ORIGINAL RESEARCH

Evaluation and refinement of a handheld health information technology tool to support the timely update of bedside visual cues to prevent falls in hospitals

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ABSTRACT

Aim: To evaluate clinicians' perspectives, before and after clinical implementation (i.e. trial) of a handheld health information technology (HIT) tool, incorporating an iPad device and automatically generated visual cues for bedside display, for falls risk assessment and prevention in hospital.

Methods: This pilot study utilized mixed-methods research with focus group discussions and Likert-scale surveys to elicit clinicians' attitudes. The study was conducted across three phases within two medical wards of the Queen Elizabeth Hospital. Phase 1 (pretrial) involved focus group discussion (five staff) and surveys (48 staff) to elicit preliminary perspectives on tool use, benefits and barriers to use and recommendations for improvement. Phase 2 (tool trial) involved HIT tool implementation on two hospital wards over consecutive 12-week periods. Phase 3 (post-trial) involved focus group discussion (five staff) and surveys (29 staff) following tool implementation, with similar themes as in Phase 1. Qualitative data were evaluated using content analysis, and quantitative data using descriptive statistics and logistic regression analysis, with subgroup analyses on user status ($P \leq 0.05$).

Results: Four findings emerged on clinicians' experience, positive perceptions, negative perceptions and recommendations for improvement of the tool. Pretrial, clinicians were familiar with using visual cues in hospital falls prevention. They identified potential benefits of the HIT tool in obtaining timely, useful falls risk assessment to improve patient care. During the trial, the wards differed in methods of tool implementation, resulting in lower uptake by clinicians on the subacute ward. Post-trial, clinicians remained supportive for incorporating the tool into clinical practice; however, there were issues with usability and lack of time for tool use. Staff who had not used the tool had less appreciation for it improving their understanding of patients' falls risk factors (odds ratio 0.12), or effectively preventing hospital falls (odds ratio 0.12). Clinicians' recommendations resulted in subsequent technological refinement of the tool, and provision of an additional iPad device for more efficient use.

Conclusion: This study adds to the limited pool of knowledge about clinicians' attitudes toward health technology use in falls avoidance. Clinicians were willing to use the HIT tool, and their concerns about its usability were addressed in ongoing tool improvement. Including end-users in the development and refinement processes, as well as having high staff uptake of new technologies, is important in improving their acceptance and usage, and in maximizing beneficial feedback to further inform tool development.

Key words: falls prevention, health information technology, mixed-methods, perspectives

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Background

Falls are the seventh most common cause of hospital-acquired injury[1] and are more prevalent among older persons.[2,3] Despite the introduction of mandatory

hospital falls risk assessment and prevention strategies as a healthcare priority, the incidence of inpatient falls continues to rise by 2% each year.[3–5] Overall, the reported incidence of falls in hospital varies widely from 2–3 (acute setting) to 46% (rehabilitation setting).[6,7] Falls are more prevalent in medical compared with surgical wards,[8] in public compared with private hospitals (4.2 vs. 1.6 per 1000 hospitalizations), and among patients living in major cities compared with remote areas (3.4 vs. 1.9 per 1000 hospitalizations).[9] Actual fall rates are likely to even be higher as there is no universal definition for a fall, and falls incidents tend to be under-reported.[10]

Hospital falls tend to cause serious complications, with 44–60% resulting in harm,[11,12] especially among older persons.[13] The 6-PACK trial (2011–2013) in six Australian hospitals demonstrated that hospital falls increased length of stay (LOS) by 8 days [95% confidence interval (CI) 5.8–10.4, $P < 0.001$], and hospital costs by AU$6669 (95% CI $3888–9450, $P < 0.001$), even after adjusting for age, sex, cognitive impairment, comorbidities and admission type.[14] Older persons who sustain hip fractures in hospital have poorer outcomes compared with their peers who sustain hip fractures in the community,[15] including longer LOS,[16] reduced return to preadmission ambulation and functional status, increased rates of discharge to permanent residential care[15] and higher mortality rates.[16] Indeed, falls may lead to chronic pain, reduced quality of life, functional impairment, permanent disability and higher rates of inpatient mortality.[13,17,18]

Health technology has the potential to influence this outcome but has been limited by the lack of rigorous evidence for effective single-technology interventions, including sensors and electronic medical records.[19] Moreover, clinicians' perspectives toward the use of health technology in falls prevention are not well-known, despite systematic review evidence that staff attitudes are crucial to successfully integrating any falls preventive strategy.[19,20]

Nursing staff are familiar with using visual cues to communicate falls risk and preventive strategies.[21] Visual cues, as part of a Falls Prevention Tool Kit, have been shown in a single randomized controlled trial to be effective in lowering hospital falls rate (3.15 vs. 4.18 per 1000 patient-days; $P = 0.04$), especially among those aged 65 years and over (rate difference 2.08 vs. 1.03 per 1000 patient-days; $P = 0.03$).[22] However, further research was needed into whether such findings could be replicated in different settings. Within the Geriatric and Evaluation (GEM) unit at the Queen Elizabeth Hospital (TQEH), a preliminary audit found 20% staff compliance with existing patient bedside posters for falls prevention (Fig. 1; Visvanathan R, Ranasinghe D, Hoskins S, Wood J, Mahajan N, unpublished data). Nursing staff reported these paper-based posters were time-consuming and hence not completed, as they involved placing adhesive colored dots on eight different locations of the poster to indicate falls risk (i.e. green for low risk, yellow for medium risk, red for high risk), before displaying the poster by the patient's bedside (Visvanathan R, Ranasinghe D, Hoskins S, Wood J, Mahajan N, unpublished data). Due to poor uptake and negative feedback of the existing posters, and mindful of the pending electronic health record (EHR) system due to roll out across public hospitals statewide in South Australia, the opportunity was seized to develop a health information technology (HIT) tool in collaboration with ward clinicians. This HIT tool incorporated an iPad 2 device (model number A1315; Apple, Cupertino, California, USA) for direct clinicians' entry of up to 13 common falls risk activities[23] (Fig. 2), with automatic generation of visual cues for bedside display (Fig. 3).

