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# A Pilot Study of Computer-Based Simulation Training for Enhancing Family Medicine Residents' Competence in Computerized Settings

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**Abstract**

*We previously developed a prototype computer-based simulation to teach residents how to integrate better EMR use in the patient-physician interaction. To evaluate the prototype, we conducted usability tests with three non-clinician students, followed by a pilot study with 16 family medicine residents. The pilot study included pre- and post-test surveys of competencies and attitudes related to using the EMR in the consultation and the acceptability of the simulation, as well as 'think aloud' observations. After using the simulation prototypes, the mean scores for competencies and attitudes improved from 14.88/20 to 15.63/20 and from 22.25/30 to 23.13/30, respectively; however, only the difference for competencies was significant (paired t-test; t=-2.535, p=0.023). Mean scores for perceived usefulness and ease of use of the simulation were good (3.81 and 4.10 on a 5-point scale, respectively). Issues identified in usability testing include confusing interaction with some features, preferences for a more interactive representation of the EMR, and more options for shared decision making. In conclusion, computer-based simulation may be an effective and acceptable tool for teaching residents how to better use EMRs in clinical encounters.*

***Keywords:***

Education; Electronic Medical Record; Physician-Patient Relationship; Simulation-Based Training.

## Introduction

The potential and actual benefits of health information technology in general, and electronic medical records (EMRs) in particular, have been widely discussed. However, some concerns have been raised over unintended consequences and especially the impact of EMRs on patient-clinician communication [1]. Communication skills are central to patient-centered care and have been associated with patient satisfaction, conflict resolution, adherence to treatment, and a myriad of health outcomes [2]. Research has shown that the use of EMRs affects the patient consultation in both positive and negative ways. On the positive side, the use of EMR improves the exchange of medical information between physicians and patients. However, it often interferes with maintaining eye contact, establishing rapport, and psychological and emotional communication. Furthermore, physicians rarely utilized resources within the EMR, and the computer in general, for patient education [3].

Currently, the training provided to clinicians focuses mostly on technical aspects (e.g. how to document, how to prescribe a medication electronically) of using the EMR and not on how to best integrate it into the patient consultation; however, the need to "go beyond the nuts and bolts (operator skills) of using new technologies" [4] has been recognized. In previous studies, we identified some of the cognitive issues underlying the impact of EMRs on patient-physician communication, as well as strategies and best practices employed by physicians in order to overcome the negative and maximize the positive influences of the EMR on the consultation. Based on these findings, we developed and tested a simulation-based training intervention with standardized patients (actors) aimed at enhancing family medicine residents' competence in computerized settings [5]. However, widespread implementation of this simulation is compromised by its cost and scalability. Therefore, we developed a prototype computer-based simulation, named EMR-sim, which can be widely distributed and implemented [6]. The purpose of this study was to pilot test the prototype computer-based simulation in an attempt to: 1) identify usability and design issues, 2) examine its impact on family medicine residents' self-reported competencies and attitudes related to using the EMR in the consultation, and 3) assess the acceptability of the simulation to its intended audience (family medicine residents).

## Methods

### The Computer Based Simulation: EMR-sim

We described the development of the computer-based simulation—EMR-sim—elsewhere [see 6]. The current version of our EMR-sim is a Flash -based application that runs in a browser. To keep the cost minimal, it was developed using Adobe Captivate 7, which does not require extensive knowledge in programming and employs basic graphics. The application presents the user with screen captures from the EMR that can be enlarged by hovering a mouse over a magnifying glass image, dialogue texts, and decision buttons (Figure 1). The scenarios captured such issues as dealing with privacy and safety concerns related to documenting information in the wrong patient's chart [7], communicating with a triadic patient who may be distracted by the computer

[8], and using the EMR for patient education (e.g. by visualizing trends in lab results and use of risk calculators). After completing each scenario, the trainee is presented with feedback, specifically tailored to his or her choices, and references to support the feedback.

