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Feasibility and acceptability of a mobile model of environmental enrichment for patients with mixed medical conditions receiving inpatient rehabilitation: a mixed methods study

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ABSTRACT

Objectives To investigate the feasibility and acceptability of a mobile model of environmental enrichment (EE), a paradigm that promotes activity engagement after stroke, in patients with mixed medical conditions receiving inpatient rehabilitation.

Design A mixed methods study design was used. An online qualitative survey assessed staff perspectives of acceptability of the mobile EE model including perceived barriers and enablers pre-implementation and post implementation. An A-B quasi-experimental case study of patient activity levels over a 2-week observational period provided feasibility data. This included recruitment and retention rates, completion of scheduled patient activity observations and validated baseline questionnaires, and number of adverse events.

Setting A 30-bed mixed medical ward in a public hospital that services Brisbane's southern bayside suburbs. The rehabilitation programme operates with patients co-located throughout the medical/surgical wards.

Participants Nursing and allied health professionals working across the rehabilitation programme completed pre-implementation (n=19) and post implementation (n=16) qualitative questions. Patients admitted to the ward and who received the inpatient rehabilitation programme from June to November 2016 were also recruited.

Interventions The mobile EE intervention included activities to primarily promote social and cognitive stimulation (eg, puzzles, board games) delivered by hospital volunteers and was designed to be moved throughout the wards.

Results Four themes emerged from staff reports, suggesting that the role of patient, staff and intervention characteristics, and the ward environment were important barriers and enablers to implementation. Of the 12 eligible patients, six consented to the study, and five completed the intervention. All patients completed the baseline measures. No adverse events were reported.

Conclusions As interest grows in human EE models, it will be important to tailor EE interventions to the unique demands of hospital rehabilitation services. A mobile EE model delivered in a small, mixed rehabilitation ward appears feasible and acceptable to study in a larger controlled feasibility trial.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study evaluated the feasibility and acceptability of the first mobile model of environmental enrichment (EE) within a small-scale rehabilitation programme.
⇒ A representative sample of nursing and allied health staff and patients with mixed medical conditions admitted to the rehabilitation programme co-located across hospital wards was included.
⇒ We did not include patient and family/carer perspectives.
⇒ Blinded assessment would have ensured unbiased data collection.
⇒ Future studies using a larger sample of patients and an experimental design would allow for evaluation of the potential clinical effectiveness of the mobile model of EE.

INTRODUCTION

Greater frequency and intensity of inpatient rehabilitation contributes to significant improvements in functional recovery after stroke.[1 2] Scheduled therapy in conjunction with strategies to increase physical activity and self-directed practice outside of scheduled therapy are recommended to optimise recovery during inpatient rehabilitation.[3] However, observation of stroke survivors indicates they spend much of their waking hours inactive and alone in hospital.[4 5] Stroke survivors spend only one-third of their day engaged in social activities and <5% engaged in cognitive activities.[6] In addition, they engage in few activities outside of scheduled therapy and have significantly lower activity levels on the weekends versus weekdays.[7] Stroke survivors perceive that there is a lack

of stimulating recreational and social activities available for use in their free (non-scheduled therapy) time and that the rehabilitation environment provides them with little to no autonomy to manage their recovery.[8]

Environmental enrichment (EE), a paradigm developed in animal models,[9 10] describes conditions which by design promote physical, cognitive and social activities. Activity promotion may be achieved through the architectural design of a space, improving access to activity-promoting equipment and/or through the provision of novel and valued activities. The use of EE in animal models of stroke is associated with significant improvements in sensorimotor function.[11]

The use of a model of EE with stroke survivors has been shown to increase activity in acute stroke[12] as well as in rehabilitation units.[6] Stroke survivors exposed to EE were also shown to spend less time inactive and alone.[6] In a randomised controlled trial (RCT), access to individual and communal EE in a designated area (the 'activity arcade') in a neurorehabilitation unit was associated with improvements in mood and better mobility and self-care, self-management and cognitive function.[13] Limited research has explored EE in medical conditions other than stroke.

There are many barriers impeding stroke survivor engagement in and rehabilitation staff uptake of EE.[14–16] These include lack of interest, low motivation, perceived lack of access to EE activities due to ward restrictions and both mobility and physical (eg, vision) limitations and staff availability.[17] Staff perceptions of EE and its effectiveness in meeting complex stroke survivor needs, workload demands and the level of staff assistance required,[18] as well as team dynamics, are also important considerations.[19] Further, organisational barriers such as staff turnover, change management and physical design of the clinical area have been shown to be significant in both the delivery and sustainability of EE over time.[19] These barriers highlight the need for careful consideration of how best to implement EE interventions in inpatient rehabilitation settings. The feasibility of EE in hospitals without a dedicated rehabilitation unit has not been examined.

