mitigate the aforementioned workflow and

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security concerns [9]. Proximity cared are enabled by the use of embedded radio frequency identification (RFID) tags that allow for wireless communication with a reader attached to the computer. When the card is brought within close range (approximately 5 cm) to the reader, the RFID tag is detected and the user's credentials are passed to the computer, allowing for automated login without the need to type a username or password. While there are anecdotal reports of the benefits of proximity cards in the clinical setting [20–23], there is little published literature about the use of these cards and their perceived benefits. This lack of evidence makes it difficult to determine the value of such systems, especially when other priorities compete for limited resources.

The primary objective of the pilot study presented herein was to determine from the perspective of 'front-line' clinical teams the perceived value and potential pitfalls of implementing a vendor-supported proximity card product in a busy clinical setting. This was done using questionnaires both before and after the experimental implementation of the proximity cards. The secondary objective was to use the data generated to help our health system determine if proximity cards were worth further investment. The main contribution of this work was to verify the previously reported anecdotal benefits of proximity cards by studying their use under actual patient-care conditions. Our pilot data suggest that proximity cards were mostly well-received by clinical users, but participants also noted some challenges and caveats.

In the remainder of this paper we first describe the clinical setting in which the study took place, followed by a description of the proximity card pilot and the questionnaires that were used in the study. We next present the results of the before-and-after study, and conclude with an analysis of our findings in the context of what has been previously reported in the literature.

2. Methods

2.1. Institutional setting

This study took place in the University of Michigan Health System (UMHS) Department of Obstetrics and Gynecology (Ob/Gyn). All clinicians at the time had been using a homegrown EHR, CareWeb, since 1998. CareWeb served as the primary means for creating and viewing documentation across UMHS, as well as viewing demographics, problems lists, medications, and other clinical data. The Department of Ob/Gyn also utilized commercial software including an ambulatory e-prescribing system (Rcopia, Dr. First, Rockville, MD), an inpatient computerized provider order entry (CPOE) system (Sunrise Clinical Manager, previously Eclipsys, now Allscripts, Chicago, IL), and, most importantly, OB TraceVue (Philips Healthcare, Andover, MA), which was used for managing inpatient and outpatient obstetrical care.

Prior to the proximity card pilot, clinicians were already using a commercial single sign-on (SSO) system (Sentillion Vergence, now called Caradigm Vergence, a joint venture of Microsoft Corporation, Bellevue, WA, and GE Healthcare, Pittsburgh, PA) installed on all clinical workstations. This system allowed for automatic authentication and login of our homegrown EHR as well as other clinical applications, with a username and password only required when logging into the operating system [7,24]. The system also supported the HL7Clinical Context Object Workgroup (CCOW) standard [25]. However, typing in the username and password was required with each computer login, as well as with other applications that did not support the SSO process, including OB TraceVue.

2.2. Proximity card pilot

In December 2010, proximity card readers (pcProx, RF IDeas, Rolling Meadows, IL) were connected to approximately 120 clinical workstations (Fig. 1) in two clinical Ob/Gyn units: the inpatient birthing center and the outpatient obstetrics clinic. The badges of employees who worked in those areas were also activated. These badges already had RFID tags embedded within them, as they could also be used for unlocking doors in some clinical areas. The proximity card readers, and the associated software, easily integrated with the existing SSO system.

Fig. 1. Photograph of a proximity card reader attached to the bottom of a monitor in one of the patient rooms where the pilot study took place. ID badges brought close (within approximately 5 cm) of the reader activated an automated login process.

The first time users logged into a workstation for the day, they had to manually enter their password (the system automatically entered the username). For a four-hour period thereafter users could login to the same workstation and SSO-supported applications by bringing their proximity badge close to the reader. Users could lock their workstations by bringing their badge close to the reader a second time. All users still had the option of manually entering usernames and passwords for each login, and choosing to manually logoff from the workstation. Because OB TraceVue did not support the SSO technology, logging into that specific application still required a manually entered username and password even when a proximity badge was used to login to the workstation. To prepare users for the addition of the card readers, the clinical teams were sent an email with a brief one page 'user guide' (Supplementary Material). Additionally, there were several IT support staff on site on the first day of the implementation.

