Effects of Information Access Cost and Accountability on Medical Residents’ Information Retrieval Strategy and Performance During Prehandover Preparation: Evidence From Interview and Simulation Study

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Objective: We aimed to examine the effects of information access cost and accountability on medical residents’ information retrieval strategy and performance during prehandover preparation.

Background: Prior studies observing doctors’ prehandover practices witnessed the use of memory-intensive strategies when retrieving patient information. These strategies impose potential threats to patient safety as human memory is prone to errors. Of interest in this work are the underlying determinants of information retrieval strategy and the potential impacts on medical residents’ information preparation performance.

Method: A two-step research approach was adopted, consisting of semistructured interviews with 21 medical residents and a simulation-based experiment with 32 medical residents.

Results: The semistructured interviews revealed that a substantial portion of medical residents (38%) relied largely on memory for preparing handover information. The simulation-based experiment showed that higher information access cost reduced information access attempts and access duration on patient documents and harmed information preparation performance. Higher accountability led to marginally longer access to patient documents.

Conclusion: It is important to understand the underlying determinants of medical residents’ information retrieval strategy and performance during prehandover preparation. We noted the criticality of easy access to patient documents in prehandover preparation. In addition, accountability marginally influenced medical residents’ information retrieval strategy.

Application: Findings from this research suggested that the cost of accessing information sources should be minimized in developing handover preparation tools.

Keywords: clinical handover preparation, information access cost, accountability, overconfidence, information retrieval

INTRODUCTION

As an essential component for providing seamless continuity of patient care, clinical handover can be conceptualized as a three-phase process, consisting of prehandover, handover communication, and posthandover (Kerr, 2002). The majority of existing literature on clinical handovers has focused on the communication phase. Although focusing on the communication phase is extremely valuable, there is a necessity to broaden the research attention to the pre- and posthandover phases, as the extension helps to pinpoint more accurately the stages responsible for the problems observed in handover transition (Raduma-Tomàs, Flin, Yule, & Close, 2012).

It is recommended that an effective handover communication should include an up-to-date summary of patient status and insight on what to anticipate or what to do during the cross-covering period (Arora et al., 2009; Arora, Johnson, Lovinger, Humphrey, & Meltzer, 2005). Although the prehandover phase is vital to ensure the accurate and adequate preparation of handover information, existing studies showed that the prehandover preparation is often insufficient (Catchpole et al., 2007; Raduma-Tomàs, Flin, Yule, & Close, 2011). In response to this shortcoming, Raduma-Tomàs et al. (2012) proposed that an ideal process of prehandover preparation should include confirming the status of requested diagnostic investigations (e.g., diagnostic tests, referral replies from other specialties), collating key patient information, and updating the written handover notes. Qualitative studies on clinical handovers reported circumstances where doctors were constrained to adopt memory-intensive strategies when preparing handover information, relying on their
memory rather than on displayed or written documentations such as patient medical records (Alem, Joseph, Kethers, Steele, & Wilkinson, 2008; Vidyarthi, Arora, Schnipper, Wall, & Wachter, 2006). Vidyarthi et al. (2006) surveyed residents at three hospitals and found many residents handed over verbally “wherever and whenever” they could find the cross-covering doctor without proper preparation. It is likely that such ad hoc processes would encourage the adoption of memory-intensive strategies. Along the same line, Alem et al. (2008) studied information environment supporting medical handovers and found that in preparation of handover outgoing doctors mainly wrote small bits of patient information on patient lists or on blank sheets of paper. The information was often used as a “memory trigger,” and much additional information would be recalled and presented during handover meetings. However, as the authors stated, there was no guarantee that a doctor would remember the patient information accurately.

Such memory-intensive strategies impose potential threats to the accuracy of patient information, as relying on long-term memory without augmentation from external memory stores predictably leads to missing and inaccurate information (Wickens, Hollands, Parasuraman, & Banbury, 2013). However, there is a lack of empirical research that addresses the underlying reasons and quantifies the potential negative impacts. This study, therefore, aims to examine the factors influencing medical residents’ information retrieval strategy and performance.