This study aimed to investigate the feasibility and acceptability of a mobile model of EE (ie, on a trolley that can be moved through the wards) for use by patients receiving acute rehabilitation care. A mobile model of EE was chosen to suit the mixed medical ward design within which patients had mixed medical conditions and were co-located (and did not have access to a communal space that would allow for the traditional model of EE). We hypothesised that the mobile EE model would be acceptable to staff in this context and that a larger controlled trial would be feasible.

METHODS

Design

Mixed methods were employed. A qualitative approach using online surveys was used to examine staff acceptability, including perceived barriers and enablers to the mobile model of EE pre-implementation and post implementation. An A-B quasiexperimental case study design was used to measure patient physical, cognitive and social activity levels (see figure 1 for a summary of the design), providing feasibility data. Due to the feasibility focus of the study, heterogeneous nature of the patient population, trialling of a new intervention in the specific hospital rehabilitation setting and resourcing constraints, the use of a single-case quasi-experimental design was considered most suitable. A minimum of three participants and at least three data collection points within each phase are recommended to meet the design standards.[20]

Setting

This study was conducted in a 30-bed mixed medical ward of a 172-bed hospital servicing Brisbane's southern bayside suburbs. The hospital employs almost 900 full-time equivalent (FTE) staff; 31 016 patients were admitted to the hospital in the 2016–2017 financial year. The small-scale rehabilitation programme includes patients with mixed medical diagnoses requiring acute and subacute rehabilitation (eg, stroke, geriatric medicine, general medicine and palliative care) and provides a goal-oriented, time-limited multidisciplinary rehabilitation model of care, overseen by a visiting geriatrician (SS; 0.2 FTE). Approximately one to two patients per week are admitted to the programme, with four to six patients receiving care at any given time. There was no dedicated rehabilitation unit within the hospital; patients were co-located throughout the medical and surgical wards of the facility. Dedicated rehabilitation staff included an occupational therapist (0.6 FTE) and a physiotherapist (0.6 FTE).

Participants

Nursing and allied health staff working across the rehabilitation programme were invited to participate in an online survey. Three months prior to commencement (April 2016), staff were invited to participate via a circulated email sent by discipline directors and information flyers were displayed in work areas.

Patients who were admitted to the ward and who received the inpatient rehabilitation programme from 1 June to 30 November 2016 were invited to participate. Screening of rehabilitation programme referrals for potential study eligibility occurred in weekly multidisciplinary case conferences, facilitated by a senior allied health practitioner (SF). Patients were then screened using the following inclusion criteria: (1) medically stable, (2) estimated length of stay for 15 days or more, (3) able to understand spoken and written English, (4) able to follow a one-stage command, (5) able to sit unsupported out of bed or in bed, and (6) prestroke modified Rankin Scale (mRS) score of <2 (administered to patients who had a stroke only) indicating no or little disability/dependency. Patients with behavioural, more severe medical, cognitive or other limiting factors (eg, infection control) preventing their safe participation in standard rehabilitation were excluded. Patients and the research assistant (AJ) were not blinded to condition. All participants provided informed consent.