2.3. Questionnaires

In July 2010, five months before the proximity card reader installation, an email invitation to complete a brief, anonymous questionnaire was sent to the faculty and staff who worked in the two Ob/Gyn clinical areas. Given the busy work schedules of those involved, our goal was to obtain a convenience sample from a mix of job roles in order to make a more informed decision about the worthiness of expanding the implementation to other clinical areas and to develop insights to inform practice, rather than to draw thorough and robust statistical inferences. Employees were reminded to complete the questionnaires during staff meetings. The pre-pilot questionnaire included questions along several dimensions including clinical role, perceptions about login speed using usernames and passwords, and self-reported frequency of sharing user sessions and passwords. Then, three months after the implementation (March 2011), another online questionnaire was administered in the same clinical areas. The post-pilot questionnaire was similar to the initial one, but included questions tailored to the newly installed proximity card readers. The post-implementation ques-

Table 1
Response to the pre and post implementation questionnaires. The specific questions for each questionnaire are shown because they differed slightly in each phase.

	Pre-Implementation Questionnaire (n = 71)			Post-Implementation Questionnaire (n = 33)			
Dimension	Question	Response	n (%)	Question	Response	n (%)	p-value
Login Frequency	How many times per shift do you login to an UMHS computer?	<10 10–19 20–29 ≥30	33 (46.5) 11 (15.5) 15 (21.1) 12 (16.9)	How many times per shift do you use Tap and Go to login to an UMHS computer?[a]	<10 10–19 20–29 ≥30	19 (57.6) 7 (21.2) 7 (21.2) 0 (0.0)	0.09
Login Time	How would you describe the time it takes to enter your username and password?	Very slow Somewhat slow Neutral Somewhat fast Very fast	7 (9.9) 19 (26.8) 16 (22.5) 25 (35.2) 2 (2.8)	How long would you describe the time it takes to login using Tap and Go?	Very slow Somewhat slow Neutral Somewhat fast Very fast	1 (3.0) 3 (9.1) 4 (12.1) 20 (60.6) 5 (15.2)	0.007
Repeated Logins	How do you feel about repeatedly logging into UMHS computers throughout your shift?	Very displeased Somewhat displeased Neutral Somewhat pleased Very pleased	18 (25.4) 24 (33.8) 24 (33.8) 4 (5.6) 1 (1.4)	How do you feel about repeatedly logging into UMHS computers throughout your shift using Tap and Go?	Very displeased Somewhat displeased Neutral Somewhat pleased Very pleased	3 (9.1) 1 (3.0) 8 (24.2) 14 (42.4) 7 (21.2)	<0.001
Security	Have you used an UMHS computer under another person's login?	Yes No	24 (33.8) 47 (66.2)	Since the installation of Tap and Go, have you used an UMHS computer under another person's login?	Yes No	2 (6.1) 31 (93.9)	0.005
Security	Have other people used an UMHS computer under your login?	Yes No	22 (31.0) 49 (69.0)	Since the installation of Tap and Go, have other people used an UMHS computer under your login?	Yes No	2 (6.1) 31 (93.9)	0.01
Workflow impact			N/A N/A N/A	How would removal of Tap and Go from clinic computers impact your workflow?	Negative impact No impact Positive impact	18 (56.3) 11 (34.4) 3 (14.3)	

UMHS: University of Michigan Health System; N/A: Not asked during pre-implementation

[a] The project was locally called "Tap & Go", which was the name given by Sentillion to the proximity reader solution, but it has been re-branded nationally as "Way to Care".

tionnaire also included an option for providing comments about experiences with the new system. The questionnaires were developed with input from clinicians as well information technology specialists who were involved with the proximity card reader implementation. The questions were carefully reviewed, discussed, and refined between both the IT and clinical teams. The final questions were considered to have met face validity and content validity, and were considered to be straightforward and worded unambiguously. The exact wording of the questions is reported in Table 1. Incentives were not provided. This study was reviewed by our medical school's institutional review board and was determined to be "not regulated", meaning that it was not considered regulated human subjects research.

2.4. Data analysis

Categorical results were compared between the pre- and post-implementation questionnaire groups using Pearson's Chi-squared test in *R*. We conducted an open, interpretive content analysis of the qualitative feedback collected according to established protocols [26]. Two members of the study team (DAH and JF) independently coded the data to identify salient and recurring themes and sentiments (positive, neutral, or negative). The results were discussed between the two researchers and disagreements were resolved through consensus development.