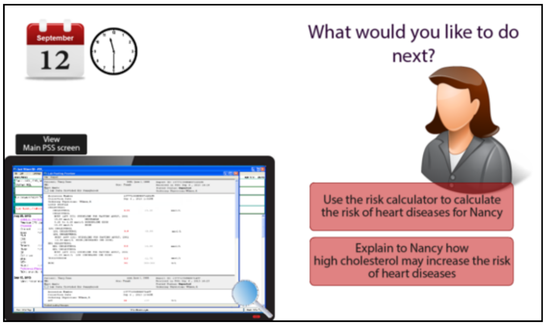


*Figure 1- Screen Capture from EMR-sim*

**Phase 1: Pre-Pilot Usability Testing**

A pre-pilot usability study was conducted as part of a course on usability evaluation at the Faculty of Information (iSchool) of the University of Toronto. Two of the authors (NF, ASk) and a third student conducted the pre-pilot under the guidance of the course instructor. A convenience sample of three Master of Information students with no clinical experience served as participants. They were assessed individually in separate 40-45 minutes sessions. Each session began with an introduction to the study and EMR-sim, followed by 'think aloud' observation [9] in which participants interacted with the simulation prototypes while verbalizing their actions, thoughts, and feelings. One of the researchers facilitated the observation using prompts such as "What are you trying to do now?," "What did you expect to happen (when you…)?," or "How did you feel about that?." A second researcher took notes.

**Phase 2: Pilot Study**

***Participants' Recruitment and Data Collection***

We sent email invitations to participate in the study to 49 Family Medicine residents from two teaching hospitals in Toronto (Sunnybrook Health Sciences Centre and Women's College Hospital), with a reminder email two weeks later. 16 residents consented (response rate: 32.7%) and were enrolled in 2 similar one-hour evaluation sessions (one with 11 and the other with 5 participants) during the lunch break (with lunch provided). At the end of the evaluation session participants received a $50 gift card honorarium.

At the beginning of each session, the purpose of the study was explained and the informed consent form was reviewed with the participants. After signing this form, participants filled in a pre-test questionnaire comprised of 5 items for self-reported competencies (measured on a 4-point scale ranging from low to excellent), and 6 attitudes items (measured on a 5-point Likert scale of agreement) related to using the EMR in the consultation. Demographic characteristics of participants (gender, age group, and year of residency) were also collected on the pre-test questionnaire.

After completing the first survey, participants interacted with the simulation prototype for two scenarios and then filled in a post-test questionnaire. The post-test questionnaire included the same measures for competencies and attitudes, plus additional items to assess the acceptability of the simulation and overall rating of the session. It also included a space for free text comments on the session.

Items measuring competencies, attitudes, and overall evaluation of the session (SEVAL) were taken from our previous study with standardized patients [5], with some modifications. Acceptability of the simulation was measured using the Technology Acceptance Model (TAM) [10]. TAM is a widely used model, which consists of 3 constructs: Perceived Usefulness (PU), Perceived Ease of Use (PEOU) and intention to use the system (INT). Although other instruments such as the Unified Theory of Acceptance and Use of Technology (UTAUT) typically explain greater portion of the variance in usage intention [11], TAM is a useful tool for practical purposes such as assessing the acceptability of an information system because of its parsimony. Our survey instrument included 6 items for perceived usefulness, 3 for perceived ease of use, and 4 items for usage intention. During the sessions, we observed 6 of the participants (3 in each session, 5 females and 1 male) as they interacted with the simulation and asked them to 'think aloud' as described before. The observers took notes and participants were audio recorded.

Prior to beginning the research, the study was approved by the research ethics boards of Sunnybrook Health Sciences Centre and the University of Toronto, and all participants gave written informed consent.

***Quantitative Data Analysis***

Reliability (Cronbach's alpha) of the measures for self-reported competencies and attitudes related to using the EMR in the consultation were tested using the pre-test data. Perceived usefulness, perceived ease of use, intention to use the simulation and participant's evaluation of the session were only measured on the post-test, and their reliability was tested using the post-test data. Except for attitudes towards using the EMR in the consultation that was low, scale reliability of all other measures was acceptable or good (Table 1).