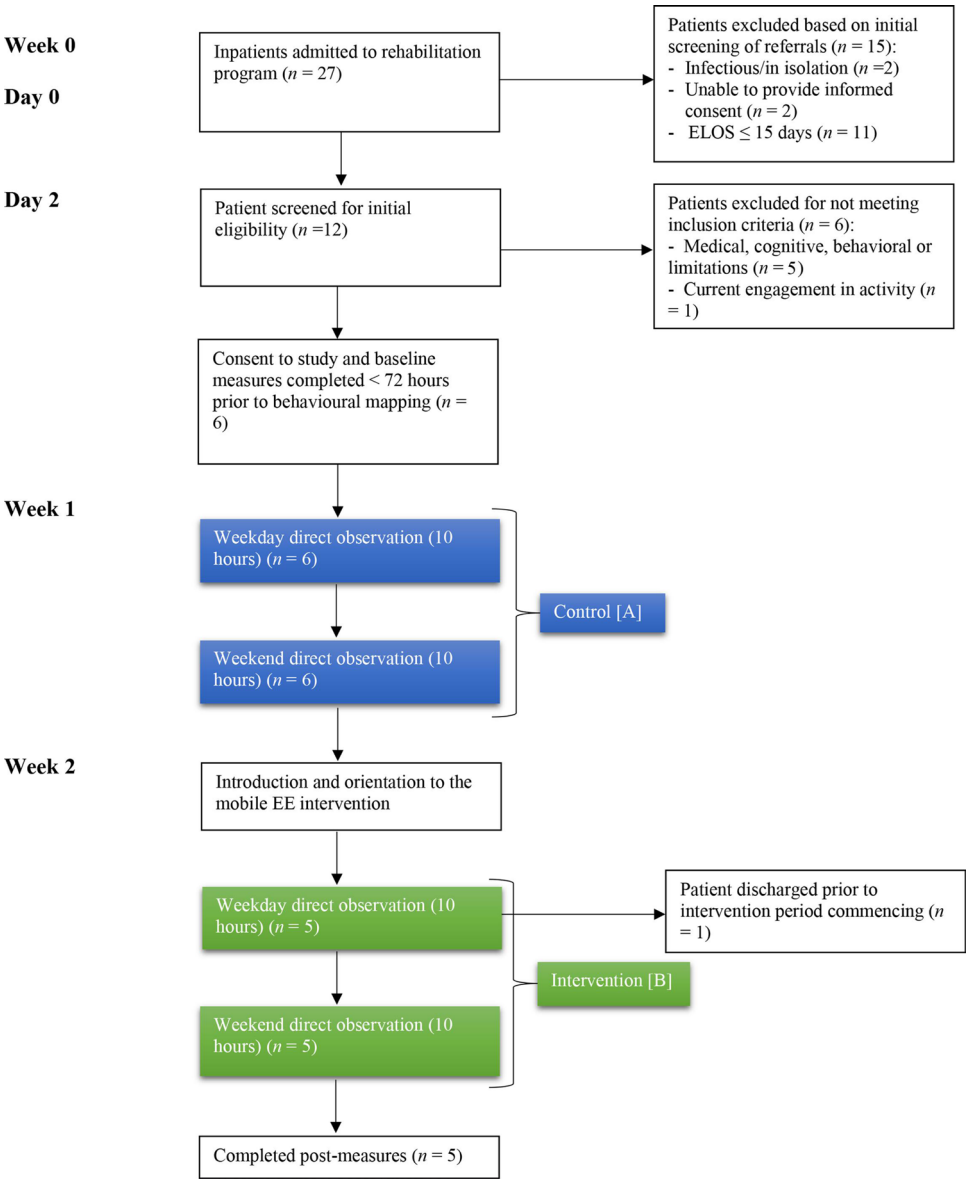

Figure 1 Design and flow of patients through the study. A-B design includes the measurement of outcomes in the control phase (A) and the intervention phase (B). EE, environmental enrichment; ELOS, estimated length of stay.

Interventions

EE mobile model intervention

The mobile EE intervention was a trolley, designed to be moved throughout the hospital wards. It included activities to primarily promote social and cognitive stimulation. Activities to promote cognition included: crosswords and mindfulness colouring pages; puzzles such as Chinese checkers; wooden construction-based activities; and digital resources including portable DVD player and DVDs, Kindles for the reading of e-books, an iPod for access to music and Nintendo DS games including Brain Training. Social engagement and activities were facilitated by patients sharing in activities (such as sharing in a card game) with visitors or patients as appropriate. Unlike previous studies,[6] there was no communal area available to stimulate physical activity in this study.

The mobile EE intervention was delivered by hospital volunteers. Patients selected their preferred activities and had daily access to the activity for 3 hours and outside of set hours via nursing/volunteer staff on request. Patients in this study received the intervention in conjunction with usual care.

Usual care (control)

Patients participated in their individual rehabilitation programme as per standard care. As part of usual care, patients had access to a standard auxiliary trolley and kiosk assisted by volunteers, which included magazines/newspaper, toiletries and snack foods.

Procedures

The first week following patient recruitment was the usual rehabilitation environment (control). This was followed

by an implementation period of 1 week where the EE mobile model was embedded into usual care.

Pre-implementation phase

Ward staff and hospital volunteers involved in the mobile EE intervention attended a 30 min education session. This was delivered by the research officer (AJ) and senior allied health professional (SF). It included an overview of the science of EE, referral and equipment loan processes and staff and volunteer roles, including equipment safety and infection control. The pre-implementation staff surveys were administered via an online link. The survey took approximately 10 min to complete.

Usual care phase

Between 1 and 7 days after recruitment, discreet observational measurement of activity levels using standardised behavioural mapping at two points including one weekday and one weekend day was conducted. In addition, on day 1 or 2 after recruitment, baseline outcome measures of function, disability and cognitive impairment were completed.

Intervention phase

Between 8 and 15 days after recruitment, patients and their caregivers were provided with access to the mobile EE intervention after receiving an information booklet, which included the range of activities available, how to access the activities and the role of caregivers, volunteers and staff (see figure 1).

On each day of the intervention phase, patients were provided with access to the activities from 13:00 to 16:00. A hospital volunteer offered the activities to the patient at their bedside at approximately 13:00, 14:00 and 15:00. At approximately 15:45, the volunteer collected any items loaned, cleaned them in line with infection control procedures and returned the activities to storage. Patients continued to have access to the activities until their hospital discharge or completion of the study.

Postintervention phase

After completion of the intervention phase, staff were then invited to complete the post-implementation survey.