3. Results

There were 71 responses to the pre-implementation questionnaire and 33 responses to the post-implementation questionnaire. The clinical roles of the respondents are shown in Fig. 2. In both phases the largest group responding was nurses. Table 1 reports on the results of the questions that were asked along several dimensions including login times and security. Respondents reported a significant perceived speed improvement for login time using the proximity cards compared to typed usernames and passwords, and were significantly less displeased about having to repeatedly login to the workstations throughout the day. Regarding security, respondents reported significantly fewer instances of sharing login sessions once the proximity cards had been installed. A small majority (56%) of respondents reported that removal of the proximity card readers would have a negative impact on their workflow, whereas another third (34%) felt it would have no impact.

About half (n = 18; 55%) of post-implementation respondents left open-ended feedback (Table 2). Most comments had a positive sentiment, although two respondents did not think the efficiency improvement was profound. While open-ended comments reflected positive attitudes towards efficiency and security, some caveats were noted. Several people noted concerns about the system's reliability because automated logins did not always occur. Readers were not installed on every computer in the clinical areas, and two respondents suggested having the readers installed on more computers. Four respondents noted that the OB TraceVue system did not support the SSO authentication process and thus still required manual entry of a username and password even when the proximity card was used to login to the computer itself. One user felt that the red light on the card reader was irritating and suggested a different configuration so it would not shine directly into his or her eyes. Last, it was noted that the mounting brackets were weak, making it difficult to keep the card readers stationary.

4. Discussion

Our pilot study suggests that proximity cards and SSO software on clinical workstations are mostly perceived as beneficial by clinical faculty and staff in busy clinical settings. Most respondents wanted to keep using the proximity cards, and respondents desired to have them on more computers. Reliability issues were reported, but it is unclear why users had such an experience. Loose connections, or unplugged cables, may have played a role. It also may have been because users did not know a manual login was required at the beginning of their work session, or that this initial manual login was required on each distinct computer used. Similar issues have previously been reported in healthcare settings. For example, an implementation study of SSO (without proximity cards) found a mismatch between how the system actually worked and the mental model of how the clinicians expected it to work [27]. The potential mismatch between users' mental models of the proximity card system and the actual operation of the system was surprising to us, but it does demonstrate the importance of testing even 'simple' technical solutions in real-world clinical settings before larger-scale implementations occur. Such testing can identify potential issues that could be resolved with additional training for the proximity card users and it could have helped our clinical teams develop realistic expectations of the system. Additionally, other more sophisticated single sign-on systems, such as those requiring biometric identifiers (e.g., fingerprint), could entirely replace the need for passwords [28]. Future work should assess these mental models both before and after implementation of SSO software to better elucidate this surprising finding.

Prior reports have also discussed reliability issues such as responsiveness of authentication processes, and this can be impacted based on the location of the card readers with respect to the user [29]. Others have reported issues with sensors that are too sensitive, which can be problematic if there are too many workers in close proximity of the readers [7]. Our participants did not report overly-sensitive readers, which may be because the readers could only detect cards within a 5 cm range, suggesting that technologies may have improved over time.

The mix of clinical applications from different vendors should also be considered when evaluating the potential value of this technology. In our case, one of the primary systems used by the Ob/Gyn clinicians did not support SSO authentication (cards could log the user into the computer, but manual username and password entry was required for the application), and thus less benefit was noted when that application was accessed. Our findings should be interpreted in that context. This system (OB TraceVue) was used in conjunction with the EHR by clinicians at almost every login, and thus the workflow impact of still needing to type in a password for that application would likely have been noticeable by the clinical teams, especially when the actual login into the computer and the EHR had become automated. Thus, the addition of proximity cards adds yet another element into the debate about the pros and cons of using a best-of-breed versus a primary, or integrated, vendor strategy [30–32]. These issues should be considered by institutions since proximity cards might seem like a minor component in a much larger IT strategy, but the workflow implications have the potential to affect end-user satisfaction of the installed systems. Further, vendors should also consider the implications of our findings since support of the HL7CCOW standard may be important for an application to fit into the complex IT 'ecosystems' that many health systems maintain. The complexity of rapid authentication and SSO should not be underestimated, however, and prior work has noted the challenges of implementing such solutions in highly collaborative, busy work environments where devices need to be shared but individual logins maintained [7,33].