Our pilot study aimed to evaluate clinicians' attitudes toward this HIT tool, in particular, their experiences, positive and negative perspectives and recommendations for improvement, both preclinical and postclinical implementation (i.e. trial), to inform ongoing tool refinement, ultimately as part of a novel movement-detection sensor technology system for hospital falls prevention.

Methods

Ethics approval

The study protocol was approved by the Human Research Ethics Committee of the Basil Hetzel Institute, South Australia (HREC/13/TQEHLMH/66), and conformed to the World Medical Association Declaration of Helsinki.[24] Each participant provided written, informed consent prior to research involvement, and participant information was deidentified.

Research methodology

Mixed methods design was applied to allow for greater robustness and richness of information gathered,[25,26] with focus group research used to obtain qualitative data simultaneously from multiple individuals on different ideas and perspectives.[27]

Study protocol

The current pilot study was divided into three phases. Phase 1 (pretrial) evaluated clinicians' perspectives on the HIT tool (i.e. study aims) prior to implementation, using focus group discussion and surveys. Phase 2 (tool trial) involved tool implementation on hospital wards. Phase 3 (post-trial) examined clinicians' perspectives on

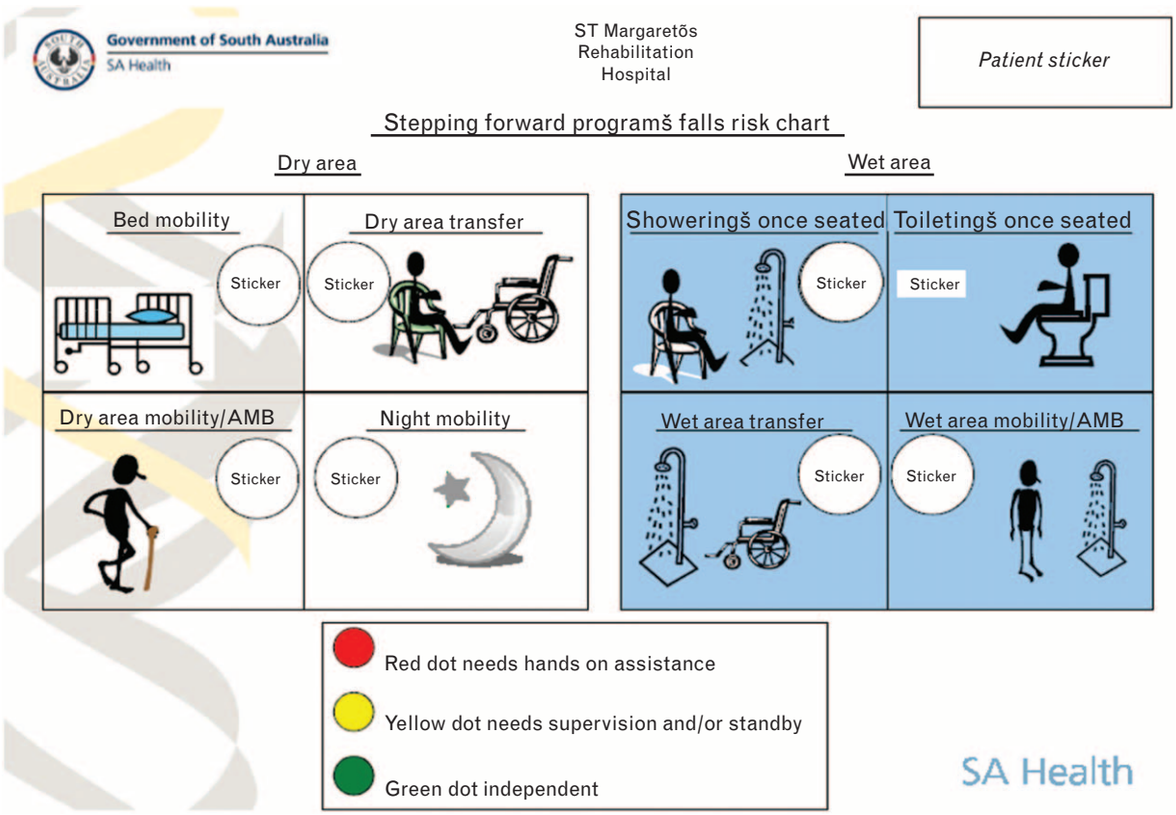

Figure 1. Example of a paper-based bedside poster using colored stick-on dots to indicate patient's falls risk.

the tool after trial completion, using focus group discussion and surveys with similar themes as in Phase 1.

Focus group sessions were led by the chief researcher, who was employed by TQEH as a medical doctor, but not working on the wards at the time of the study. The chief researcher defined focus group goals (i.e. study aims) at each session and facilitated discussion for an hour or until data saturation was reached (i.e. when information occurred so repeatedly that additional data collection had no additional worth).[28] Textual data were transcribed verbatim by the chief researcher from Dictaphone (Philips PocketMemo voice recorder DPM8000; Atlanta, Georgia, USA) recordings and written notes. Transcripts were not returned to participants for comment.

Likert-scale surveys were derived following focus group discussion and utilized similar themes. These were distributed to ward staff over 2 week periods, before and after the tool trial, by the chief researcher and two ward clinical nurse consultants (CNCs), who were considered nursing leaders and experts in clinical care.[29] Completed nonidentifiable questionnaires were returned to the researcher personally or via a designated tray on the wards.