We postulate that information access cost (IAC) is one possible factor influencing medical residents’ information retrieval strategies from either knowledge in the head (KIH; i.e., a resident’s memory of patient information) or knowledge in the world (KIW: i.e., displayed or written patient information). Studies in human–computer interaction (HCI) have consistently shown that the effort or cost to retrieve a particular piece of information from either KIH or KIW affects one’s retrieval strategy and performance: an increasing IAC from the world encourages a more memory-intensive strategy to access KIH, and discourages access to better information in the world (Ballard, Hayhoe, & Pelz, 1995; Gray & Fu, 2001, 2004; Gray, Sims, Fu, & Schoelles, 2006). In hospitals, IAC from the world could be manifested via various means. For example, the poor compatibility between existing health care information technology (HIT) and clinical tasks (Vitanena et al., 2011), poor usability of HIT such as deep multi-keypress menu structures (Nemeth, Nunnally, O’Connor, Klock, & Cook, 2005), and the inadequate integration between electronic health record (EHR) and other systems (Flanagan, Patterson, Frankel, & Doebbeling, 2009; Goldschmidt, 2005) are likely to increase the temporal cost, mental workload, and the level of frustration of accessing patient information from KIW and thus bias the information retrieval strategies toward memory-intensive ones. In hospitals lacking HIT infrastructures, IAC could be represented by both the effort used to physically obtain documented information such as patient charts, and the temporal cost of performing corresponding physical activities. The compounded costs may further encourage doctors to rely on internal memory over external memory stores.

The choice between relying on KIH and KIW may be considered within the context of the speed–accuracy trade-off (SATO) in applied settings (Drury, 1994). KIH is often a more rapid way of accessing information, but as we have seen, can be error prone. In contrast, KIW is often more accurate, but may take longer to acquire. Just as various incentives and payoffs have been employed to move people toward different ends of the SATO (Fitts, 1966; Wickens et al., 2013), in the present study we manipulated IAC indirectly by imposing or not imposing a 5-m distance, the former presumably inducing greater cost than the latter.

The second factor of interest in the present study is medical residents’ accountability in pre-handover preparation. Accountability is defined as the “condition of being answerable to audiences for performing up to certain standards, thereby fulfilling responsibilities, duties, expectations, and other charges” (Weigold & Schlenker, 1991, p. 25). Studies have reported the lack of definition and measurement on accountability in handover (Jeffcott, Evans, Cameron, Chin, & Ibrahim, 2009; Petersen, Brennan, & O’Neil, 1994). Specifically, the majority of health care
organizations have not yet established explicit expectations as to who is responsible within care teams to prepare patient information for handover (Jeffcott et al., 2009), let alone the accountability on the accuracy and adequacy of information preparation.

Past research suggested that when held accountable for the outcome, people achieved superior performance in simple judgment and decision-making tasks (Pelham & Neter, 1995). Therefore we hypothesize that medical residents under high accountability conditions would show more frequent and longer access to KIW, and achieve better performance. Furthermore, we speculated that the effect of accountability could be due to a combination of two underlying mechanisms. First, accountability oftentimes implies that people who justify their performance adequately will gain rewards and people who do not will suffer from penalties (Lerner & Tetlock, 1999). Therefore, it is reasonable to expect that when accountability is high, medical residents motivated to obtain rewards and avoid penalties would make more frequent and longer access to displayed or written patient information and attain better performance. Second, accountability may boost performance by reducing medical residents’ overconfidence bias. There is a growing body of knowledge that people are overconfident when judging their memory accuracy (Allwood, Granhag, & Johansson, 2003; Bornstein & Zickafoose, 1999). Under such conditions, one’s confidence judgment in the accuracy of memory is overestimated, biasing the decision toward a memory-intensive strategy more than it should have and thereby impairing performance. Several studies provided consistent findings that increasing accountability reduces overconfidence (Ronis & Yates, 1987; Sniezek, Paese, & Switzer, 1990; Tetlock & Kim, 1987). Therefore, we expect that by increasing medical residents’ accountability, their overconfidence bias will decrease, and thus they would make adequate access to KIW, resulting in better preparation performance.

