RESEARCH PAPER

A software to prevent delirium in hospitalised older adults: development and feasibility assessment

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Abstract

Background: non-pharmacological interventions to prevent delirium are useful in hospitalised older adults. However, they are poorly implemented in clinical practice. We aimed to develop a software for bedside use by hospitalised older adults and to improve their access to these interventions.

Methods: a transdisciplinary team composed of healthcare professionals, designers, engineers and older adults participated in the development of the software. Scrum methodology was used to coordinate the work of the team, and the software was evaluated in a feasibility study.

Results: a software for touchscreen mobile devices that supports Android 5.0 or later was produced, including modules for time-spatial re-orientation, cognitive stimulation, early mobilisation, sensorial support use promotion, sleep hygiene and pain management optimisation. Horizontal disposition, use of colour contrast and large interaction areas were used to improve accessibility. The software's usability and accessibility were evaluated in 34 older adults (average age 73.2 ± 9.1 years) showing that 91.1% of them got access to all the software functions without previous instructions. The clinical feasibility assessment showed that 83.3% of the 30 enrolled hospitalised patients (76 ± 8 years) completed the 5-day protocol of software usage during hospitalisation. Software use was associated with a decreased trend in delirium incidence of 5 of 32 (15.6%) at baseline to 2 of 30 (6.6%) after its implementation.

Conclusion: a highly accessible and implementable software, designed to improve access to non-pharmacological interventions to prevent delirium in hospitalised older adults, was developed. The effectiveness of the software will be evaluated in a randomised clinical trial.

Keywords: delirium, software, non-pharmacological interventions, prevention, gerontechnology

Key points

- Multicomponent interventions are effective in preventing incident delirium, however they are poorly implemented in clinical practice.
- Gerontechnology is the field of knowledge dedicated to the study of the application of technologies to improve wellbeing of older adults.
- To create technology that suits the needs and wishes of older people require their involvement in the design and development process.
- A highly accessible and implementable software, designed to improve access to non-pharmacological interventions to prevent delirium in hospitalized older adults, was developed.

Introduction

Delirium is a common complication in hospitalised older adults, with incidences of 20–29% in general wards and up to 82% in critical care units [1]. Delirium is associated with important adverse outcomes, including morbidity, mortality, long-term cognitive and functional impairment, increase in hospitalisation length, institutionalisation rates and healthcare costs [2]. Furthermore, delirium has been associated with adverse effects in caregivers, including anxiety, emotional stress and burnout [3].

Several randomised clinical trials have shown that bundles of non-pharmacological interventions are effective to prevent delirium, decreasing its incidence between 30 and 40% [4]. Although the implemented non-pharmacological interventions to prevent delirium differ slightly between the different bundles, many of these interventions are frequently promoted, including systematic monitoring of delirium, time and spatial reorientation, cognitive stimulation, early mobilisation, promotion of the use of sensory adaptations such as lenses and hearing aids, sleep protocols (use of earplugs or ear protective devices, eye masks, reduction of environmental noise), optimisation of pain management and ensuring an adequate nutrition and hydration [1, 5, 6]. Based on the evidence of their efficacy, many clinical guidelines and medical societies promote their routine use in clinical practice [7]. However, despite the extensive evidence on the effectiveness of non-pharmacological interventions to prevent delirium, they are poorly implemented in clinical practice. Considering the variety of domains included, the implementation of bundles of non-pharmacological interventions to prevent delirium requires an efficient interprofessional teamwork, including physicians, nurses, physiotherapists, occupational therapists, patients and relatives, which are difficult to implement in clinical practice [8]. Several other difficulties in their implementation have been identified, including lack of time, fear of increased workload and limited knowledge/skills to implement them [9, 10]. The use of technologies to improve the management of patients with delirium is quickly evolving and in view of the kind of barriers described its use could help to face this problem. Rutter *et al.* have developed a software to improve delirium screening/diagnosis [11] and Zhang *et al.* designed a software to improve education in healthcare professionals [12]. However, because of the multiple domains involved in bundles of delirium prevention, we believe that a more comprehensive solution is needed.

Our aim was to develop a software for bedside use by hospitalised older adults designed to improve their access to a bundle of non-pharmacological interventions to prevent delirium.

