Faculty of Design

2011

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Abstract

For many Healthcare Technology Interventions (HIT) attitudes and experiences can have a significant impact on successful implementations. Within transfusion services it is recognized that differences in perspective between blood bank staff and nursing staff affect the adoption of safety practices or interventions. This multi-center study used a questionnaire survey to investigate differences in technology acceptance and attitudes towards Electronic Remote Blood Delivery (ERBD) between blood bank and operating room staff. The results of the survey revealed a significant correlation between attitudes and usage of technology and ERBD acceptance and usability scores ($p<.01$) as well as a significant effect of role on ERBD acceptance and usability scores ($p<.05$).

Introduction

Many technology interventions to improve healthcare safety and efficiency are the subject of research, formal evaluations studies, and assessments to understand impacts on work practice, efficiency and error. Such research is essential for new technologies that can be disruptive and that may have unintended consequences [1]. There is increasing evidence from evaluation studies of healthcare information technologies (HIT), such as computerized physician order entry systems (CPOE), that there are significant barriers to successful implementation of technology-based interventions [2,3]. Review of the literature on CPOE has revealed unanticipated effects on work behaviors of physicians and nurses that impact the success of integrating technology based interventions with existing work practices [4]. Increases in rates of certain errors, new kinds of error, and unanticipated negative impacts on communication and teamwork have been highlighted as possible negative outcomes of HIT. Researching possible negative outcomes with the aim of providing guidelines for design and implementation of HIT has become a priority.

One application of HIT that has not received the same attention as CPOE, for example, is HIT for transfusion medicine. Methods advocated for the reduction of error in transfusion medicine include technology interventions such as bar code technology and electronically controlled self-serve fridges (Electronic Remote Blood Delivery – ERBD). ERBD is proposed as a means to meet the information needs of blood banks, control blood inventories, and control the steps involved in blood delivery to patients during surgery - thereby reducing the risk of procedural errors. Although, errors in transfusion can originate at any point in the blood management and transfusion process, the majority of fatal errors have been attributed to procedural errors [5]. The introduction of ERBD as a patient safety practice is relatively recent. The process of adoption and adaptation after implementation has taken place is little understood. Within transfusion services it is recognized that differences in perspective between blood bank staff and nursing staff affect the adoption of safety practices or interventions [6]. This study was designed to investigate differences in technology acceptance and attitudes towards ERBD between blood bank and nursing staff (the effect of role), controlling for demographic effects and site effects.

Methodology

A multi-center mixed methods study was designed to research the implementation of ERBD. The implementation of three ERBD systems in close succession presented a unique opportunity for a natural or quasi-experiment to compare implementation of the same HIT intervention.

Site Selection

This study of technology acceptance was part of a larger mixed methods study that included a comparison of work patterns, near misses, blood wastage and blood utilization between existing methods of blood delivery and ERBD. Three hospitals in Canada were selected for inclusion in the study of ERBD implementation. The selection criteria included hospitals that were implementing the same ERBD within the same calendar year. Only 2 of three hospitals that were part of the larger study participated in this study on technology acceptance.

System

The Haemonetics BloodTrack® Self-serve System consists of a database and monitor at the blood bank/transfusion lab that is used to identify and track blood units and a remote fridge and kiosk that is located in the OR that dispenses blood units. When blood is needed in an OR a staff member approaches the fridge and identifies him/herself by scanning an ID badge. The kiosk system then prompts the staff member for information about the patient, the system identifies the blood type for that patient, and the fridge is unlocked. Once the unit is removed, the staff member scans the unit, and the system checks the unit type with the patient type (electronic cross-match). If the unit and patient types match correctly the system prints the patient label to be fixed to the blood unit. A safety check second scan of the label and unit is then carried out.

Instrument Selection and Procedures

A questionnaire set was compiled to investigate differences in perception and attitudes. To assess possible differences in technology readiness or acceptance among staff that might confound results for the acceptance of ERBD, a validated scale was selected that is sensitive to familiarity or frequency of use of technology and sensitive to differences in anxiety about technology and technology interest levels. The Technology Inventory Profile (TPI)[7] was specifically developed to be sensitive to these differences. For this study the example major construct items were used for a total of 14 items. Basic demographic data was collected to test for possible confounds identified with willingness to adopt new technology [8,9]. The IBM Computer Use and Satisfaction Questionnaire (IBM CUSQ) has been recommended for use in healthcare IT assessment [10] and there are several examples of its successful application [11,12,13]. This instrument was selected for this study to measure staff acceptance and usability of ERBD. IBM CUSQ includes items specifically addressing error, error recovery, as well as items addressing task efficiency. Participants were asked to assess items using a 7 point lickert scale.

The full set of questionnaires containing demographic, TPI, and CUSQ items was introduced to staff at normal weekly staff meetings by the blood bank manager at each site for blood bank/transfusion lab staff, and by the OR nurse manager and OR Educator at each site. The questionnaires were designed to be self-administered. Completed questionnaires were collected anonymously using a drop box in the OR and blood bank staff areas of each site. (The collection and analysis of data was consistent with the Human Subjects protocol approved by the Research Ethics Boards of the two hospitals that participated in this study).