The HIT tool was implemented on the GEM unit (June to August 2014), followed by the Acute Medical Unit (AMU) (September to November 2014), over two consecutive 12-week periods. Ward clinicians had up to 6 weeks of researcher training and reminders on tool use (3-h-long sessions each week) and were independent for the remaining 6 weeks. GEM staff utilized the full period of researcher-led support, whereas AMU staff declined researcher input after 1 day, citing staff confidence with tool use.

The HIT tool took less than 5 min to use for each patient. There was no automatic trigger for staff to use the tool, other than reminders from the researcher in the first 6 weeks. The iPad device was carried by the clinician responsible for using the tool. This person directly entered patient's details (age, bed location, mobility aid) and their own clinical judgment (yes/no responses) about the patient's day and nighttime falls risk for 13 different movement and location types (Fig. 2).

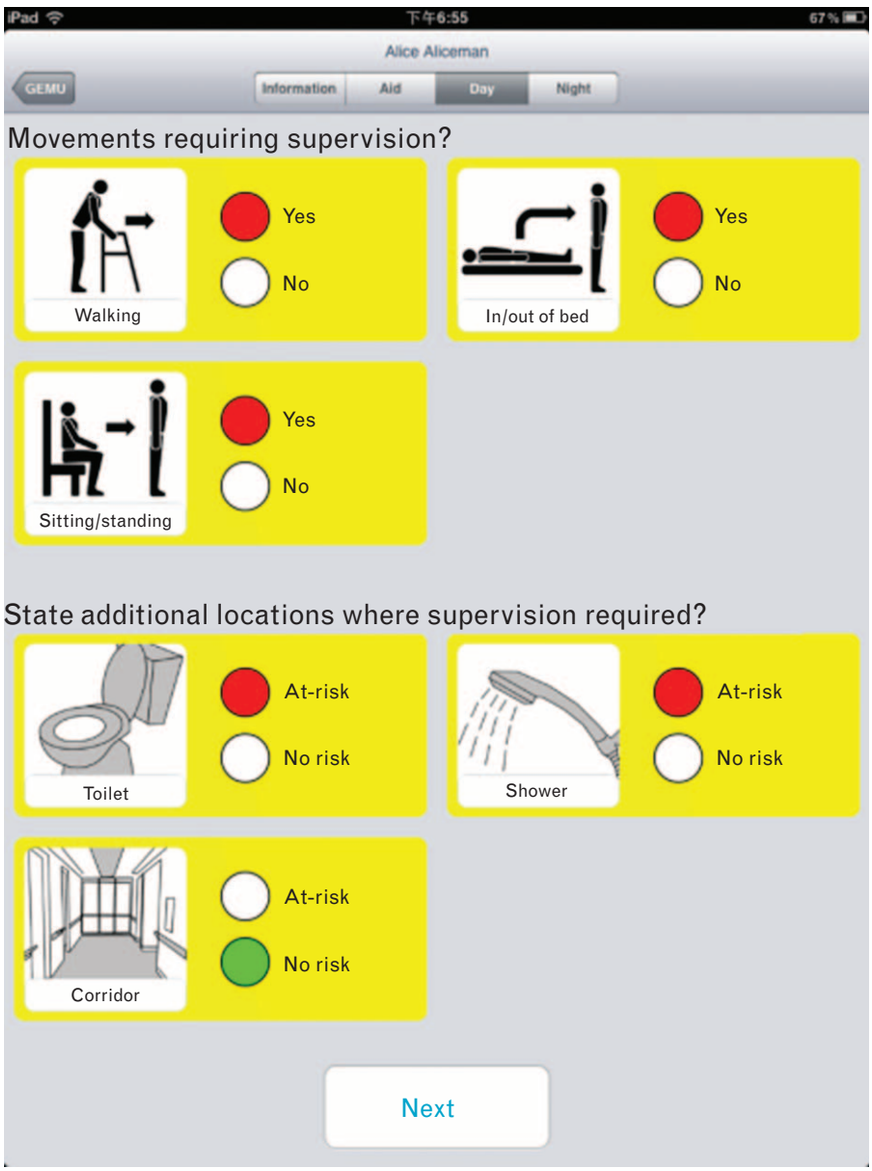

Figure 2. Example of a screenshot of direct clinician entry of patient's falls risk assessment using the health information technology tool.

Black-and-white A4-sized visual cues were automatically printed at assessment completion (Fig. 3), and the same clinician was responsible for displaying these paper-based visual cues by the patient's bedside. Ward staff subsequently targeted falls preventive interventions according to clinical judgment.

Both wards were given freedom on how to implement the HIT tool. AMU staff used the tool daily on all ward patients. All registered nurses on AMU were rotated to use the tool, which was usually completed by the registered nurse allocated to nonpatient-related duties (e.g. ward medication management), to allow for timely use of the HIT tool, unencumbered by other duties. GEM staff used the tool on new admissions and in which falls risk altered (e.g. posthospital fall), reasoning this as appropriate for a subacute setting, in which patients' falls risk changed less often compared with an acute ward. The CNC and two registered nurses from GEM used the HIT tool, due to limited confidence by the rest of the staff in using the device.