In the present study, the accuracy of KIW was assumed to be 100%. To simplify the notations, from this point onward IAC refers to the cost of accessing KIW. The present study aimed to examine the following hypotheses (Figure 1).

**Hypothesis 1 (H1):** As suggested by previous studies (Ronis & Yates, 1987; Sniezek et al., 1990; Tetlock & Kim, 1987), an increase of accountability will increase accuracy and reduce overconfidence.

**Hypothesis 2a (H2a):** An increase of IAC will reduce the number of information access attempts (Gray et al., 2006; Gray & Fu, 2001, 2004) and the information access duration.

**Hypothesis 2b (H2b):** An increase of IAC will harm information preparation performance.

**Hypothesis 3a (H3a):** An increase of accountability will increase the number of information access attempts and information access duration.

**Hypothesis 3b (H3b):** An increase of accountability will improve information preparation performance.

Two separate studies were performed: semi-structured interviews and a simulation-based experiment. The National Healthcare Group Domain Specific Review Board and Hospital Institutional Review Board approved the study and all participants gave informed consent.

**SEMISTRUCTURED INTERVIEW**

**Method**

**Participants.** The semistructured interviews were conducted with 21 junior medical residents over a 3-month period at a tertiary and referral hospital in Singapore. All participants were from general medicine, with an average age of 27.2 years (SD = 1.9 years) and an average experience of 2.5 years (SD = 1.2 years).

**Interview questionnaire.** The interview questionnaire was developed based on the three-phase handover framework. The questions pertaining to prehandover preparation focused on three areas: the number of patients cared by and handed over by a primary team physician, the type of patients handed over by the physician, and the sources of patient information where the physician referred to in preparation of handover.

The semistructured interviews were audio-recorded and transcribed using Transcriber (http://trans.sourceforge.net/). One human factors researcher analyzed the data following standard
procedures for inductive analysis (Johnson & Christensen, 2004).

**Results**

When a patient was hospitalized, he or she was under the charge of a primary team usually comprising one consultant (equivalent to attending physician), one or two senior residents, and one or two junior residents. Depending on the medical subspecialty, the team was responsible for 5 to 20 patients, from which normally less than 3 patients were handed over. The decision whether or not to hand over a patient was team-based, but usually made by senior members of the team during the exit rounds. Once the decision was made, a junior resident was responsible for preparing and conducting the handover with another junior resident from the cross-covering team. Table 1 shows the types of patients and the corresponding frequency of mentions.

Since there was no handover preparation protocol implemented at the research site during the study, the information preparation strategy varied appreciably across the participants. Among them, only one participant mentioned the preparation of a formal handover sheet. All participants stated that they checked the computerized medical record system for the completeness of the ordered investigations if any to prepare for the handover. More than half of the participating residents (13/21) checked the patient charts and other information sources including patient lists and personal notes before the handover communication. The others (8/21) relied largely on memory-intensive strategies, although they also mentioned referring to displayed or written information sources. The contrast between relying on KIW and KIH can be illustrated by two participants’ comments: “I will have a computer in front of me [and] relevant investigations in front of me [and] charts in front of me and then I will handover. That means all the information I need to tell them is in front of me” versus “I have a patient list, [which] will note which patient for handover. Usually [I] will just recall the patient information cos [because] you [I] will know them pretty well.”

The semistructured interview revealed the use of different information retrieval strategies by the medical residents and the prevalence of relying on one’s own memory. We examined two possible causes for this in the following experiment.