Results

A total of 46 participants responded to the questionnaires (out of a total pool of approximately 400 eligible participants). At site 1, respondents included 10 anesthesiologists, 11 nursing staff, 8 blood bank staff, and 3 others. At site 2, respondents included 5 nursing staff, 7 blood bank staff, and 2 others. Demographic, TPI and IBM CUSQ responses were entered into SPSS. The Mann-Whitney U test was used to test for an effect of site. There was no significant effect of site on acceptance and attitude towards technology and ERBD measures. The data was pooled across sites for all subsequent analysis. A Kruskal-Wallis test was used to test for an effect of demographic measures. There were no significant effects on acceptance and attitude towards technology and ERBD acceptance usability measures.

Factor Analysis Technology Profile Inventory and Computer User Satisfaction – ERBD

Factor analysis using principal components analysis and varimax rotation was used to assess content validity and identify scale constructs for both technology profile inventory (TPI) scale items and Computer Usability and Satisfaction (CUSQ) scale items.

The factor analysis of TPI items suggested 2 factors explaining 36% and 22% of the variance respectively. The first factor clustered items that on attitudes towards technology and the second factor clustered items on usage of technology. Five items were not found to contribute to any one factor. Inter-item reliability analysis was used to determine the internal consistency. Attitude items had a Cronbach's Alpha of .908. The Usage items had a Cronbach's Alpha of .849. A factor analysis of CUSQ items using principal components analysis suggested 1 dominant factor and one other factor explaining 66% and 10% of the variance respectively. The first factor clustered items on support for use of ERBD, such as information and simplicity of the interface, and the second factor clustered items on the task of retrieving blood. Seven items were not found to contribute to any one factor. Inter-item reliability analysis was used to determine the internal consistency of each newly identified cluster of items (Support and Task). The Support items had a Cronbach's Alpha of .95. The Task items had a Cronbach's Alpha of .951. Two participant's data were removed prior to any analysis due to large amounts of missing data.

Technology Acceptance and ERBD

A Spearman's Rank Order correlation was run to determine the relationship between technology acceptance measures (Total TPI Score, TPI Attitude, TPI Usage) and ERBD acceptance usability measures (Total CUSQ Score, CUSQ Support, CUSQ Task). There was a significant positive correlation between technology acceptance and ERBD measures, (Total CUSQ Score $r_s(44) = .411$, P = .006, CUSQ Support $r_s(44) = .289$, P = .006, CUSQ Task $r_s(44) = .295$, P = .005). There were also significant positive correlations between TPI Attitude and all ERBD measures (Total CUSQ Score $r_s(44) = .421$, P = .004, CUSQ Support $r_s(44) = .475$, P = .001, CUSQ Task $r_s(44) = .354$, P = .018). There were marginally statistically significant positive correlations between TPI Usage and two ERBD measures (Total CUSQ Score $r_s(44) = .301$, P = .047, CUSQ Task $r_s(44) = .344$, P = .022).

Role, Technology Acceptance, and ERBD

A Kruskal-Wallis test was used to test for an effect of role (anesthesiology, nursing, blood bank) on acceptance and attitude towards technology and ERBD acceptance and usability measures. There was no significant effect of role on acceptance and attitude towards technology but there was a significant effect of role on ERBD acceptance and usability measures (Total CUSQ Score ($H(3) = 14.132$, $P = 0.003$), CUSQ Support ($H(3) = 11.045$, $P = 0.011$), CUSQ Task ($H(3) = 15.367$, $P = 0.003$). A K-means cluster analysis was performed using 3 clusters, Total TPI and Total CUSQ scores. A chi-squared analysis was used to test for an effect of role on cluster groups, the effect of role was significant ($\chi^2(8)= 22.21$, $P = 0.005$). The effect size was .710.

Cluster membership by role (Table 1) indicates that blood bank staff have the highest technology acceptance and ERBD acceptance and usability scores. Nursing staff span two clusters but the majority are members of cluster 1 (moderate technology acceptance-moderate ERBD acceptance and usability scores). Anesthesiology spans both cluster 1 and 2.

Table 1. Mean Cluster Scores.

Measure	Cluster 1 (n=14)	Cluster 2 (n=23)	Cluster 3 (n=7)
Mean New Process Total CUSQ Score (F=4.51)	87.24	114.3	56.76
Mean TPI Score (F=148.62)	60.18	62.6	54.20
Mean Usage	3.48	3.56	2.88
Mean Attitude	5.7	5.99	5.31
Mean Support	4.89	6.06	3.16
Mean Task	4.1	5.97	2.71

Table 2. Cluster membership by Role.

Role	Cluster 1 (n=14)	Cluster 2 (n=23)	Cluster 3 (n=7)
Nursing	8	3	3
Blood Bank	1	13	1
Anesthesiology	5	4	1
Other	0	3	2

Mean Attitude scores for clusters 1 and 2 are not markedly different (Table 2).