Measures

Staff surveys

Pre-implementation and post-implementation surveys were disseminated to staff to determine the acceptability of the mobile EE intervention. Demographic characteristics included length of time working on the ward and occupation. Open-ended questions examined perceived enablers and barriers to implementation of the mobile model of EE.

Patient activity levels

Activity levels of patients were estimated using a behavioural mapping technique, conducted in line with reported protocol.[6 21] Over four sessions, each patient was observed using a standardised behavioural mapping form for a 3-hour period (13:00–16:00), including two weekdays (one control, one intervention) and two weekend days (one control, one intervention). Observations were made every 5 min, with one 10 min break taken at 14:40 during each observation period. When participants were not able to be directly observed, activity was recorded after conferring with nursing staff if possible or observations were not included in the count. In total, 36 observations per session, and 144 observations, could be made for each participant. The research officer (AJ) conducted all observations.

Type of activity was categorised at the time of observation as physical, cognitive, social or sleeping using the adapted behavioural monitoring tool.[6 21] Physical activity consisted of any purposeful physical movement, including activities such as eating, drinking, all personal activities of daily living and active participation in activity during intensive therapies. Cognitive activity included any non-physical mental activity in which the participant could be observed to be actively engaging; for example, reading a book or newspaper, listening to music or the radio, crosswords, puzzles, board or video games, writing, computer use and watching movies on a portable DVD player. Social activity encompassed any interaction which involved verbal communication with people present or through telecommunication devices, and other non-verbal interactions such as touching, kissing or holding. For instance, talking, laughing, touching, use of the phone/email and being present within a group of people engaged in 'group therapies or activities' were included. Sleeping was defined as sitting or lying with eyes closed. Participants could be recorded as engaged in more than one type of activity at the same time; for example, if they were walking (a physical activity) while talking (a social activity).

Patient demographics

Demographic data including age, sex, medical diagnosis and length of stay were collected from patient records.

modified Rankin Scale

The mRS measures the level of disability/dependency of patients who had a stroke.[22 23] The treating clinician scores the patient's disability on a 6-point assessment scale (0=indicating no symptoms at all, 5=severe disability defined as bedridden, incontinent and requiring constant nursing care and attention). This tool was only used on patients with a stroke diagnosis.

Functional Independence Measure

The Functional Independence Measure (FIM) estimates a patient's degree of function and assistance required for activities of daily living.[24] It contains 18 items: 13 related to motor tasks and 5 related to cognitive tasks. Example items include 'eating' or 'toileting'. Each item was rated by one of the treating allied health clinicians on a 7-point scale (1=total assistance required, 7=complete independence). Scores were summed, with higher scores

indicating greater function. FIM was measured on admission to the ward.

Standardised Mini-Mental State Examination

The Mini-Mental State Examination was administered by the treating clinician to measure patients' level of cognitive ability and impairment.[25 26] It contains five sections, including orientation; registration; attention and calculation; recall; and language. A total score of 23 or less indicates cognitive impairment.

Feasibility criteria

We considered the EE intervention feasible if we could (1) recruit >50% of eligible patients over a 3-month period and retain 80%; (2) complete 80% of baseline patient assessments; (3) achieve <1 adverse event or complaint, with no serious adverse events reported; and (4) conduct patient activity observations on at least 80% of scheduled occasions.

Data analysis

Descriptive statistics were calculated to summarise patient and staff characteristics. Primary feasibility outcomes were summarised including recruitment and retention rates, completion of baseline assessment measures and patient observations and number of adverse events/complaints. A thematic analysis[27] was used to analyse qualitative responses from staff. An initial coding index was developed (SF; AJ). These were then used to group codes into key themes and subthemes (SF; RAE; HJ). Relationships between codes were examined to inform themes, and theme development was also supported by contextual information from the research team.

The patients' observational data were coded as either 0 (indicating no, category did not apply to participant in that particular epoch) or 1 (indicating yes, category did apply to participant in that epoch) during each 3-hour observational period (3 hours weekday and 3 hours weekend for each participant). A behavioural mapping tool was used to determine whether a relationship exists between introduction of the intervention and change in activity levels and whether these changes are reliably and consistently replicated across multiple participants.[28]

Patient and public involvement

Hospital volunteers who volunteered to participate in this study contributed to the development of guidelines for operation and storage of the mobile EE trolley including how it would be implemented during their shift. Volunteers participated in training in the research protocol for use of the EE trolley and the ethical considerations. Allied health and nursing staff were engaged in research team meetings to develop the research protocol and operating guidelines for the EE trolley. There was no direct involvement of patients in the design of the study or analysis of the results.

RESULTS

Staff acceptability of the mobile EE intervention

Most staff had been working in the ward for two or more years (n=12, 63.2%). Pre-implementation surveys were completed by 19 staff (n=11 allied health, n=7 nursing, n=1 other/unspecified). Post implementation surveys were completed by 16 staff (n=8 allied health, n=4 nursing, n=4 other/unspecified).