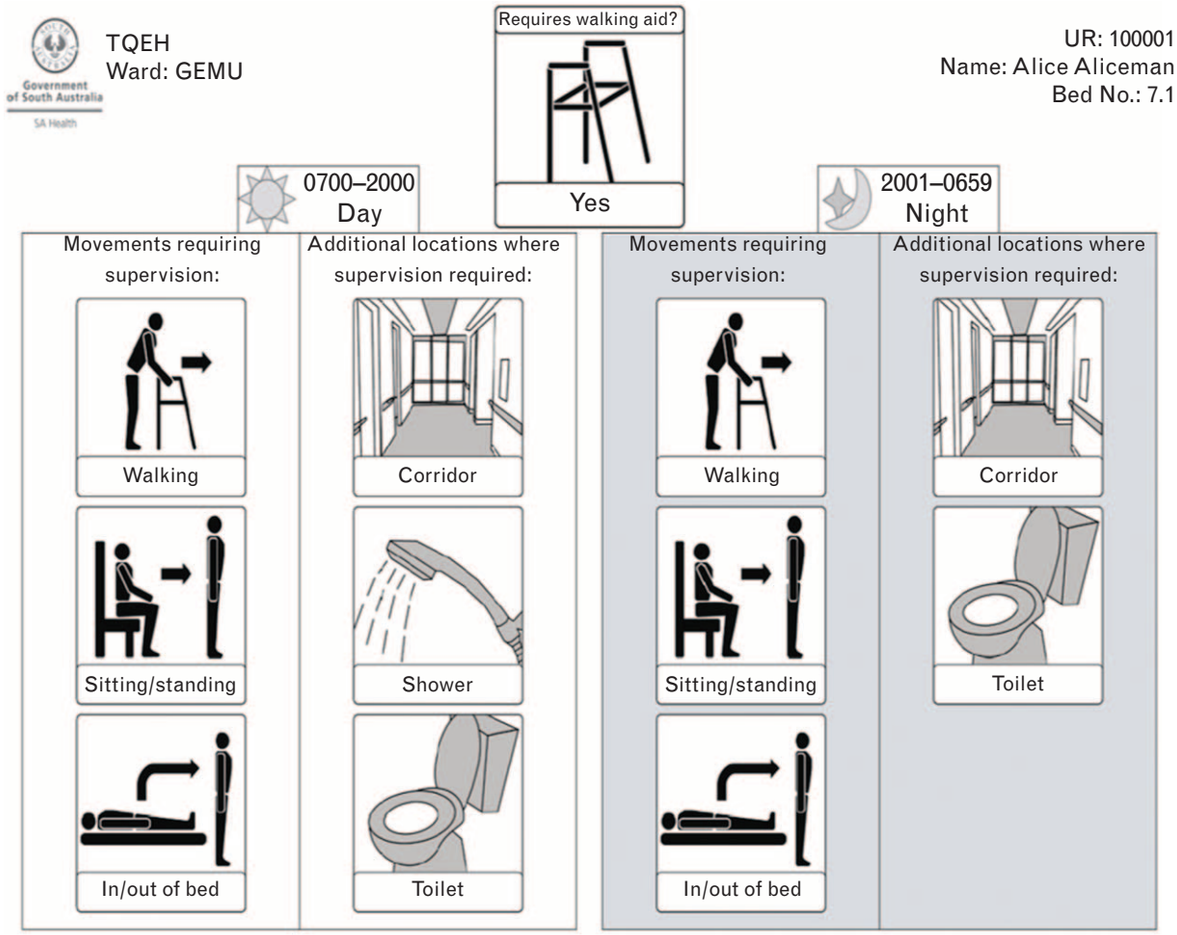

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Figure 3. Example of an automatically generated visual cue from the health information technology tool.

Setting and participants

The study was conducted on two ground-floor medical wards at TQEH, a tertiary teaching hospital in metropolitan Adelaide, South Australia. The 16-bed AMU managed patients in the acute phase of illness, whereas the 20-bed GEM unit provided rehabilitative care aimed at restoring patients' function and independence after an acute illness, usually with the goal of returning back home.[30]

Ward clinicians consisted of nursing [38.68 FTE (full-time equivalent) GEM, 32 FTE AMU], junior medical (four FTE GEM, five FTE AMU), and allied health staff, meaning occupational and physical therapists (2.5 FTE GEM, two FTE AMU). No pharmacists, speech therapists, dieticians, social workers or senior medical staff were approached to be part of this study.

Focus group participants were identified by ward CNCs as clinicians having an expertise in falls prevention, with greater than 5 years of clinical experience, and working within GEM, AMU or the Central Adelaide Local Health Network (CALHN) Falls Prevention group at the time of the study. Five clinicians were involved in each pretrial and post-trial focus group discussion, with one participant involved on both occasions. All five post-trial focus group participants were HIT tool users from AMU, with six clinicians from GEM and CALHN declining to participate as they had not used the tool or were unable to attend the focus group session.

Survey participants consisted of clinicians working within GEM or AMU at the time of the study, and consecutively approached by the chief researcher in the 2-week periods, before and after the tool trial. There were 49 pretrial (29 GEM, 20 AMU) and 28 post-trial (20 GEM, eight AMU) participants. It was not recorded which participants were involved both pretrial and post-trial.

Post-trial, both those who had used the HIT tool (i.e. tool users, $n = 11$) and those who had not (i.e. nonusers, $n = 17$), were included to reflect tool uptake. Post-trial, 54 clinicians (65.9%) declined to participate as they had no experience with or recommendations for improving the HIT tool. Participation was voluntary with the option to withdraw at any point.

Analysis

Qualitative data from focus group sessions were manually analyzed using content analysis to systematically code data and identify themes, to gain new knowledge and initiate action.[31,32] Descriptive statistics and logistic regression were performed on quantitative survey data, to describe and evaluate differences between clinicians' perspectives pretrial and post-trial ($P < 0.05$), with subgroup analysis on users and nonusers using SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, New York, USA). Responses indicating 'strongly agree' or 'agree' were classified as positive, whereas those indicating 'strongly disagree', 'disagree' or 'uncertain' were classified as negative responses to the item statement.

Results

The qualitative and quantitative data were integrated into four main findings, and presented from Phase 1 (pretrial), followed by Phase 3 (post-trial), regarding clinicians' experience, positive perceptions, negative perceptions and barriers to use, and recommendations for refinement of the HIT tool.