*Table 1 – Scale reliabilities of the measure instrument*

| Measure | Reliability (Cronbach's alpha) |
|---|---|
| Patient-physician-EMR competencies | 0.75 |
| Attitudes towards using the EMR in the consultation | 0.28 |
| Perceived usefulness of the simulation | 0.92 |
| Perceived ease of use of the simulation | 0.76 |
| Intention to use the simulation | 0.80 |
| Overall evaluation of the session | 0.75 |

Data were analyzed using IBM SPSS Statistics 22. Combined scores for competencies and attitudes were calculated by summarizing the scores of all individual items and average scores were calculated for perceived usefulness, perceived ease of use, intention, and evaluation of the session. After testing for normality of the data distribution, we used paired-samples t-tests to compare competencies and attitudes scores before and after using the simulation prototypes. Effect sizes were calculated using G*Power 3.0.10 software. Inter-rater agreements on perceived usefulness, perceived ease of use, intention, and evaluation of the session were calculated by entering the data into MS-Excel and using the rWG(j) formula [12].

***Qualitative Data Analysis***

Qualitative data were analyzed as follows. First, researchers read through the free-text comments and notes from the 'think aloud' observations to familiarize themselves with the data. The three researchers who conducted 'think aloud' observations (AS, NF, and AS) met to review their notes for clarification, compare the notes, and discuss preliminary themes that emerged. Then, free-text comments, notes, and audio recordings of the 'think aloud' sessions were entered into NVivo 8 qualitative data analysis software. The first author applied open coding to the data, adding new codes as they emerged. Codes were then grouped into categories and reorganized to develop the final coding scheme. The first author then used the scheme to recode all the data. To establish trustworthiness, a second researcher (EB) also coded a subset of the data (the free-text comments) using the same coding scheme. There was high agreement on coding (91% as calculated by NVivo) and moderate agreement on categorization (κ=0.56). The two researchers then discussed their interpretations, following which consensus on coding and themes had been reached.

## Results

### Pre-Pilot Usability Testing (Phase 1)

As participants were not clinicians, they gave little feedback on the content of the simulations and focused mainly on the navigation, clarity, and overall usability of the scenarios. Positive findings included reaction to emotions shown by the patient's avatar, particularly when tears were shed. All participants found this to be very effective.

The pace of the doctor-patient dialogue was one of the main issues identified by our participants. The unnaturally slow pace caused users to attempt to rush through the dialogue and subsequent navigational prompts and miss certain cues. Another key issue was a lack of clarity of system navigation. The original prototypes included a video play bar, which is added by Adobe Captivate by default. The majority of participants attempted to interact with this bar, instead of using the decision buttons, to progress through the scenario. A third issue was the 'mouse over' interaction with the magnifying glass that was confusing.

Based on these findings, we modified the pace of the dialogue and removed the video bar from the prototypes. The interaction with the magnifying glass is more difficult to change. We decided not to change it at this time but explain this mode of interaction at the beginning of the pilot sessions.

### Characteristics of Study Participants

Descriptive statistics of the phase 2 pilot study participants are presented in Table 2. Of the 16 Family Medicine residents who participated in the study, the majority (n=14) were women. Except for one participant who was 40 or older, all participants were between ages 20 and 39—most of them (n=9) in their twenties. The majority of participants (n=10) were in their first year of residency (PGY1).

*Table 2 – Characteristics of phase 2 study participants (N=16)*

| Participant characteristic | N |
|---|---|
| Gender | |
| Female | 14 (81.2%) |
| Male | 2 (12.5%) |
| Age group | |
| 20-29 | 9 (56.3%) |
| 30-39 | 6 (37.5%) |
| 40-49 | 1 (6.3%) |
| Year of residency | |
| 1st year | 10 (62.5%) |
| 2nd year | 6 (37.5%) |

### Effect of Using the Simulation Prototypes on Skills and Attitudes

The combined score for self-reported competencies of integrating the EMR into the patient consultation improved from 14.88±2.63 before to 15.63±2.80 (M±SD; out of maximum 20 points possible) after using the simulation prototypes. This difference was statistically significant with a large effect size (Table 3). When the scores for individual items were compared, the scores for 4 of 5 items increased from pre- to post-simulation, but this improvement was only significant for 2 items: technical aspects of operating the EMR during the patient visit (paired t-test; t=-2.611, p=0.020) and using the computer for patient education (paired t-test; t=-2.611, p=0.020), which improved from 2.63±0.81 to 2.94±0.77 and from 2.75±0.86 to 3.06±0.77 (M±SD; on a 4-point scale), respectively. The score for one item (prevention of EMR-related errors) dropped from 3.31±0.60 to 3.06±0.68 (M±SD; on a 4-point scale), but this was not statistically significant (paired t-test; t=1.73, p=0.104).