Given the similarities in barriers and enablers identified by staff pre-implementation and post implementation, four broad themes relating to acceptability of the EE intervention are outlined: the role of staff, patient characteristics, intervention characteristics and the ward environment. See table 1 (pre-implementation) and table 2 (post-implementation) for barriers and enablers.

The role of staff

The role of staff was a commonly reported barrier prior to implementation. Concerns regarding limitations in volunteer availability to assist and support the mobile EE intervention were identified, particularly in the context of the intervention operating across multiple hospital wards and multipurpose environments. The lack of access to volunteers to support the intervention particularly over the weekend was a concern. Poor staff attitudes and engagement with the intervention were also cited as potential barriers, as well as lack of knowledge and skills to support EE.

These common concerns about the role of staff identified at pre-implementation were not identified at post-implementation. There were limited comments suggesting the role of staff was a barrier post-implementation. Operational limitations which related to staff availability and time constraints were instead identified. Poor staff engagement was identified as a possible barrier to the longer term translation of EE into routine practice.

Positive staff attitudes and behaviours were reported as enabling factors pre-implementation. Sufficient staff availability to facilitate access and provide support (eg, 'having staff at bedside to help with instructions'; P10) was considered important. Promotion of the potential positive benefits of EE was also reported as an enabler as well as EE training and education.

Patient characteristics

Patient characteristics were highlighted as a barrier to implementation, with fewer comments related to this identified post-implementation. Initially, concerns were about patient suitability, patient functioning and medical status. Staff also cited that patient motivation and engagement may be a barrier, particularly as the mobile EE intervention required a degree of patient self-management. Patient suitability remained a barrier post-implementation; however, comments were mainly related to the eligibility criteria. While staff reported that identifying suitable patients to participate in the EE activities would be an enabling factor pre-implementation, patient motivation and involvement were key enablers

Table 1 Pre-implementation staff barriers and enablers

Themes	Subthemes	Examples	Frequency
Enablers			
Role of staff	Positive staff attitudes and behaviours	'Encouragement by all staff members for the patient to utilise the trolley'	7
	Staff assistance and availability	'Staff support to ensure time is available for patients to participate in the activities'	13
	Staff preparation	'Clear parameters re: the aim behind EE on Wheels'	2
Patient characteristics		'Suitable patient identification e.g. Cognitive and physical ability to use items'	5
Intervention characteristics	Variety and quality of activities	'Variety of choices of activities'	8
	Activities tailored to patient needs	'Ensuring activities are appropriate for patients' level of function'	3
	Ease of access and use	'Clear and simple instructions'	6
Barriers			
Role of staff	Poor engagement/uptake	'Staff engagement of process'	5
	Staff availability	'Availability of volunteer to support'	7
	Knowledge and skills	'Volunteers may need education regarding dementia etc. on dealing with patients'	4
Patient characteristics	Patient suitability	'Lack of appropriate patients on ward'	4
	Patient functioning and medical status	'…Patients level of understanding and function'	7
Intervention characteristics	Poor variety	'Poor variety, with resources not interesting for patients'	3
Ward environment	Infection control	'Infection control is going to be a big issue with electronic gadgets'	8
	Maintenance of activities	'Items may become lost or destroyed'	2
	Competing treatment demands	'Time - during therapist work hours clash with therapy time'	2
	Equitable access	'Jealousy from other patients'	7

EE, environmental enrichment.

that contributed to the success of the intervention post-implementation.

Intervention characteristics

There was emphasis on the variety of activities offered as an enabler pre-implementation, and that activities would be tailored to patient needs and easy to use. Concerns regarding the quality and variety of resources were also a barrier pre-implementation. Variety and stock of activities remained a post-implementation barrier; however, comments highlighted how the variety of activities and how they were implemented contributed to the intervention success. Ease of access by patients remained a post-implementation barrier.

Ward environment

Aspects of the ward environment including concerns regarding the maintenance of activity items (eg, keeping them in working order), competing treatment demands, equitable access and infection control were considered as barriers to implementation. Challenges with meeting infection control requirements was the most cited subtheme. Possible competing treatment demands were related to the balance of time spent accessing the intervention versus with time spent in targeted therapy. The mixed medical and surgical ward setting highlighted unique challenges for access and equity, as patients in the rehabilitation programme accessing the intervention were located with non-rehabilitation patients within the same bed bay or area. While infection control remained a barrier post-implementation, no other ward environment barriers or enablers were documented.