**SIMULATION-BASED EXPERIMENT**

**Method**

*Participants.* Thirty-two junior medical residents from two tertiary and referring hospitals in
Singapore participated in the simulation-based experiment. The results of two participants were excluded from the analysis because one of them marked confidence rating as 0/50 for all the questions and the other answered “not sure” for 90% of the recall questions. The remaining 30 participants had an average age of 28.1 years (SD = 3.1 years) and an average experience of 3.6 years (SD = 2.5 years). Of the 30 participants, 26 were from general medicine, 3 from general surgery, and 1 from anesthesia. Each participant received 50 Singapore dollars (about US$39.40) for his or her participation.

**Development of mock-up patient cases.** Based on real patient cases, a group of subject matter experts (SMEs), consisting of one consultant, one senior resident, and one junior resident, developed a pool of mock-up patient cases from gastroenterology, neurology, respiratory, and cardiology. The SMEs followed five steps to develop the patient cases. First, they identified representative cases in the general medical ward. Second, for each case they selected one corresponding patient and copied the patient’s hospitalization history lasting for 48 to 72 hr after admission. Third, the SMEs developed an exit round entry (i.e., an entry on the patient chart documenting a patient’s condition and status observed during the exit round and the primary team’s management plan for the patient during the on-call period; Figure 2). After that, relevant supporting information such as general lab results, X-rays, and patient pictures were assembled. Last, all identifiable information was anonymized with fictional names, numbers, and dates.

Eight patient cases were selected from the pool. The selected medical conditions were congestive cardiac failure, pneumonia and do not resuscitate (DNR), deep vein thrombosis, constipation colic, fast atrial fibrillation, fluid overload secondary to cardiac failure, acute stroke, and gastrointestinal bleeding. A sample mock-up case is presented in Figure 3.

Furthermore, for each patient case, the SMEs developed 10 recognition and 10 recall questions that were critical for the understanding of the patient case. An example recognition question is “Was the patient’s hemoglobin level above 7?” and an example recall question is “Besides chest pain, what is the other symptom the patient presenting with during exit round?” The 20 questions were used in the two recognition/recall tests.

**Experimental task.** Figure 4 shows the flowchart of the experimental task. Each participant studied four randomly assigned patient cases. After that, the accountability of a particular patient was announced. In the experiment, participants went through two tests, each of which included 5 recognition and 5 recall questions. In Test 1 designed to assess overconfidence, participants answered the questions depending only on their memory and provided confidence estimates. Confidence rating was a 6-point scale ranging from 50% to 100% for each recognition question and an 11-point scale ranging from 0% to 100% for each recall question, with the leftmost point labeled “just guessing” and the rightmost point “absolutely confident.” In Test 2 designed to assess information retrieval strategy and performance, participants were allowed to access the original patient cases (KIW) from a PC, the location of which was manipulated either next to the desk or 5 m away depending on the IAC conditions.
The choice of IAC manipulation was determined by the handover practices at the research sites. During the time of the study, neither of the research sites had implemented the EHR system. A large portion of patient information was recorded using paper-based patient charts, which could be located at various physical places such as patient bedsides and nurse stations, incurring different travel distances.

Through a pilot study with two medical residents, the study time and difficulty of the test questions were determined. The study time per patient case was adjusted to 150 s to ensure the performance fell in the middle range. The difficulty of Test 1 and Test 2 questions were balanced by stratified randomization. The difficulty score of each recognition and recall question was obtained (based on memory accuracy results from Test 1), and used a priori to stratify the questions into hard, moderate, and easy questions. The assignment of the 20 questions into Test 1 and Test 2 were then randomized within each stratum. Moreover, the difficulty score was constantly updated after each participant completed the experiment.

Experimental design. There were two 2-level independent variables manipulated within subjects: accountability and IAC. After Tetlock and Kim (1987), in the low accountability condition, participants were assured that their performance would be completely confidential, whereas in the high accountability condition they were informed that the test performance would be assessed at the end of the study. The second independent variable (IAC) was manifest as the physical distance required to access the patient information. In the low cost setting, the original patient cases were available on the same PC that was used to study the four patient cases, whereas in the high cost setting, the patient cases were available on a separate PC located 5 m away.