Phase 1 (pretrial): Qualitative results from focus group session

Clinicians' experience

Pretrial, no participant had used the HIT tool. All participants were familiar with using visual cues in falls prevention, with four participants expressing negative views about the existing posters using colored stick-on dots to indicate falls risk. These were seen as *a bit complicated,* tedious to complete, ineffective and therefore, underutilized, due to time constraints with high patient turnover and competing clinical duties.

Positive perceptions

Incorporating technology into falls risk assessment was identified by three participants as beneficial in providing staff with a fun, quick means of risk assessment. One participant stated the HIT tool would serve as *a stress reduction tool* for staff, in providing *an immediate visual* of each patient's falls risk factors. Four participants cited benefits to patients and their families in increasing knowledge on falls risk and preventive strategies, both in hospital and on discharge.

Negative perceptions and barriers to use

Clinicians perceived the main barrier to tool implementation to be shifting a workplace culture that resisted change and did not view hospital falls as a problem. The HIT tool was seen as increasing work for clinicians, with time pressures on staff thought to compromise accuracy of falls risk assessment and placement of visual cues at the correct patient's bedside. Three participants expressed apprehension about clinicians using new health technology, with one participant especially concerned about older workers and technology use.

Recommendations for refinement

Three participants requested tool technology be simple to use, and eventually incorporated into the upcoming EHR system. They recommended providing staff with tool education, with training attendance linked to points for continuous professional development (CPD). CPD referred to the number of hours stipulated by national registration standards for clinicians to engage in ongoing professional education per annum.[33] Four participants suggested involving patients and families in the tool process, to improve adherence to falls preventive measures in hospital and at home. One participant advocated senior leadership endorsement to drive tool integration into hospital programs.

Phase 1 (pretrial): Quantitative results from survey participants

The majority of survey participants were women (81.6%), nursing staff (73.4%), aged between 18 and 39 years old (63.3%) and had 10 years or less of experience in clinical care (57.1%).

Clinicians' experience

No participants had used the HIT tool pretrial.

Positive perceptions

The majority perceived the HIT tool as an easy, accurate and timely means of assessing patients' falls risk (items 1, 2 and 3, Table 1). Over 70% thought it facilitated safer, better quality patient care, improved staff's understanding of patients' falls risk factors, effectively prevented falls, and were willing to use the tool if made available (items 4, 5, 6, 8 and 9). Half the participants cited that it would effectively prevent inpatient falls (item 7).

Negative perceptions and barriers to use

Less than half the participants considered potential barriers to tool use as being duplication of written work (44.9%), lack of time to use the tool (38.8%) and lack of

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IJEBH-D-17-00030

Table 1. Comparison between pretrial and post-trial results of clinicians' perspectives of the health information technology tool, with subgroup analyses for user status

		Post-trial						
	Pretrial, n = 49 (%)	Total, n = 28 (%)	Users, n = 11 (%)	Nonusers, n = 17 (%)	Preusers vs. postusers	Prenonusers vs. postnonusers	Pre vs. post (users + nonusers)	Postusers vs. postnonusers
Benefits of HIT tool use					OR	OR	OR	OR
Easy to use during bed to bed handover	39 (75%)	13 (46.4%)	6 (54.5%)	7 (41.2%)	0.22*	0.13*	0.16*	0.58
More accurate updating falls risk information *cf.* current method	37 (75.5%)	17 (60.7%)	7 (63.6%)	10 (58.8%)	0.57	0.54	0.55	0.95
Updates falls risk information in a timely manner	36 (73.5%)	17 (60.7%)	8 (72.7%)	9 (52.9%)	0.89	0.43	0.62	0.48
Provides safer care for patients at risk of falls	39 (79.6%)	19 (67.9%)	9 (81.8%)	10 (58.8%)	1.15	0.43	0.70	0.37
Improves quality of patient care	43 (87.8%)	19 (67.9%)	9 (81.8%)	10 (58.8%)	0.63	0.23*	0.38	0.37
Improves staff's understanding of patients' falls risk factors	35 (71.4%)	12 (42.9%)	8 (72.7%)	4 (23.5%)	1.07	0.12*	0.36	0.12*
Effectively prevents falls	26 (53.1%)	7 (25%)	5 (45.5%)	2 (11.8%)	0.74	0.12*	0.29*	0.16
Allows more time for staff to attend to other duties	7 (14.3%)	3 (10.7%)	2 (18.2%)	1 (5.9%)	1.33	0.38	0.71	0.28
I will use this tool if it is made available	44 (89.8%)	21 (75%)	10 (90.9%)	11 (64.7%)	1.14	0.25	0.53	0.22
Barriers to implementing HIT tool								
Lack of time	19 (38.8%)	11 (39.3%)	6 (54.5%)	5 (29.4%)	1.90	0.66	1.11	0.35
Lack of familiarity with technology	14 (28.6%)	5 (17.9%)	3 (27.3%)	2 (11.8%)	0.94	0.33	0.56	0.36
Duplicates written work	22 (44.9%)	4 (14.3%)	3 (27.3%)	1 (5.9%)	0.46	0.08*	0.19*	0.17
Lack of usability	0 (0%)	6 (21.4%)	1 (9.1%)	5 (29.4%)	>100	>100	Undefined	4.17
Suggested tool improvements								
Providing tool feedback to staff	31 (63.3%)	4 (14.3%)	4 (36.4%)	0 (0%)	0.33	0.00	<0.01	<0.01
Providing educational presentations on tool to staff	19 (38.8%)	9 (32.1%)	8 (72.3%)	1 (5.9%)	4.21	0.10*	0.65	0.02*
Awarding CPD points to staff for attending tool education	15 (30.6%)	3 (10.7%)	3 (27.3%)	0 (0%)	0.85	0.00	<0.01	<0.01

cf., compared with; CPD, continuous professional development; HIT, health information technology; OR, odds ratio.
*$P \leq 0.05$, i.e. significant.

familiarity with tool technology (28.6%) (items 10, 11 and 12). No participants perceived the HIT tool as lacking usability (item 13).