Feasibility of EE

Twelve patients met initial eligibility criteria and six patients were recruited to the study (feasibility criteria 1 met; recruit >50%). Five patients (80% male) with a mean age of 74 years (IQR 72–79) participated in the EE intervention; one patient (patient A) was discharged earlier than expected and did not complete all aspects of the intervention (feasibility criteria 1 met; retain 80%). Time to consent from admission to the rehabilitation programme was 2 days or less. See figure 1 for patient

Table 2 Post-implementation staff barriers and enablers

Themes	Subthemes	Examples	Frequency
Enablers			
Role of staff	Stakeholder engagement and facilitation	'Staff engagement' 'Volunteers' will' 'Families responses to EE on Wheels'	3
	Staff assistance and availability	'Assistance of volunteers' 'Staff feedback'	3
Patient characteristics		'Patient motivation' 'Patient's involvement'	3
Intervention characteristics	Variety and quality of activities	'Good activities' 'Choice of activities'	3
	Activities tailored to patient needs	'Having activities that appealed to the participant' 'Diversional activity'	2
	Ease of access and use	'Having them brought to the patient' 'Having it available on the weekend'	4
Barriers			
Role of staff	Staff engagement and facilitation	'Unlikely to be part of the culture given limited number of rehab patients being co-located on a medical ward - not driven optimally by ward staff, not engaged with by peers'	1
	Staff availability	'Time constraint'	1
	Knowledge and skills	'Lack of advertisement – may need to provide in-service to staff' 'Do not know where it is stored'	3
Patient characteristics	Patient functioning and medical status	'Lack of patients' 'Participant criteria' 'Patient's confusion'	3
	Patient motivation	'Patient motivation'	1
Intervention characteristics	Variety and stock of activities	'Broad array of interests among participants and the ability for the EE to cater for same (both initially and in an ongoing capacity)' 'Assuming participant numbers pick up - limited quantity of the same piece of equipment'	2
	Impact of external activities	'Patients having their own activities (iPad, puzzle books, magazines) and not interested in trolley' 'Patient already had access too own phone/iPad'	2
	Access	'Accessibility'	3
Ward environment	Infection control	'Infection control'	1

EE, environmental enrichment.

flow. Patient characteristics are outlined in table 3. All eligible patients completed the baseline assessments and postassessments (feasibility criteria 2 met; 80% of baseline assessments completed). There were no adverse events or complaints reported (feasibility criteria 3 met; <1 adverse event/complaint). Patient activity observations were

Table 3 Baseline characteristics of patients

	Sex	Age range (years)	Diagnosis	FIM	MMSE	mRS
Patient B	M	50–54	Stroke	87	30/30	0
Patient C	M	70–74	Stroke	64	30/30	0
Patient D	F	75–85	Fractured NOF	58	27/30	N/A
Patient E	M	70–74	Stroke	79	18/29	1
Patient F	M	75–85	Stroke	60	27/30	0

FIM, Functional Independence Measure; MMSE, Mini-Mental State Examination; mRS, modified Rankin Scale; N/A, not applicable; NOF, neck of femur.

conducted as scheduled on all occasions, except for one occasion when a patient was out of the hospital on planned day leave (feasibility criteria 4 met; activity observations conducted >80% of scheduled occasions). See the online supplemental materials for individual patient activity data in the control and intervention phases. Overall, increases in any activity and specific activity (cognitive; social) types were observed for four of the five participants (B, C, E and F) in the intervention compared with the control phases.

DISCUSSION

This study investigated the feasibility and acceptability of implementing a mobile model of EE in a mixed inpatient rehabilitation ward. The recruitment rate of eligible referrals was 50%. Completion of patient activity observations and the EE intervention were high (>80%) and all patients completed the baseline assessments. There were no reported adverse events. Pre-implementation barriers and enablers were identified: (1) the role of staff, (2) patient characteristics, (3) intervention characteristics, and (4) the ward environment. However, few barriers remained post-implementation. Together, these findings provide initial support for the feasibility and acceptability of a mobile EE model delivered as part of acute rehabilitation care to patients with a range of medical conditions and suggest the need for consideration of a larger feasibility trial.

The four themes identified are consistent with staff perceived barriers reported in previous studies.[17–19] Workload demands and staff availability to support patient access to the intervention are common concerns prior to the implementation of EE[18] and were similarly frequently reported (33%) as pre-implementation barriers in this study. Staff were initially concerned about their ability to engage in the EE intervention as well as the availability of volunteers to provide support. Post-implementation, the role of staff was viewed as important to the success of the EE intervention, including how patients were encouraged to engage in EE and the availability of staff to support implementation. It is possible that the delivery of staff training addressed some concerns and better prepared staff for EE implementation.

The ward environment was the most common barrier (39%) reported pre-implementation; specifically, infection control and equitable access to EE. A stringent infection control procedure aimed to ensure safety of patients and staff. The nature of the mixed ward environment raised ethical issues about providing EE to the specific patient cohort but not to other patients on the ward. Education about the safety procedures and pilot nature of the research was provided to address these concerns. Following implementation, only one staff member highlighted infection control as a barrier, suggesting infection control protocols were effectively managed. Future studies should consider in the context of routine care access to EE in more severe conditions and different patient populations (eg, dementia/delirium; subacute). However, safety issues should be paramount.