Material and methods

Transdisciplinary development

An interdisciplinary team including (i) clinicians with experience in delirium/older adults, (ii) engineers with experience in coordinating interdisciplinary teamwork, (iii) engineers with expertise in software programming for touchscreen technology for mobile devices and (iv) graphic designers was established. The team was composed of one geriatrician, one critical care physician, two occupational therapists, one nurse, one physiotherapist, two industrial engineers, one computer engineer and one graphical designer. The adequate interaction of the team was coordinated through the Scrum methodology, which through successive iterations called 'sprints', allowed the construction and revision of the software [13, 14]. Each iteration had a predefined duration of 2 hours and a periodicity of 3–4 weeks. The entire multidisciplinary team was present in each of the 'sprints' sessions. Specifically, the occupational therapists developed cognitive activities and the physiotherapist developed the plan of physical activities that were incorporated as videos. All the contents were reviewed by the rest of the team prior to their incorporation. Doctors and nurses facilitated the integration of these activities. The team of programmers facilitated the design of modules that allowed the incorporation of the activities into the software. A total of 12 scrum iterations were done. To ensure a broad base design of accessible software, healthy older adults were included in the development process through their participation in special 'sprint' sessions. A total of two iterations with 15 cognitively normal community-dwelling older people were done. The inclusion criteria for the pilot study were older than 65 years old, no history of cognitive impairment, no visual impairment or adequately corrected by glasses or surgery, a cognitive assessment method (CAM) negative at study entry and signed consent to participate in the investigation.

Software contents and accessibility

For selection of software contents, a search for reviews and systematic reviews on non-pharmacological delirium prevention in PubMED and Epistemonikos database of systematic reviews was made, using the keywords [Delirium], [elderly], [older adults] and [non-pharmacological prevention] without limit of dates or languages. The data were reviewed and the multidisciplinary team selected specific interventions based on their evidence and their feasibility to be incorporated in the software. To define software design characteristics to optimise the accessibility for older adults, a search of the literature was carried out in PubMED using the keywords [touch screen], [software], [interaction techniques], [drag and drop], [Mobile applications (apps)] and [elderly] or [older adults] without a limit of dates or languages. The data were reviewed, and the multidisciplinary team selected specific design characteristic based on their clinical experience, the technical feasibility to be incorporated in the software and the opinion of the healthy older adults who participated in the software development.

Feasibility assessment

The main objectives at this stage of the study were to determine the accessibility of the software by older adults and the feasibility of its implementation in a real clinical scenario. In case the software showed low accessibility, it would be necessary to improve its development prior to its clinical feasibility evaluation, and for this reason, both outcomes were evaluated step by step starting with volunteers from the community, continuing with individual assessment of hospitalised patients and ending with an evaluation in a clinical setting.

To assess the accessibility, focus group interviews including two populations—community dwelling older adults and hospitalised older adults—were exposed to the software. All focus group participants were older than 65 years with more than 6 years of education, without cognitive impairment, delirium or non-treated visual impairment, and signed investigation consent. The software was systematically assessed using a standardised survey considering the essential domains to evaluate software prototypes, including 'Role', 'Look and Feel' and 'implementation' [15]. Domains were quantified based on the 5-point Likert scale [16, 17] (Supplementary Appendix 1). Data were prospectively analysed to determine saturation point. Interview size was estimated for 80% power [15]. The results were presented with descriptive statistic, including mean (±standard deviation) and percentages.

To assess the feasibility of software implementation in a clinical scenario, a before–after methodology was used. To determine baseline delirium incidence (before condition), older adults hospitalised in general ward (no ICU) for <24 hours were prospectively enrolled. Inclusion criteria were as follows: (i) older than 65 years, no history of cognitive impairment including absence of clinical register of dementia or cognitive impairment and no history

of cognitive decline during the previous year declared by patient or relative; (ii) no visual impairment or adequately corrected by glasses or surgery; (iii) CAM negative at the time of the evaluation and (iv) signed consent to participate in the investigation. Delirium incidence was assessed using CAM, applied by a trained occupational therapist twice a day during the first 5 days of hospitalisation including weekends. CAM diagnostic criteria are fulfilled by the presence of either (i) acute change or fluctuation, obtained from a family member or nurse aware of the patient's baseline mental status or (ii) inattention assessed by month of the year backwards or digit-span backwards (4 digits) plus either (iii) disorganised thinking, defined as unclear or illogical flow or of ideas during patient assessment or a wrong answer to questions such as place/time orientation or relevant personal data including age or birth date, or (iv) an altered level of consciousness, defined as a sedation agitation scale different of 4. As part of their initial evaluation, a mini-mental state evaluation (MMSE) was assessed by a trained occupational therapist, and the illness burden was evaluated using the Charlson index. After completing the baseline measurement, a second cohort of patients, with the same inclusion/exclusion criteria, was enrolled in the same clinical units. The software was installed in a tablet *Alcatel OneTouch Pixi-3 (10)* and delivered every day to each patient between 9:00 and 20:00 hours. Software use and patient's opinions were recorded daily. Delirium incidence was assessed using the same strategy previously described. Sample size was estimated using recommendations for pilot studies design [18]. The results were presented with descriptive statistic, including mean (±standard deviation) and percentages, and the before–after comparison of delirium incidence was done using chi-square.