Recommendations for refinement

Over 60% recommended providing regular feedback to clinicians to improve tool uptake (item 14, Table 1). A third felt regular staff education on tool use and awarding of CPD points for training attendance would help foster HIT tool use (items 14, 15 and 16)

Phase 3 (post-trial): Qualitative findings from focus group session

Clinicians' experience

Post-trial, all focus group participants had used the HIT tool. Participants A (tool use >10 times) and B (tool use 1–2 times) were the most verbal during discussion.

Positive perceptions

All participants were positive about the tool's benefits and wanted to continue using it after trial completion. It was perceived as beneficial to staff in being a visually appealing and useful *snapshot* of patients' falls risks. Participants A and B cited its benefit to patients and families as a teaching tool for falls risk and preventive strategies.

Negative perceptions and barriers to use

Competing clinical duties and time pressures on a busy ward were seen as barriers to tool use. One participant outlined these barriers extended to challenges ensuring visual cues were physically moved when patients were swapped into another bed. Participants A and B reported difficulties with technical aspects of the iPad application, including difficulties managing these bed swaps and surplus patient numbers, and re-entering the same medical record number and demographic details for returned patients.

Recommendations for refinement

Participants debated and decided against displaying extra falls risk information on visual cues, preferring to keep these uncluttered for simplicity and visual appeal. Having A4-sized black-and-white visual cues, as opposed to larger colored posters, was seen as appropriate given already cluttered bedside walls and ongoing printing costs. Participant B recommended coding high falls risk status as a red dot on visual cues, with an automatic trigger for staff to provide patients with printed information on falls prevention. Participants A and B requested an extra iPad device for more efficient and timely tool use.

Phase 3 (post-trial): Quantitative findings from survey participants

Post-trial, survey participants were mainly women (85.7%), nurses (92.9%), and had 10 years or less of clinical experience (67.8%). Half were aged between 18 and 39 years old (50%). More than half ($n = 54$, 65.9%) of ward clinicians declined to participate, citing lack of use of, or recommendations for improving, the HIT tool.

Clinicians' experience

Of the 28 participants surveyed, 11 [eight (100%) AMU, three (15%) GEM] had used the HIT tool on researcher questioning. Most survey participants (60.7%) had not used the tool, mainly due to low uptake on GEM unit.

Positive perceptions

The majority of participants advocated ongoing use of the HIT tool in clinical practice (75%) and were positive about its accuracy, timeliness and facilitation of safer patient care (items 2, 3, 4 and 9, Table 1). Compared with pretrial, there were significantly lower numbers of nonusers who thought the tool was easy to use [odds ratio (OR) 0.13], improved quality of patient care (OR 0.23) or informed staff's understanding of patients' falls risk factors (OR 0.12) post-trial (items 1, 5 and 6, Table 1).

Negative perceptions and barriers to use

Participants identified the main barriers to tool use as lack of time to complete the tool (39.3%) and lack of tool usability (21.4%) (items 10 and 13, Table 1). Significantly, fewer participants thought duplication of written work was a barrier, post-trial vs. pretrial (OR 0.19, item 12).

Recommendations for refinement

The main recommendation for improvement was for staff education on the HIT tool (32.1%); however, this was less so among nonusers compared with users (OR 0.02, item 15, Table 1).

Discussion

The majority of clinicians advocated incorporating the HIT tool in clinical practice, both pretrial and post-trial, due to the benefits for staff and patients in hospital falls risk assessment and prevention. Pretrial, clinicians were positive about using a tool that incorporated visual cues and health technology, both well accepted methods of evaluating risk and preventing falls within literature.[20,34] Post-trial, most clinicians continued to view the HIT tool as useful to staff as an accurate, quick and timely means of assessing patients' falls risk. Indeed ease of workflow has been identified by clinicians as an advantage of

incorporating EHR into clinical routine.[35] Clinicians within this study cited benefits to patients in facilitating safer, better quality care and increasing their knowledge of and participation in falls preventive strategies. This echoes previous research espousing the advantages of technology in promoting patient and family education and engagement in health care.[35]

Pretrial, clinicians were concerned about potential barriers to tool use being duplication of existing paperwork, lack of time for tool use, difficulties navigating new technology and workplace resistance to change. Paperwork duplication and time constraints are well documented barriers to clinicians using EHRs.[36,37] Systematic review evidence has shown technical concerns and opposition to change are frequently cited barriers to EHR adoption.[38] Addressing nihilistic staff attitudes and workplace resistance to change have proved important in the success of many hospital falls prevention programs.[20,39,40]

Post-trial, clinicians criticized the HIT tool in terms of lack of usability, lack of time to use it amidst competing clinical duties and lack of clinical effectiveness in preventing inpatient falls. Usability has been shown to be a key factor in determining user acceptance of health technology.[41,42] Software difficulties are known barriers to using technology in falls prevention programs,[20,43] with users often requesting increasingly sophisticated software function over time.[44] Similar to our findings, a previous qualitative study found clinicians viewed EHRs negatively as *one more thing to do* in an already overburdened healthcare system, felt time constraints limited their use and wanted technology to accommodate heavy patient volumes and busy clinical workloads.[45]

The perceived barriers of lack of usability and time to use the tool were reflected in clinicians' recommendations for technological refinement of the iPad application and provision of another iPad device for more efficient tool completion. User engagement and feedback have been used to refine the HIT tool as part of action research methodology,[46–48] by improving technology, color coding falls risk, having an automated patient education trigger and providing an additional iPad device. Other recommendations for improving tool uptake included providing staff education, a key component of many effective hospital falls prevention programs,[20] and ensuring leadership endorsement, an important factor in sustaining best nursing practice.[49]