In Test 1, memory accuracy and confidence judgment were measured. Confidence was calculated by averaging the confidence judgment of question $i$ ($i = 1$ to $N$), and overconfidence was calculated as the difference between confidence and accuracy (Koriat, Lichtenstein, & Fischhoff, 1980). A positive sign indicates overconfidence and a negative sign underconfidence.

\[
Confidence = \frac{1}{N} \sum_{i=1}^{N} \text{Confidence}_i
\]

\[
Overconfidence = Confidence - Accuracy
\]

In Test 2, number of information access attempts, the total information access duration to original patient cases, and information preparation performance accuracy were measured.

The experiment followed a two by two within-subject design. To minimize the potential...
Figure 3. A sample mock-up patient case (male with onset of shortness of breath and left leg swelling) comprising patient photos, medical record, and lab results.
carryover effect, a 4 × 4 reduced Latin square design was employed (Table 2), with a 1-min break between experimental conditions.

**Experimental apparatus and procedure.** The information display program was coded in Visual Basic 2008 and ran on two PCs with two 24-inch color monitors. Participants first received general information about the study and signed the consent form. They completed a practice trial prior to the actual experiment. No feedback on performance was given during the experiment.

**Results**

To account for potential order effects, we conducted preliminary analyses using three-way mixed ANOVAs, with accountability and IAC as within-subject factors and order as the between-subject factor. No main effects of order or any Order × Accountability, Order × IAC, or Order × Accountability × IAC interactions were significant (all ps > .05; please refer to the supplementary material for more details).

As the order effects were not significant, we excluded order from the final analysis. Table 3 summarizes the descriptive statistics for response variables under each experimental condition. Two-way repeated measures ANOVAs tested the main and interaction effects of accountability and IAC on memory accuracy, confidence, overconfidence, information access attempts, access duration, and preparation performance.

The results revealed that accountability significantly increased memory accuracy from 55.2% to 61.2%, $F(1, 29) = 7.695, p < .01$, partial $\eta^2 = .210$, and significantly reduced overconfidence from 13.9% to 8.5%, $F(1, 29) = 4.395, p < .05$, partial $\eta^2 = .132$, which were consistent with past results (Ronis & Yates, 1987; Sniezek et al., 1990; Tetlock & Kim, 1987) and confirmed H1. Since IAC was not varied in Test

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**TABLE 2: The 4 × 4 Reduced Latin Square Design in the Experiment**

<table>
<thead>
<tr>
<th>Accountability</th>
<th>Information Access Cost</th>
<th>Cases for Each Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>Patient 1 Patient 2 Patient 3 Patient 4</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>Patient 2 Patient 1 Patient 4 Patient 3</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>Patient 3 Patient 4 Patient 1 Patient 2</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
<td>Patient 4 Patient 3 Patient 2 Patient 1 Subject 1 Subject 2 Subject 3 Subject 4</td>
</tr>
</tbody>
</table>

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Figure 4. Flowchart of experimental task.
TABLE 3: Mean and 95% Confidence Interval of Accuracy, Confidence, Overconfidence, Information Access Attempts (IAAs), Information Access Duration, and Information Preparation Performance