Ethics

All the older adults signed an informed consent document. The investigation was authorised by the Ethics Committee of Hospital Clínico Universidad de Chile.

Results

The software

The developed software is an application for mobile devices designed for Android platforms. While designed to be used on a 10.1-inch tablet, 1 GB of RAM and a 1.3 GHz quad-core processor, it can be run on any device that supports Android 5.0—Marshmallow or later. The non-pharmacological interventions to prevent delirium included in the software were as follows: (i) time-spatial re-orientation, (ii) cognitive stimulation, (iii) early mobilisation, (iv) promotion of the use of sensory supports, (v) sleep hygiene, (vi) improve pain assessment and (vii) education on delirium. Several design aspects were included in the software to improve its accessibility [19], including (i) at the visual level: (a) use of a horizontal screen; (b) use of simple shape

icons, over photographs; (c) texts size and colours that were contrasted with the background; (d) large space between activity icons, to facilitate identification and precision when touching the screen; (e) minimising the use of peripheral vision and (f) screen size bigger than 9" and (ii) from the user perspective: (a) use of direct touch rather than digital pencil, (b) use of single touch rather than drag and drop, (c) instant visual feedback of performance in every step and (d) use of simple language.

The user interface

The included non-pharmacological interventions to prevent delirium were organised in several modules to facilitate its access (Figure 1A), including:

- 'A desktop module' as the first screen that the user faces when the software is turned on. It continuously delivers information on time and space to facilitate orientation and allows the access to other modules (Figure 1B).
- 'An exercise module' containing 12 videos of physiotherapist-guided physical activities that can be easily replicated by the older adults. All exercises were focused on functional activities (Figure 1C).
- 'A documentaries module' containing short videos destined to be a cognitive stimulation tool, an entertainment activity during leisure time and a tool to educate about delirium.
- 'A games module' including eight different cognitive activities to stimulate attention, memory and executive function. Colloquial names were selected to improve accessibility (Figure 1D). Two different difficulty categories were considered, depending on education level of the patient, based on previous data [20] (Figure 1F).
- 'An alert module' with a series of pre-established alerts displayed during software use, including promotion of sensory support measures (glasses, hearing aids), pain level questions and sleep recommendations with a frequency that could be customised (Figure 1E and F).
- 'A configuration module' allowing software customisation. Patient data including educational level, use of sensorial support and restriction of patient movement if needed could be set-up (Figure 1F). The access to this module was protected by a password for medical use only. Healthcare personnel, especially the nursing staff, could use this module to personalise the software according to the profile of each patient. For example, if the patient has an indication of absolute rest, it is possible to hide all the videos of physical activities, and if there is a ban on aerobic activity, only exercises of low metabolic demand are displayed.

In addition, the software saved a complete record of its usage including total time and the time spent on every single module. It also recorded the number of correct or incorrect answers in cognitive games (Figure 1F).

Software accessibility assessment

Thirteen community-dwelling and 21 hospitalised older adults (average age 73.2 ± 9.1 years) assessed the software

accessibility. Patient demographic characteristics are shown in Table 1. No new comments about the software were collected after the seventh interview for both groups. Most of the hospitalised older adults got access to all the software functions without previous instructions about its operation (88%) and 100% after a short-standardised training process (Table 1). The results of the complete evaluation are shown in Supplementary Table 1.

### Software clinical feasibility assessment

In the clinical assessment, 62 patients were evaluated (32 without and 30 with the software implementation) using a before–after methodology. Patient characteristics are shown in Table 2. Most of the patients, 25 of 30 (83.3%) completed the protocol of 5 days using the software. Of the five patients who did not complete the protocol, two of them (16.6%) felt sick/not in the mood, two did not remember how to use the software and one thought the software was too simple. At baseline assessment, 5 of 32 (15.6%) patients developed delirium during the first 5 days of hospitalisation, compared with 2 of 30 (6.6%) of those who used the software (chi-square 1.24; $P = 0.26$).