The combined score for attitudes related to using the EMR during the patient visit also increased from 22.25±2.44 before to 23.13±2.16 (M±SD; out of maximum 30 points possible) after using the simulation prototypes. However, this difference was not significant (Table 3). The scores for 5 of 6 attitude items improved from pre- to post-simulation and decreased for one item ("use of the EMR enhances my performance"); however, none of these changes were statistically significant.

*Table 3 – Self-reported competencies and attitudes related to the use of the EMR in the consultation.*

| | Pre-test | | Post-test | | t(df=15) | Sig. | Effect size (dz) |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | | | |
| Competencies[a] | 14.88 | 2.63 | 15.63 | 2.80 | -2.535 | 0.023 | 0.63 |
| Attitudes[b] | 22.25 | 2.44 | 23.13 | 2.16 | -1.754 | 0.100 | 0.44 |

[a] Combined score out of maximum 20 points possible.
[b] Combined score out of maximum 30 points possible.

Analysis of the free-text comments from the post-simulation questionnaire supports the positive impact of the computer-based simulation. In particular, respondents commented that the simulation increased their awareness of issues surrounding the use of EMR in the consultation *("Awareness of EMR pros and cons"* [p. 4]), and that it provided them with reassurance for their current practices *("Served to reinforce that my current practice is consistent with recommended/ acceptable practices"* [p. 7]).

### Acceptability of the Simulation

The mean scores for acceptability of the simulation and overall evaluation of the simulation session, as measured on the post-simulation questionnaire, are presented in Table 4. Scores for perceived ease of use and perceived usefulness were good (4.10±0.73 and 3.81±0.74 on a 5-point scale, respectively). Intention to use the simulation and overall evaluation of the session were rated just above average. Inter-rater agreement on all scores was high (rWG(j)≥0.8)

*Table 4 – Acceptability of the simulation and overall evaluation of the session.*

| | **PU** | | **PEOU** | | **INT** | | **SEVAL** | |
|---|---|---|---|---|---|---|---|---|
| | **M** | **SD** | **M** | **SD** | **M** | **SD** | **M** | **SD** |
| | 3.81 | 0.74 | 4.10 | 0.73 | 3.50 | 0.63 | 3.16 | 0.79 |
| **rWG(j)** | 0.90 | | 0.82 | | 0.89 | | 0.80 | |

The qualitative data analysis provided additional support for the acceptability of the computer-based simulation. Participants commented that the scenarios were realistic, that the prototypes were easy to use and enjoyable *("Great, fun, simulation that is very realistic"* [p.7]), and that it would be effective for teaching Family Medicine residents how to better use the EMR in clinical encounters. However, they thought it would be most effective in earlier stages of the Family Medicine residency program: *"Use this to teach all residents! Would have been an excellent tool to have in the first month of residency. I would have definitely used this tool often when first learning how to use an EMR ..."* [p. 5]. Two participants, however, thought it would be difficult to teach these issues using a software application that cannot fully capture the nuances and range of patient behaviors: *"I find it is difficult to teach you how to balance using the computer during the actual encounter with patient interaction through an app, as the balancing act requires 'learning through doing' and is better done at clinic"* [p.12].

### Usability and Scenario Design Issues

Several usability and scenario design issues emerged from the 'think aloud' observations. First, it was noted that, as opposed to the Master of Information students who focused mostly on the software itself, residents concentrated on the clinical aspects of the simulation; i.e., they spent substantial amount of time reviewing the information presented on the EMR and commented on the clinical decision options. Participants commented that they would like the EMR representation in the simulation to be more interactive—much more like the real system they were using (*"Creating an interface where we can actually use EMR during the simulation session"* [p. 8, in response to the question "what would improve the simulation?"]). They also wanted to have additional choices available—especially for shared decision making (e.g. "*I would ask her if she would like... it's hard for me to choose what I recommend"* [p.1,'think aloud' session]).