Our study has limitations that should be noted. First, these questionnaires were deployed in two clinical settings in an Ob/Gyn department at a single academic medical center. Other clinical specialties, smaller clinical settings or non-academic hospitals may have different needs and clinical workflows. Additionally, because

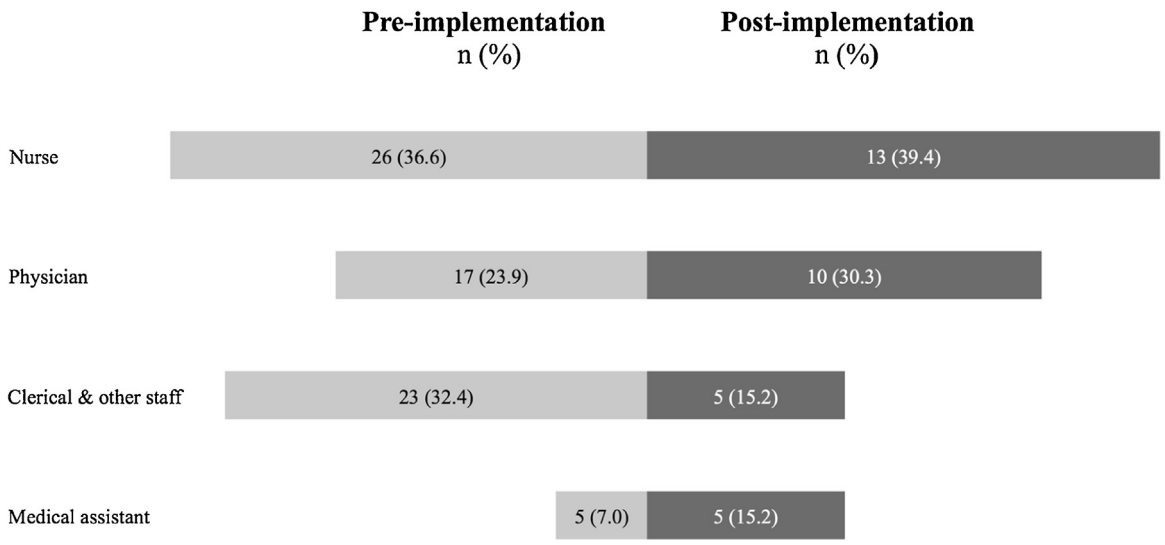

Fig. 2. Self-reported clinical roles of the respondents. The length of the bars represents the percentage of respondents per category in each of the two survey phases. No significant difference was found in the distribution of roles between the pre- and post-implementation groups (Chi-squared test p-value: 0.22).

Table 2
Results from the qualitative analysis of the 18 comments provided by respondents in the post-implementation questionnaire. Some comments were brief and non-specific (e.g., "It is great") and were thus counted for sentiment but not included within one of the five themes.

Sentiment/Theme	n	Illustrative Comments
Sentiment		
Positive	13	• "My experience with using the Tap and Go system was extremely good. I have been asked by other UMHS employees when they are going to get the Tap and Go system. I am very impressed with the system" • "My favorite thing about using the tap and go was when I was training an extern in the clinic and I was able to log into everything ahead of time and just use the tap and go when the patient was in the room. I feel as though it made training easier. I would love to keep the tap and go!!!"
Neutral	2	• "While the workflow is enhanced, it is not a dramatic improvement, and, as such, the investment in these devices should not be dramatic"
Negative	3	• "I always try it once a shift and the stupid thing never works. I log in first manually and then the next time try to use it. I have yet to be able to log in with it. It does not save me anytime and really is just frustrating. Plus, if it did work, I would still have to log into TraceVue, email, etc. So, how does that really save time?" • "Tap and go does not always work. Often will just put my name into login screen but not password and truly dont know how helpful that really is"
Theme		
Efficiency	8	• "I love how quick and easy it is to log into the computer when in an exam room with patients." • "It does take a fraction of time off logging in every time"
Reliability	4	• "My concerns are that some card readers don't actually log you in especially in the rooms. The actual holders for the card readers aren't very sturdy." • "It's useful when it works, but it doesn't work consistently"
Integration with othersoftware applications	4	• "Would love it if there was a system that logged you onto TraceVue as well because we still have to log into that manually everytime which is very time consuming" • "It would be really nice if it logged into TraceVue! hint!!!"
Security	2	• "The tap and go system. . .increases the likelihood of signing out of my computer (as opposed to the manual logging in and logging out process)" • "It has cut down on people charting/logged in on someone else. . ."
Workstation coverage	2	• "It would be nice to have it in more computers in the OB/GYN clinics, L&D, and the resident office next to the perinatal assessment center" • "Biggest problem with tap and go is that it is not currently at every workstation. If it were, then I would automatically be using it all the time"