Discussion

This article describes the development of a software for mobile devices, with a highly accessible interface, to bring non-pharmacological interventions for delirium prevention closer to hospitalised older adult patients. Considering the lack of implementation research on delirium care [8] and literature showing that lack of human resources and difficulties in maintaining continuous education programs are some of the main problems in the implementation of non-pharmacological interventions to prevent delirium [21–23], we believe that the use of technologies will contribute with a sustainable solution to address this problem.

Gerontechnology is the field of knowledge dedicated to the study of the application of technologies to improve well-being of older adults [24]. Although the use of technologies by older people is increasing worldwide [25], their implementation remains a great challenge [26, 27]. The generation of products focused on the person, ensuring their accessibility, usability and acceptability are critical [28], and for this purpose, the inclusion of older adults in the development process is firmly promoted. To face this challenge, in this study, we incorporated older adults all through the software development process, which probably resulted in the high levels of accessibility and usability observed during software assessment.

The data collected from the feasibility assessment suggest that the software can be implemented in clinical practice. As this is a feasibility study, sample size was not estimated to find differences in delirium incidence; however, the results suggest the efficacy of the software. All the collected data will be used to plan a clinical trial specifically designed to assess the efficacy of the software to prevent delirium.
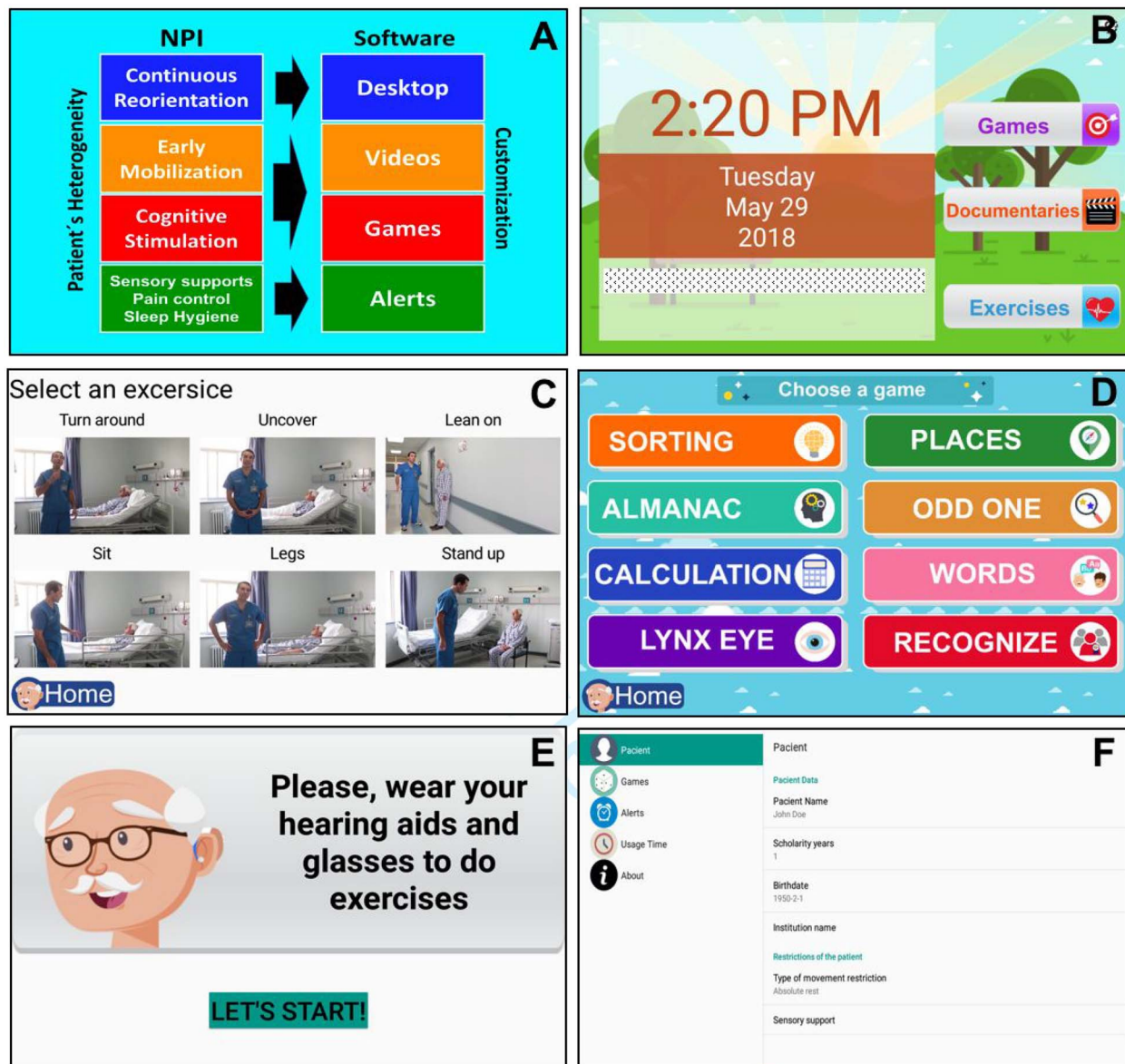
Figure 1. Software description. Images were translated into English to facilitate the understanding, insomuch as the version of the software is only available in Spanish. (A) How different non-pharmacological interventions to prevent delirium are incorporated into the software in several modules. (B) Software desktop continuously shows time and spatial information and gives easy and quick access to activities to promote cognitive and physical activation. (C) Short video capsules of physiotherapist-guided physical activities were designed to promote early mobilisation of the patients. (D) Different cognitive activities focused on attention and memory are displayed in an accessible interface; (E) visual alerts promote the use of sensorial supports, such as glasses or ear plugs and (F) the configuration panel that allows personalisation of the activities to the requirements of each patient, such as the level of difficulty of cognitive or physical activities, reminding the patient of the usage of sensorial supports, etc.