The pace of the simulation, which has been modified following the pre-pilot, did not seem to be an issue for most residents, except for two who commented on it on the post-simulation survey—one of whom was also observed in the 'think aloud' and seemed to be a very fast reader. Interaction with the magnifying glass was still confusing for some of the participants. Finally, through the 'think aloud' observation, we discovered a number of additional usability and scenario design issues that were not captured in the pre-pilot. For example, we noted that in a scenario discussing recent discovery of hypercholesterolemia, the EMR's screen capture indicated that the patient was already taking medications for this problem, which was confusing to participants. Other minor issues included a blank references screen when no references for the feedback were available, and one slide transition that was too fast.

## Discussion

The effect of using EMRs on patient-clinician relationships has gained considerable research attention. However, educational interventions aimed at improving clinicians' competence in computerized settings are still rare. As part of our effort to bridge this gap, we have developed several interventions, of which EMR-sim is one [5, 6].

The results of this pilot study suggest that a computer-based simulation would be a useful tool for teaching Family Medicine residents how to better integrate the use of EMRs—and the computer in general—into the patient consultation. The combined scores for both self-reported competencies and attitudes related to using the EMR in the consultation improved from pre- to post-simulation (although this change was only significant for competencies), and so did most individual item scores. Our data suggest that the simulation is acceptable to users with good scores for perceived ease of use and usefulness. Free-text comments provided by participants support this analysis and suggest that the simulation may be especially useful in the early stages of the Family Medicine residency program. As a computer-based simulation is more scalable, compared to previous interventions such as simulation with standardized patients [5], we believe that it is worth further development and testing.

A pre-pilot usability testing with Master of Information students and a pilot test with Family Medicine residents proved to be a useful combination, as the students focused more on the interaction with the tool itself, whereas the residents examined mostly the medical information and decisions, and the display of the EMR component on the simulation prototype. This allowed us to identify some human-computer interaction issues, such as the pace of the conversation and interaction with the magnifying glass, as well as issues related to decision choices and interaction with the EMR component of the simulation prototype. In particular, residents pointed out that they would like to have more options for shared decision making. It has been suggested that the EMR can be effectively utilized for sharing understanding between patients and clinicians [13]. Additional scenarios that address this issue should be developed and tested. Second, residents preferred the simulated EMR to be more interactive—much like the real system they use. A potential way to achieve this is by integrating the simulation with an educational EHR system, such as the one developed by Borycki et al. [14].

### Limitations and Directions for Future Research

The main limitations of this pilot study are that we used a small convenience sample and relied on self-reported measures. Although the results are promising, they should be taken with caution as the possibility of type 1 errors cannot be excluded. The intervention was short and only two simulation prototypes were tested, which may explain the lower score for the overall evaluation of the session. For future research, more extensive interventions should be developed and evaluated. A randomized controlled trial with a larger sample and using more objective measures could be implemented, such as video observation of real-life consultations and rating of patient-physician-EMR skills by external observers.

Scale reliability for attitudes related to using the EMR in the consultation was low. This may be due to the small sample size and the fact that items are substantially different from each other that they may not be unidimensional [15]. To overcome this limitation, we summarized the scores for all items to create a combined attitudes score. However, future research may seek to develop a more reliable instrument for measuring participants' attitudes related to using the EMR in the consultation.

Our goal was to develop a simple, low cost, simulation using tools that do not require expertise in programming or graphic design [6]. However, some participants suggested a more realistic representation of the patients may be useful. Alternative designs that include animation or video segments may better portray patient behaviors—including non-verbal communication—and should be explored.

Finally, the simulation focused exclusively on the use of an EMR system. Increased use of more comprehensive EHRs and patients' access to their information through portals and personal health records (PHRs) introduce new challenges to the patient-clinician interaction during the patient visit. These challenges should be further explored and addressed in future designs of the simulation.

## Conclusion

The study suggests that computer-based simulation may be an effective and acceptable tool for teaching Family Medicine residents how to better use the EMR in the consultation, and potentially other clinicians who face similar challenges of using EMRs in the clinical encounter. This potential should be further explored in future research. Usability testing with both clinicians and non-clinicians is a useful approach for identifying a variety of human-computer interaction and scenario design issues.

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