A plot of TPI and CUSQ scores organized by role (Figure 1) illustrates the interaction between role and TPI and CUSQ scores.

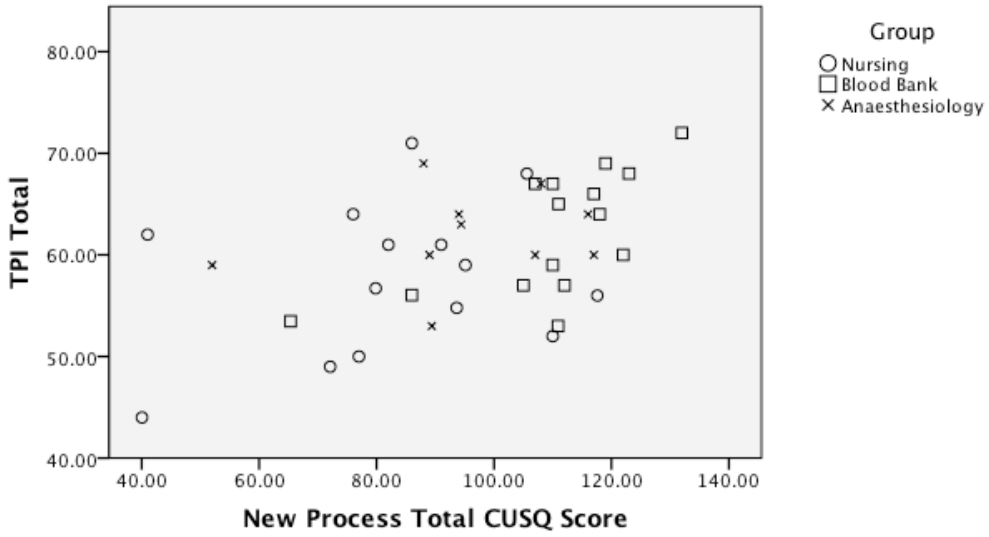

Figure 1. Plot of Total CUSQ by Total TPI Scores organized by role group (others excluded).

Discussion

Introducing interventions in transfusion management has been shown to depend on the attitudes of both blood bank staff and OR staff and, as has been discussed above, these two groups may not share the same perspectives or have the same needs [8,16]. The analysis above showed no association between role and general TPI scores or Attitude and Usage factors. However, there was a strong association between role and ERBD acceptance and usability scores, both for Support and especially for Task related factors. This suggests that for ERBD acceptance and usability, particular attention should be paid to supporting the needs of individual roles at the same time as addressing general attitudes towards technology (which were generally positive across roles (see Table 1 above).

The factor analysis of TPI items indicated that only two factors were being measured by TPI, attitudes and usage. We might expect that usage would have an equal if not bigger influence on acceptance and usability scores for ERBD, since higher usage scores would indicate familiarity with using technology generally, experience of using touchscreens, for example, or familiarity with other aspects of the design of the ERBD system. It might be expected then, that the Usage factor would be closer conceptually to the CUSQ Task factor. Usage was correlated with CUSQ scores and CUSQ Task factor scores, supporting this link. Attitudes to technology, however, were significantly positively correlated with every ERBD acceptance and usability measure. Attitude seems to have a much stronger relationship with acceptance of ERBD both for factors relating to support for using ERBD, and, for how well respondents were able to use ERBD to complete their task. The fact that there is no relationship between role and Attitude suggests that for some roles (nursing and anesthesiology) range in Attitude and Usage may be influencing ERBD acceptance and usability. Nursing, in particular, has a wider range of cluster membership, for example. The majority of nursing staff are moderately accepting of technology and of ERBD.

A small minority is highly accepting of technology and ERBD, and a minority is not as accepting of technology or positive towards their experience of ERBD. It is membership of cluster 3 that is of concern and these results suggest implementation efforts should include support for staff with lower familiarity and use of technology at work.

Other studies of technology acceptance indicate that demographic factors often influence results [8,9]. This study shows that demographic differences did not influence the acceptance and usability scores for ERBD nor did they influence scores for general technology acceptance levels. This suggests that the results of this study apply to the work setting specifically and are not influenced greatly be external use of familiarity with technology. Although, there were slight differences in the implementation of ERBD at each site, site did not influence acceptance and usability scores for ERBD. We might expect to see the effect of different work practices at the two sites reflected in the data on Task scores (items relating to completing the task of retrieving blood) between sites. No such association may indicate that the questionnaire was indeed measuring factors relating to ERBD and was not inadvertently measuring other situational factors. This study is limited to quantitative measures of acceptance and the response rate was relatively low. Qualitative methods will be needed to research the relationships and conclusions discussed.

Conclusion

This study of ERBD implementation reveals a pattern of technology and ERBD acceptance that is associated with attitudes towards technology and role, supporting the observations of other researchers. However, this study also suggests that some roles, nursing in particular, will have a range of attitudes and familiarity with technology in the work setting that may require special support in order to maximize acceptance and usability scores.

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