The medical stability of patients was an important concern identified pre-implementation. Most of the patients who were excluded had more severe medical, behavioural or cognitive problems that prevented their safe participation in the study. Staff training provided education about medical oversight and the need for ongoing monitoring to detect any patient deterioration during the intervention phase. Further consideration of specific patient supports and modifications to the intervention for patients with more severe medical, cognitive or behavioural problems is needed.

Intervention characteristics including the variety, choice and quality of activities were important enablers to implementation success as were patient characteristics such as motivation and involvement. However, staff were initially concerned about who would be responsible for delivering EE. These concerns appeared to be in part related to staff capacity to facilitate EE within their standard working hours and workloads (ie, the *role of staff* theme). Maintaining the variety and stock of activities and integrating patient interests and resources were frequently reported as postimplementation barriers and enablers. Some patients had access to electronic devices or other leisure materials from home. Use of the patient's resources was encouraged as access to stimulating materials, regardless of source, provides the type of enrichment and stimulation that EE aimed to provide. Tailoring of the EE intervention to patient's needs and abilities was shown to be important. That is, matching their cognitive and physical capabilities and motivation levels with activities that met these needs. Future research should investigate how to better address patient needs, such as incorporating patient's personal devices and resources/activities to enhance the inpatient experience.

Several operational constraints existed during EE implementation. These included limited dedicated allied health rehabilitation staff, non-specialised nursing staff, colocation of acute, palliative and rehabilitation patients in the ward and frequent bed reallocations. Despite these challenges, a multidisciplinary team including allied health, nursing staff and volunteers supported EE implementation. In particular, the critical role of volunteers featured strongly in the identified themes. Access to the volunteer workforce enabled an existing resource within the hospital to be used for the intervention at no additional cost, other than the time invested in training. Future research should examine whether there are any differences in these interventions when supported by volunteers versus health professionals.

The results met or exceeded our set parameters suggesting that EE was feasible in this inpatient rehabilitation setting. In addition, observational data provided preliminary evidence for increased overall, social and cognitive activity levels in four out of five patients in the intervention versus control phases. These findings add to the growing body of work demonstrating the benefits

of EE in inpatient rehabilitation settings.[6 12 13] Previous research has shown that stroke survivors spend a higher proportion of their day engaged in social and physical activities when exposed to EE.[6 11] Unlike other EE studies which involved the creation of a communal/social space ('communal enrichment'),[6 13] the mobile EE model was delivered at the bedside, with no such space available on the ward. The mobile model provides an alternative to standard EE and could be used in settings where communal spaces are not available.

Strengths and limitations

This study is the first of its kind to test the feasibility and acceptability of a mobile model of EE in a mixed rehabilitation ward. It integrated staff perspectives of acceptability and feasibility metrics. The quasiexperimental A-B case study design was suited to the heterogenous nature of the inpatient sample, resourcing constraints of the ward and inpatient environment and initial feasibility testing aims. However, this study has several limitations. This study was undertaken at one hospital with a small rehabilitation programme limiting the generalisability of findings. Blinded assessment would have ensured unbiased data collection. An open-ended survey was used to examine staff perceptions; future studies could also include interview or focus group formats. Future studies examining patient-reported outcomes such as mental health would be informative, as would inclusion of patient and family/carer perspectives in codesigning mobile models of EE. Finally, the study is limited by the small sample of patients. Future research with a larger sample using an experimental single-case design or feasibility RCT is needed to demonstrate preliminary effectiveness.

CONCLUSION

A mobile model of EE might be feasible and acceptable as an intervention for patients with different medical conditions receiving inpatient rehabilitation. Results of this study will inform further development and testing of a mobile model of EE for the purposes of improving patient access to stimulating activities outside of therapy hours to maximise recovery. Importantly, it provides metrics which can inform the design of a future controlled feasibility trial.

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Contributors RAE and SF initially conceptualised the study and received funding support. SS and HJ provided input into the conceptual design. SF and AJ were involved in data collection, overseen by RAE, HJ and SS. The analyses were conducted by RAE, SF, HJ and AJ, and all members of the team were involved in interpretation. SF and RAE drafted the manuscript, with edits provided by all members of the team. All members of the team approved the final manuscript. RAE is responsible for the overall content as the guarantor.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Metro South Hospital and Health Service (HREC/16/QPAH/289). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

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REFERENCES

1 Lohse KR, Lang CE, Boyd LA. Is more better? using metadata to explore dose-response relationships in stroke rehabilitation. *Stroke* 2014;45:2053–8.
2 Veerbeek JM, van Wegen E, van Peppen R, *et al*. What is the evidence for physical therapy poststroke? A systematic review and meta-analysis. *PLoS One* 2014;9:e87987.
3 Stroke Foundation. *Clinical guidelines for stroke management*. Melbourne, Australia, 2019.
4 Bernhardt J, Dewey H, Thrift A, *et al*. Inactive and alone: physical activity within the first 14 days of acute stroke unit care. *Stroke* 2004;35:1005–9.
5 West T, Bernhardt J. Physical activity in hospitalised stroke patients. *Stroke Res Treat* 2012;2012:13
6 Janssen H, Ada L, Bernhardt J, *et al*. Physical, cognitive and social activity levels of stroke patients undergoing rehabilitation within a mixed rehabilitation unit. *Clin Rehabil* 2014;28:91–101.