Although the software was particularly designed for older adult patients, during the implementation assessment, we realised that the software is a tool that facilitates the interaction between the older adult patient and their families, as it provides the family with a package of useful activities that they can carry out with their relatives while they are hospitalised. The software does not require an internet connection and was developed to be installed on simple tablets, making its implementation feasible even for healthcare systems with limited resources.

Cognitive impairment is a well-recognised risk factor for delirium, but at this stage of development we chose to exclude this population at this stage to avoid cognitive impairment as a confounding factor. In addition, delirium superimposed on dementia is an entity for which there is poor guidance regarding the specific tests to assess the

Table 1. Characteristics of older adults who participated in in the evaluation of accessibility and usability of the software.

	Community dwelling	In-Hospital	Total
n	13	21	34
Age (years)	71.8 (±10.3)	74 (±8.3)	73.2 (±9.17)
Gender (female %)	76.9	62	67.6
Education (years)	9.4 (±5.05)	8.76 (±2.79)	9 (±3.7)
Previous use of technology (% yes)	46.1	23	32.3
Access to main functions without instruction (% yes)	100	88	91.1
Access to main functions with instruction (% yes)	100	100	100
Date and time recall (% yes)	100	100	100
The use of the cognitive games was easy? (1–5 scale)	4.8 (±0.38)	4.4 (±0.33)	4.5 (±0.57)
Do you like the contents (exercises) of this software? (1–5 scale)	5 (±0)	4.7 (±0.47)	4.8 (±0.7)
Would you use this software during your hospital stay? (% yes)	100	100	100

Results are presented as average (±SD) or as percentage.

Table 2. Characteristics of older adults who participated in the software clinical feasibility assessment.

	Baseline	Software	Total
n	32	30	62
Age (years)	76.64 (±7.62)	75.72 (±8.37)	76 (±8)
Gender (female %)	61.2	58	59.5
Education (years)	9.85 (±5.33)	10.95 (±5.42)	10.53 (±5.32)
MMSE	27.6 (±2.22)	27.96 (±2.02)	27.82 (±2.12)
Charlson index	2.46 (±2.47)	1.82 (±1.41)	2.06 (±1.88)
Delirium (%)	15.6	6.6	11.29

Results are presented as average (±SD) or as percentage. No significant statistical differences between baseline and software groups were found.

cognitive processes impaired in delirium, which makes the feasibility assessment more difficult [29]. However, it is undoubtedly a population in which the applicability of this technology should be addressed in future research.

A current challenge is to solve some limitations, including the limited number of activities and contents, the need of a training session before its first use involving family/caregivers, its translation into other languages and its evaluation in patients with cognitive impairment.

Conclusions and implications

To our knowledge, this is the first software designed to improve the delivery of non-pharmacological interventions for delirium prevention in hospitalised older adults. The use of this technology might help healthcare providers to complement and improve non-pharmacological interventions to prevent delirium, enhancing the quality of care of hospitalised older adults.

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