Strengths and limitations

Despite user attitudes being a major factor in intervention uptake,[20] there remains a gap in knowledge on staff perspectives of health technology use in falls assessment and prevention.[19] This article adds to the depth and richness of understanding of this area, through the employment of mixed-methods design.[50] Research limitations included small sample size, single hospital setting, poor response rate, lack of consistency in participant follow-up and incomplete data on which participants took the survey on both occasions and how many times they had used the tool. Sample sizes and withdrawal rates within this pilot study, were influenced by the pragmatics of recruitment and the need to assess study feasibility.[51] In addition, items developed for survey data collection (based on interviews with five focus group participants) may not have been representative of all relevant issues. These survey biases may limit generalizability of outcomes and comparison of pretrial and post-trial results. Additional biases may have been introduced by focus group participants' reluctance to provide their opinions, due to researcher presence and concerns about workplace implications, and researcher bias in interpreting textual responses to match preconceived notions.

Future research directions

The refined HIT tool will be retrialed on the wards, with future research directed at evaluating clinicians' use and perspectives, and clinical effectiveness in falls avoidance, of this improved HIT tool. The HIT tool could be implemented in healthcare facilities with high prevalence of falls, and among those patients who are at high falls risk, such as older persons and those in residential care. Ensuring the same clinicians participate in pretrial and post-trial focus group discussions and surveys would enhance the robustness of data gathered. In addition, greater depth of information may be elicited by including patients and caregivers in discussion, conducting personal interviews and discussing one topic per focus group session.

Conclusion

The findings from this study contributed to the limited pool of evidence on clinicians' perspectives toward health technology use in falls prevention. Clinicians were willing to use the HIT tool, identifying benefits to themselves and patients. Their concerns about usability and time constraints were addressed in ongoing tool refinement, with technological improvement and provision of an additional iPad device for more efficient use. Including end-users in development processes, as well as having high staff uptake, are important in improving the acceptance and usage of new technologies, and in maximizing beneficial feedback to further inform tool development. Further research directions may include

evaluating clinicians' and patients' perspectives of the refined HIT tool, and evaluating its clinical effectiveness in hospital falls prevention.

Acknowledgements

Conflicts of interest

The authors report no conflicts of interest.

References

1. Australian Institute of Health and Welfare. Australian hospital statistics 2012–13. Health services series no. 54. Cat. no. HSE 145. Canberra: AIHW; 2014.
2. Lord S, Sherrington C, Menz H. Falls in older people: risk factors and strategies for prevention Sydney: Cambridge University Press; 2001.
3. Bradley C. Hospitalisations due to falls by older people, Australia 2009–10. Injury research and statistics series. Canberra: AIHW; 2013.
4. Moller J. Patterns of fall injury in an ageing population in South Australia: a challenge for prevention and care Flagstaff Hill: New Directions in Health and Safety; 2003.
5. Rutledge D, Donaldson N, Pravikoff D. Update 2003: fall risk assessment and prevention in hospitalized patients. *J Clin Innovat* 2003; 6: 1–55.
6. Department of Health and Ageing. An analysis of research on preventing falls and falls injury in older people: community, residential care and hospital settings Canberra: Australian Government; 2004.
7. Halm M, Quigley P. Reducing falls and fall-related injuries in acutely and critically ill patients. *Am J Crit Care* 2011; 20: 480–4.
8. Staggs V, Dunton N. Associations between rates of unassisted inpatient falls and levels of registered and non-registered nurse staffing. *Int J Qual Health Care* 2014; 26: 87–92.
9. Australian Institute of Health and Welfare. Admitted patient care 2014–15: Australian hospital statistics Canberra: AIHW; 2016.
10. Shorr RI, Mion LC, Chandler AM, *et al*. Improving the capture of fall events in hospitals: combining a service for evaluating inpatient falls with an incident report system. *J Am Geriatr Soc* 2008; 56: 701–4.
11. Cumming R, Sherrington C, Lord S, *et al*. Cluster randomised trial of a targeted multifactorial intervention to prevent falls among older people in hospital. *BMJ* 2008; 336: 758–60.
12. Barker A, Kamar J, Morton A, Berlowitz D. Bridging the gap between research and practice: review of a targeted hospital inpatient fall prevention programme. *Qual Saf Health Care* 2008; 18: 467–72.
13. Zhao Y, Kim H. Older adult inpatient falls in acute care hospitals: intrinsic, extrinsic, and environmental factors. *J Gerontol Nurs* 2015; 41: 29–43.
14. Morello R, Barker A, Watts J, *et al*. The extra resource burden of in-hospital falls: a cost of falls study. *Med J Aust* 2015; 203: 367.
15. Murray G, Cameron I, Cumming R. The consequences of falls in acute and subacute hospitals in Australia that cause proximal femoral fractures. *J Am Geriatr Soc* 2007; 55: 577–82.
16. Brand C, Sundararajan V. A 10-year cohort study of the burden and risk of in-hospital falls and fractures using routinely collected hospital data. *Qual Saf Health Care* 2010; 19: e51.
17. Kannus P, Khan K, Lord S. Preventing falls among elderly people in the hospital environment. *Med J Aust* 2006; 184: 372–3.
18. Kannus P, Sievanen H, Palvanen M, *et al*. Prevention of falls and consequent injuries in elderly people. *Lancet* 2005; 366: 1885–93.
19. Teh R, Mahajan N, Visvanathan R, Wilson A. Clinical effectiveness of and attitudes and beliefs of health professionals towards the use of health technology in falls prevention among older adults. *Int J Evid Based Healthc* 2015; 13: 213–23.
20. Miake-Lye I, Hempel S, Ganz D, Shekelle P. Inpatient fall prevention programs as a patient safety strategy: a systematic review. *Ann Intern Med* 2013; 158 (5 Pt 2): 390–6.
21. Dykes PC, Carroll DL, Hurley AC, *et al*. Why do patients in acute care hospitals fall? Can falls be prevented? *J Nurs Adm* 2009; 39: 299–304.
22. Dykes PC, Carroll DL, Hurley A, *et al*. Fall prevention in acute care hospitals: a randomized trial. *JAMA* 2010; 304: 1912–8.
23. Hitcho E, Krauss M, Birge S, *et al*. Characteristics and circumstances of falls in a hospital setting: a prospective analysis. *J Gen Intern Med* 2004; 19: 732–9.
24. World Medical Association. World Medical Association Declaration of Helsinki – ethical principles for medical research involving human subjects. 1964.
25. Morse J. Approaches to qualitative-quantitative methodological triangulation. *Nurs Res* 1991; 40: 120–3.
26. Johnson R, Onwuegbuzie A. Mixed methods research: a research paradigm whose time has come. *Educ Res* 2004; 33: 14–26.
27. Krueger R, Casey M. Focus groups: a practical guide for applied researchers. 3rd ed Thousand Oaks: SAGE; 2000.
28. Sandelowski M. Theoretical saturation. In: Given L, editor. *The SAGE encyclopedia of qualitative methods*. 1st ed. Thousand Oaks: SAGE, 2008;875–6.
29. Wilkes L, Luck L, O'Baugh J. The role of a clinical nurse consultant in an Australian Health District: a quantitative survey. *BMC Nurs* 2015; 14: 25.
30. South Australia Health. Terms of reference: SALHN (South Adelaide Local Health Network) Adelaide: Falls Prevention and Management Committee; 2014.
31. Krippendorff K. Content analysis: an introduction to its methodology. 2nd ed Newbury Park: SAGE; 1980.
32. Hsieh H, Shannon S. Three approaches to qualitative content analysis. *Qual Health Res* 2005; 15: 1277–88.
33. Australian Health Practitioner Regulation Agency. Continuing professional development. Canberra: Australian Health Practitioner Regulation Agency; 2016 ; Available from: https://www.ahpra.gov.au/Education/Continuing-Professional-Development.aspx. [Updated 26 May 2014].