7 King A, McCluskey A, Schurr K. The time use and activity levels of inpatients in a co-located acute and rehabilitation stroke unit: an observational study. *Top Stroke Rehabil* 2011;18 Suppl 1:654–65.
8 Luker J, Lynch E, Bernhardsson S, *et al*. Stroke survivors' experiences of physical rehabilitation: a systematic review of qualitative studies. *Arch Phys Med Rehabil* 2015;96:e10.:1698–708.
9 van Praag H, Kempermann G, Gage FH. Neural consequences of environmental enrichment. *Nat Rev Neurosci* 2000;1:191–8.
10 Nithianantharajah J, Hannan AJ. Enriched environments, experience-dependent plasticity and disorders of the nervous system. *Nat Rev Neurosci* 2006;7:697–709.
11 Janssen H, Bernhardt J, Collier JM, *et al*. An enriched environment improves sensorimotor function post-ischemic stroke. *Neurorehabil Neural Repair* 2010;24:802–13.
12 Rosbergen IC, Grimley RS, Hayward KS, *et al*. Embedding an enriched environment in an acute stroke unit increases activity in people with stroke: a controlled before-after pilot study. *Clin Rehabil* 2017;31:1516–28.
13 Khan F, Amatya B, Elmalik A, *et al*. An enriched environmental programme during inpatient neuro-rehabilitation: a randomized controlled trial. *J Rehabil Med* 2016;48:417–25.
14 Menon A, Bitensky NK, Straus S. Best practise use in stroke rehabilitation: from trials and tribulations to solutions! *Disabil Rehabil* 2010;32:646–9.
15 Moore JE, Marquez C, Dufresne K, *et al*. Supporting the implementation of stroke quality-based procedures (QBPs): a mixed methods evaluation to identify knowledge translation activities, knowledge translation interventions, and determinants of implementation across Ontario. *BMC Health Serv Res* 2018;18:466.
16 Bayley MT, Hurdowar A, Richards CL, *et al*. Barriers to implementation of stroke rehabilitation evidence: findings from a multi-site pilot project. *Disabil Rehabil* 2012;34:1633–8.
17 White JH, Bartley E, Janssen H, *et al*. Exploring stroke survivor experience of participation in an enriched environment: a qualitative study. *Disabil Rehabil* 2015;37:593–600.
18 White JH, Alborough K, Janssen H, *et al*. Exploring staff experience of an "enriched environment" within stroke rehabilitation: a qualitative sub-study. *Disabil Rehabil* 2014;36:1783–9.
19 Rosbergen ICM, Brauer SG, Fitzhenry S, *et al*. Qualitative investigation of the perceptions and experiences of nursing and allied health professionals involved in the implementation of an enriched environment in an Australian acute stroke unit. *BMJ Open* 2017;7:e018226.
20 Kratochwill TR, Hitchcock JH, Horner RH, *et al*. Single-Case intervention research design standards. *Remedial and Special Education* 2013;34:26–38.
21 Janssen H, Ada L, Bernhardt J, *et al*. An enriched environment increases activity in stroke patients undergoing rehabilitation in a mixed rehabilitation unit: a pilot non-randomized controlled trial. *Disabil Rehabil* 2014;36:255–62.
22 Banks JL, Marotta CA. Outcomes validity and reliability of the modified Rankin scale: implications for stroke clinical trials: a literature review and synthesis. *Stroke* 2007;38:1091–6.
23 Wilson JTL, Hareendran A, Grant M, *et al*. Improving the assessment of outcomes in stroke: use of a structured interview to assign grades on the modified Rankin scale. *Stroke* 2002;33:2243–6.
24 Mackintosh S. Functional independence measure. *Aust J Physiother* 2009;55:65.
25 Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975;12:189–98.
26 Molloy DW, Alemayehu E, Roberts R. Reliability of a standardized Mini-Mental state examination compared with the traditional Mini-Mental state examination. *Am J Psychiatry* 1991;148:206–7.
27 Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006;3:77–101.
28 Lane JD, Gast DL. Visual analysis in single case experimental design studies: brief review and guidelines. *Neuropsychol Rehabil* 2014;24:445–63.

Patient activity data: See Figure below.