<table>
<thead>
<tr>
<th></th>
<th>Low Accountability</th>
<th>High Accountability</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test 1: Accuracy (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low IAC (0 m)</td>
<td>54.7 (50.5–58.8)</td>
<td>59.3 (54.5–64.1)</td>
<td>57.0 (53.9–60.1)</td>
</tr>
<tr>
<td>High IAC (5 m)</td>
<td>55.7 (51.4–60.0)</td>
<td>63.0 (57.2–68.8)</td>
<td>59.3 (55.6–63.0)</td>
</tr>
<tr>
<td>Average</td>
<td>55.2 (52.4–58.0)</td>
<td>61.2 (57.4–64.9)**</td>
<td>58.2 (55.7–60.6)</td>
</tr>
<tr>
<td><strong>Test 1: Confidence judgment (%)</strong></td>
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<td></td>
</tr>
<tr>
<td>Low IAC (0 m)</td>
<td>69.2 (63.7–74.6)</td>
<td>68.2 (61.9–74.6)</td>
<td>68.7 (63.3–74.1)</td>
</tr>
<tr>
<td>High IAC (5 m)</td>
<td>68.9 (63.8–74.1)</td>
<td>71.1 (66.3–75.9)</td>
<td>70.0 (65.7–74.4)</td>
</tr>
<tr>
<td>Average</td>
<td>69.0 (64.3–73.7)</td>
<td>69.7 (64.7–74.6)</td>
<td>70.2 (65.2–75.3)</td>
</tr>
<tr>
<td><strong>Test 1: Overconfidence (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low IAC (0 m)</td>
<td>14.5 (8.8–20.2)</td>
<td>8.9 (1.7–16.1)</td>
<td>11.7 (6.2–17.2)</td>
</tr>
<tr>
<td>High IAC (5 m)</td>
<td>13.3 (7.0–19.5)</td>
<td>8.1 (1.9–14.4)</td>
<td>10.7 (6.1–15.3)</td>
</tr>
<tr>
<td>Average</td>
<td>13.9 (8.8–19.0)</td>
<td>8.5 (3.4–13.6)*</td>
<td>11.2 (6.8–15.6)</td>
</tr>
<tr>
<td><strong>Test 2: IAAs (out of 10 questions; n = 30)</strong></td>
<td></td>
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<tr>
<td>Low IAC (0 m)</td>
<td>6.5 (5.1–7.8)</td>
<td>5.9 (4.6–7.2)</td>
<td>6.2 (5.0–7.3)***</td>
</tr>
<tr>
<td>High IAC (5 m)</td>
<td>1.5 (0.7–2.2)</td>
<td>2.1 (1.2–2.9)</td>
<td>1.8 (1.1–2.4)</td>
</tr>
<tr>
<td>Average</td>
<td>4.0 (3.1–4.9)</td>
<td>4.0 (3.0–5.0)</td>
<td>4.0 (3.1–4.8)</td>
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<tr>
<td><strong>Test 2: Information access duration (seconds; n = 27)</strong></td>
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<tr>
<td>Low IAC (0 m)</td>
<td>82.1 (62.3–102.0)</td>
<td>97.6 (71.6–123.6)</td>
<td>88.9 (70.5–109.3)***</td>
</tr>
<tr>
<td>High IAC (5 m)</td>
<td>36.8 (16.6–57.0)</td>
<td>56.6 (31.8–81.3)</td>
<td>46.7 (25.9–67.5)</td>
</tr>
<tr>
<td>Average</td>
<td>59.5 (41.8–77.2)</td>
<td>77.1 (54.2–100.0)†</td>
<td>68.3 (50.1–86.4)</td>
</tr>
<tr>
<td><strong>Test 2: Information preparation performance (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low IAC (0 m)</td>
<td>78.7 (71.2–86.1)</td>
<td>78.3 (72.4–84.3)</td>
<td>78.5 (72.4–84.6)***</td>
</tr>
<tr>
<td>High IAC (5 m)</td>
<td>62.3 (55.4–69.3)</td>
<td>69.0 (62.3–75.8)</td>
<td>65.7 (59.6–71.7)</td>
</tr>
<tr>
<td>Average</td>
<td>70.5 (64.1–76.9)</td>
<td>73.7 (68.7–78.6)</td>
<td>72.1 (66.7–77.4)</td>
</tr>
</tbody>
</table>

Note. IAC = information access cost.

aData of 30 subjects were captured with four missing data points. The four data points were calculated by expectation-maximization imputation (Dempster, Laird, & Rubin, 1977) available in SPSS Statistics 21.

†p < .10. *p < .05. **p < .01. ***p < .001 (contrasts with performance at low accountability and low IAC).