34. Dykes P, Carroll D, Hurley A, *et al*. Fall prevention in acute care hospitals: a randomized trial. *JAMA* 2010; 304: 1912–8.
35. Bell S, Roche S, Johansson A, *et al*. Clinician perspectives on an electronic portal to improve communication with patients and families in the intensive care unit. *Ann Am Thorac Soc* 2016; 13: 2197–206.
36. Fung C. Computerized condition-specific templates for improving care of geriatric syndromes in a primary care setting. *J Gen Intern Med* 2006; 21: 989–94.
37. Ammenwerth E, Mansmann U, Iller C, Eichstädter R. Factors affecting and affected by user acceptance of computer-based nursing documentation: results of a two-year study. *J Am Med Inform Assoc* 2003; 10: 69–84.
38. Kruse C, Kristof C, Jones B, *et al*. Barriers to electronic health record adoption: a systematic literature review. *J Med Syst* 2016; 40: 252.
39. Semin-Goossens A, van der Helm J, Bossuyt P. A failed model-based attempt to implement an evidence-based nursing guideline for fall prevention. *J Nurs Care Qual* 2003; 18: 217–25.
40. Dempsey J. Falls prevention revisited: a call for a new approach. *J Clin Nurs* 2004; 13: 479–85.
41. Dillon T, McDowell D, Salimian F, Conklin D. Perceived ease of use and usefulness of bedside-computer systems. *Comput Nurs* 1998; 16: 151–6.
42. Abdekhoda M, Ahmadi M, Dehnad A, Hosseini A. Information technology acceptance in health information management. *Methods Inf Med* 2014; 53: 14–20.
43. El Mahalli A. Adoption and barriers to adoption of electronic health records by nurses in three governmental hospitals in Eastern Province, Saudi Arabia. *Perspect Health Inf Manag* 2015; 12: 1f.
44. Campbell E, Sittig D, Ash J, *et al*. Types of unintended consequences related to computerized provider order entry. *J Am Med Inform Assoc* 2006; 13: 547–56.
45. Nápoles A, Appelle N, Kalkhoran S, *et al*. Perceptions of clinicians and staff about the use of digital technology in primary care: qualitative interviews prior to implementation of a computer-facilitated 5As intervention. *BMC Med Inform Decis Mak* 2016; 16: 44.
46. McNiff JWJ. All you need to know about action research. Thousand Oaks: SAGE; 2006.
47. Dykes PC, Carroll DL, Hurley A, *et al*. Fall TIPS: strategies to promote adoption and use of a fall prevention toolkit. *AMIA Annu Symp Proc* 2009; 2009: 153–7.
48. Green L, Seifert C. Translation of research into practice: why we can't 'just do it'. *J Am Board Fam Pract* 2005; 18: 541–5.
49. Fleiszer A, Semenic S, Ritchie J, *et al*. An organizational perspective on the long-term sustainability of a nursing best practice guidelines program: a case study. *BMC Health Serv Res* 2015; 15: 535.
50. Creswell J, Plano-Clark V, Gutman M, Hanson W. Advanced mixed methods research designs. In: Tashakkori A, Teddlie C, editors. *Handbook of mixed methods in social & behavioral research*. Thousand Oaks: SAGE, 2003;209–40.
51. Leon A, Davis L, Kraemer H. The role and interpretation of pilot studies in clinical research. *J Psychiatr Res* 2011; 45: 626–9.