our goal was to obtain a convenience sample, our findings may not be representative of the entire clinical workforce that used the proximity cards. However, we did have a reasonable mix of clinical roles responding to both questionnaires despite the drop in the number of responses for the post-implementation survey. Responses were anonymous so we were not able to determine characteristics of the post-implementation survey non-responders. It is possible that some of the non-responders in the post-implementation survey were satisfied with the proximity cards and felt no need to further express their opinions. The lower response rate may also have been due to new clinical team members rotating onto the services while those from the pre-implementation survey rotated off. Nevertheless, it is worth noting that prior studies have shown that low response rates, at least among physicians, does

Summary points
What was already known on the topic:

- Workflow is a major factor affecting productivity in clinical settings.
- Clinicians often need to log in and out of workstations throughout the day, leading to real or perceived productivity losses.
- Workstations login sessions and passwords are often shared by busy clinicians in clinical settings.
- Anecdotal reports have suggested that the use of proximity cards, wherein a user can login to a workstation by bringing a card near a reader, can improve workflow and security.

What this study has added to our knowledge:

- Password sharing decreased when proximity cards were used for workstation authentication; thus, security may be improved.
- Most respondents to our questionnaire were pleased with the use of proximity cards along with single sign-on software in a busy clinical environment.
- The perceived value of proximity cards can be diminished if not all clinical applications can use the single sign-on software along with the proximity cards.

not necessarily lead to response bias [34–38]. Future work is warranted, including direct observation time and motion studies, to better quantify the time-savings, potential workflow changes, as well as user behavior changes (e.g., sharing user sessions) that may result from using proximity cards for workstation authentication. Log files might also help quantify the frequency of repeated logins per computer or user.

Our findings may be useful for informatics leaders and other health IT professionals in making decisions about the value and utility of time-saving and security-enhancing technologies such as proximity cards and readers. The badges used at our institution already had embedded RFID tags, so additional proximity cards were not needed. Further, we already had single sign-on software installed, so users were already familiar with the concept. Our institution reviewed the data collected in this study and ultimately approved the installation 4000 card readers throughout the hospitals and clinics, at a cost of about $80 per reader, with additional costs related to account provisioning, user training, and deployment. This installation was completed in 2015.

5. Conclusion

The use of proximity cards for rapid authentication of health professionals into clinical workstations, along with single sign-on software for automated authentication into clinical applications is generally well-liked by clinicians. Perceived utility is diminished if all necessary clinical applications do not support the single sign-on technology. Security may be improved with less sharing of logins, since switching between users becomes easier. Further work is needed to better quantify and verify the benefits of proximity cards, but our initial pilot data points to a benefit for their use in busy clinical settings.

Author contributions

Jacqueline Fontaine: analysis and interpretation of the data, drafting the manuscript.

Kai Zheng: analysis and interpretation of the data, drafting the manuscript.

Cosmas Van de Ven: conception and design of the study, acquisition of data, analysis and interpretation of the data, drafting the manuscript.

Huiyang Li: conception and design of the study, acquisition of data, analysis and interpretation of the data, drafting the manuscript.

James Hiner: conception and design of the study, acquisition of data, analysis and interpretation of the data, drafting the manuscript.

Kathy Mitchell: conception and design of the study, acquisition of data, analysis and interpretation of the data, drafting the manuscript.

Stephen Gendler: conception and design of the study, acquisition of data, analysis and interpretation of the data, drafting the manuscript.

David Hanauer: analysis and interpretation of the data, drafting the manuscript.

All authors approved the final version to be published and agree to be accountable for all aspects of the work.

Conflict of interest

None.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijmedinf.2016.04.015.

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