1 (represented only by the treatment that participants would receive in subsequent Test 2), its effect on memory accuracy, confidence and overconfidence was not significant. The effect of accountability on confidence (as opposed to overconfidence) was not significant, F(1, 29) = .249, p = .622, partial η² = .009. Therefore the increase in overconfidence was characterized by a loss in accuracy in low accountability condition without a corresponding loss in confidence, reflecting a faulty calibration of metacognition (Wickens et al., 2013).

The results for Test 2 assessing the retrieval strategy and performance under varying IAC conditions supported H2a. With relocation of the patient case data to the PC 5 m away, the number of information access attempts decreased from 6.2 to 1.8 times, F(1, 29) = 113.87, p < .001, partial η² = .797, and the total information access duration decreased from 88.9 to 46.7 s, F(1, 26) = 26.34, p < .001, partial η² = .503. In H2b, we hypothesized that an increase in IAC would degrade the information preparation performance. Indeed, there was a significant decrease in performance from 78.5% to 65.7%, F(1, 29) = 20.226, p < .001, partial η² = .411. The effect on information access attempts and performance is consistent with the findings of Gray and Fu.
(2001, 2004; Gray et al., 2006) showing that as IAC increased the adoption of memory-intensive strategies increased and performance degraded.

Moreover, we found that the effect of accountability on total information access duration approached statistical significance, $F(1, 26) = 3.699$, $p = .065$, partial $\eta^2 = .125$, and this variable had no effect on information access attempts, $F(1, 29) = 0.001$, $p = .979$, partial $\eta^2 = .000$. Thus, this finding does not support H3a. Finally, the increase of accountability also did not affect information preparation performance, $F(1, 29) = 2.706$, $p = .11$, partial $\eta^2 = .085$, hence not supporting H3b. In examining this effect in more detail, we do note that the information preparation performance was unchanged by the accountability manipulation when the display was close (78.3% versus 78.7%), but benefited from increasing accountability when the display was 5 m away (62.3% versus 69.0%). When testing the effect of accountability on information preparation performance at the high IAC level, the result showed a significant difference, $F(1, 29) = 4.567$, $p < .05$, partial $\eta^2 = .136$, although the interaction was not statistically significant, $F(1, 29) = 2.391$, $p = .13$, partial $\eta^2 = .076$.

GENERAL DISCUSSION AND CONCLUSION

Consistent with previous safety investigations (Alem et al., 2008; Vidyarthi et al., 2006), our interview study revealed that a substantial portion of medical residents relied largely on memory for preparing their handover information. We reasoned that one of the possible causes may have been the high IAC of referring to displayed or written medical information. The other factor hypothesized to influence the retrieval strategy and performance is medical residents’ accountability.

When we varied access costs of KIW in our experiment we strongly confirmed such an interpretation: when people had to travel farther to access the displays, they made fewer visits and spent less time viewing them overall (H2a) and this reduced their final performance (H2b). The results suggest that patient information needs to be easily accessible in handover preparation. In addition, past studies have used various methods to manipulate IAC, including eye movement versus mouse movement, varying levels of Fitts’s index and varying levels of lockout time (Ballard et al., 1995; Gray et al., 2006; Gray & Fu, 2001, 2004; Morgan, Patrick, Waldron, King, & Patrick, 2009; Morgan, Waldron, King, & Patrick, 2007). Results of this study showed that besides these factors, physical distance was a viable way to inducing varied IAC, a critical variable in health care, where patient records may be located at various locations (e.g., bedside, doorway, at a ward-central desk).

When we manipulated accountability, participants became more accountable and their memory accuracy for Test 1 items increased whereas confidence did not, creating the anticipated reduction in overconfidence in memory accuracy (H1); a reduction we infer would have been manifest in Test 2, even though we did not assess it there.

Furthermore, we found a marginal significant relationship between accountability and total information access duration (part of H3a). However, this effect of accountability did not cascade through the overall information preparation performance (thus not supporting H3b). In interpreting the null effect of H3b (accountability effect on performance), as noted, there remained the intriguing hint of an interaction between the two independent variables on performance. Further research is required to assess the interaction effect, particularly as this type of effect—the loss of performance due to low accountability when displays are distant—has profound safety implications for health care quality.

LIMITATIONS

This research has some limitations and challenges, which should be taken into consideration when interpreting and generalizing the findings. First, the experiment used patient photos, medical records, and diagnostic test results to simulate patient cases, which limited simulation fidelity. Since the interaction with a patient in real settings often takes place with additional modalities including auditory and tactile channels, and lasts for a longer time, the differences in interaction may affect information retrieval strategies and performance. However, we noted that pure text-based simulation has been used in past studies, generating satisfactory results (Bhabra, Mackeith, Monteiro, & Pothier, 2007; Pothier, Monteiro,
Mooktiar, & Shaw, 2005; Wallston et al., 2014). Also, the simulation was focused on the accuracy of explicit information retrieved from either KIW or KIH. Handover preparation is not merely about information retrieval and its accuracy, but also other cognitive activities such as determining what information to include, organizing and synthesizing patient information into a coherent picture. Further research is needed to examine these cognitive activities. Moreover, IAC was manipulated by imposing different physical distance in the present simulation, whereas IAC can be affected by other factors and would be highly context dependent in real medical settings as we discussed in the introduction.

Second, the participants were junior medical residents with limited clinical experience. Thus the findings are limited in its external validity. Past literature showed that experience and training sometimes may lead to better accuracy–confidence calibration (Keren, 1987; Lichtenstein & Fischhoff, 1977; although not invariably so—Kahneman & Klein, 2009). Therefore, more experienced clinicians may possess a smaller overconfidence bias, resulting in higher information preparation performance. It is also possible that experienced clinicians have higher levels of accountability toward patients and the manipulation of accountability might not be effective.

Third, the present study assumed that the accuracy of KIW is perfect, whereas of course displayed or written documents in real medical settings may contain errors (Arora, Kao, Lovinger, Seiden, & Meltzer, 2007) and are often not up-to-date. The issue of inaccurate KIW may be exacerbated by the use of EHR, for example, due to the propagation of error by cloning (i.e., copying and pasting from one record to another; Thielke, Hammond, & Helbig, 2007) and to increased documentation burden due to poor EHR usability (Karsh, Weinger, Abbott, & Wears, 2010), respectively. Also, inadequate information presentation may have detrimental effects on KIW accuracy. For instance, poor handwriting in medical records has long been identified as a significant problem in medicine (Sokol & Hettige, 2006). Such information illegibility at best increase IAC, at worst contributes to imperfect KIW, as it’s impossible to decipher the intended message.

Fourth, the present study primarily focused on handover senders during prehandover preparation. In fact, both preparation and presentation are a two-way process. A recent study of Hilligoss and Zheng (2013) examined how inpatient clinicians (handover receivers) used the “chart biopsy” in preparation for handovers from emergency department clinicians (handover senders). This two-way collaboration can then mitigate the shortcomings of prehandover preparation by the handover sender.

Finally, we acknowledge that limited availability of participants required us to conduct the experiment with insufficient statistical power to accurately establish the strength of all of the influence links in the model shown in Figure 1. The model however can certainly act as a framework within which others can pursue answers to some of these important research questions.

These limitations notwithstanding, the current study examines two important phenomena that could compromise information preparation. In particular we point to the criticality of easy access to information source in handover preparation. This compromise has been observed in hospital settings when formal procedures are not fully established or complied with. Well-designed information technology and practice and organizational changes promoting accountability are needed to maximize the quality of prehandover preparation.

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KEY POINTS

- Memory-intensive strategies when retrieving patient information during prehandover preparation were observed.
- The effects of information access cost and accountability on information retrieval strategy and performance were examined in a simulation-based experiment.
• Increasing information access cost led to more memory-intensive strategies and harmed information preparation performance.

• Higher accountability led to marginally longer information access to patient documents.

REFERENCES


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