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Association between voice-activated technology interventions and well-being in older adults living alone: a protocol for a systematic review and meta-analysis

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ABSTRACT

Introduction A growing number of community-dwelling older adults living alone face a range of physical, psychological and social challenges that negatively impact their well-being. Various technologies have been developed to support healthy ageing, with voice-activated technology (VAT) offering particularly promising opportunities to improve later life well-being. However, its effect on older adults living alone has not yet been systematically evaluated. Thus, this study aims to provide an evidence base for the effectiveness of VAT interventions in enhancing the physical, psychological and social well-being of older adults living alone.

Methods and analysis We will conduct a systematic review and meta-analysis of studies examining the use of VAT interventions among older adults living alone. The eligible study designs include randomised controlled trials and quasi-experimental studies. Primary outcomes will focus on physical, psychological and social well-being. A comprehensive search will be conducted across international (PubMed, Embase, Cochrane Library, CINAHL, PsycINFO, ProQuest and Web of Science) and Korean databases (RISS, DBpia and KISS). Two reviewers will independently conduct study selection, risk-of-bias assessment and data extraction. A meta-analysis will be conducted to synthesise the effects of VAT interventions on psychological, physical and social domains of well-being.

Ethics and dissemination Synthesising existing evidence, this review aims to inform the development of targeted interventions and support strategies to improve the well-being of older adults living alone. As no new data will be collected, ethical approval is not required. Findings will be published in a peer-reviewed journal to guide targeted intervention strategies and engage both academic and policy audiences.

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STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This review will comprehensively synthesise the effects of voice-activated technology (VAT) on older adults living alone, a vulnerable population at increased risk of poor well-being.
⇒ Conducted in accordance with rigorous standards, the review evaluates the quality of the included studies using a reliable, validated instrument.
⇒ This study will provide evidence on the effectiveness of VAT interventions to support their integration into community care for older adults living alone.

INTRODUCTION

Population ageing is accelerating globally, accompanied by a steady rise in the number of older adults living alone.[1] Older adults frequently experience complex health issues, including multimorbidity and age-related decline in mobility, vision, memory and hearing.[2] According to the United Nations Decade of Healthy Aging, well-being is a central component of successful ageing,[3] which is defined by WHO as 'the total universe of human life domains, including physical, mental and social aspects, that make up what can be called a good life'.[4] This definition underscores the need to consider physical, mental and social dimensions in promoting successful ageing.

Living alone has been recognised as a significant social determinant of both mental and physical health in older adults.[5] It is associated with a higher prevalence of multiple chronic conditions, as well as increased rates of hospitalisation and mortality.[6 7] Living alone is further associated with a heightened risk of cognitive decline, including dementia, and is strongly correlated with mental health issues such as depression, anxiety and loneliness.[8–11] Notably, previous studies estimate that 31.6–58% of older adults living alone have depressive symptoms, which are increasingly being recognised as a major public health and social concern.[12] These combined

physical and psychological challenges can substantially diminish quality of life and overall well-being.

Moreover, older adults living alone tend to have significantly lower levels of social connections with family, neighbours and community activities compared with those living with others, thereby increasing their risk of social isolation.[13–15] In contrast, those with strong social connections and group affiliations are more likely to experience better health and enhanced well-being.[16] As such, addressing social aspects is considered a critical factor in promoting well-being in later life.[17] Given these risk factors, older adults living alone should be identified as a high-risk group early on and prioritised for interventions aimed at reducing social isolation. Such proactive, targeted interventions may be vital for improving overall well-being among this population.[18]

Meanwhile, digital health interventions using laptops, tablet computers, smartphones and wearable devices have rapidly expanded in response to the growing need to promote well-being among older adults living alone.[19] These technologies can play a vital role in supporting older adults in their daily lives, particularly by enhancing health monitoring, ensuring safety and improving comfort. As such, they are considered promising solutions to the many challenges faced by this population.[20]

Among the recent advances in digital technologies offering new opportunities to improve well-being in later life,[21] voice-activated technology (VAT) has gained attention for its potential to enhance accessibility and interaction with digital systems.[22] Together with automatic speech recognition, VAT also enables spoken term detection, allowing users to initiate and complete tasks through voice commands.[23] By replacing the need for typing, voice-based interfaces significantly expand access to digital devices for older adults.[24] Commercial applications of VAT have recently been integrated into smart home systems, facilitating daily risk management and environmental control.[25] Moreover, these technologies are increasingly being embedded in robotic platforms, supporting functions such as schedule management and conversational interaction, thereby offering the potential for emotional support and companionship.[26 27] These technologies are hence increasingly recognised not merely as tools, but as potential social companions, with growing evidence suggesting their effectiveness in improving mental health.[26 28]

Various scoping and systematic reviews have examined the effects of digital interventions on older adults' psychological and social health.[29 30] For instance, an umbrella review found that most studies focused on information and communication technology and video conferencing, both of which improved social connectedness.[30] Reviews on VAT specifically have largely addressed older adults' perceptions, usability and acceptability of such devices.[24 31–33] While communication barriers were reported due to voice recognition errors, simple functions such as listening to music and checking the weather were frequently used. To date, only one systematic review has quantitatively evaluated the effects of VAT interventions in older adults, reporting a significant reduction in loneliness.[34] However, despite recognition that physical, psychological and social well-being are key elements of successful ageing, existing reviews have primarily examined VAT's impact on loneliness alone, leaving its broader impact on overall well-being unexplored. Moreover, no review to date has focused specifically on older adults living alone—a group at particularly high risk. A systematic review and meta-analysis are therefore warranted to synthesise current evidence on the effects of VAT interventions on well-being outcomes among this vulnerable population.

METHODS AND ANALYSIS

Objectives

Primary objective

To evaluate the effects of VAT interventions on three domains of well-being among older adults living alone:

1. Physical well-being (eg, activities of daily living, pain).
2. Psychological well-being (eg, loneliness, depression).
3. Social well-being (eg, social support, social participation).

Secondary objectives

1. To compare the effects of VAT interventions across the physical, psychological and social domains of well-being.
2. To examine whether the effectiveness of VAT interventions varies by intervention type (eg, smart speakers, mobile applications).

Design

This systematic review and meta-analysis will be conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The protocol for the review was registered with the International Prospective Register of Systematic Reviews before commencement.

Selection criteria

The selection of studies will follow the eligibility criteria under the PICOS format detailed below.

Population

Participants were defined as older adults living alone, including those described as older adults in the original studies. Studies with broader populations were eligible for inclusion if they provided separate outcome data for older adults living alone.

Intervention

Interventions were defined as the use of VAT, which executes user commands through voice recognition, natural language processing, machine learning or speech-to-text conversion.

Control

For randomised controlled trials (RCTs), all types of control conditions, including conventional care or waitlist

comparison groups, will be considered eligible. For pre-post studies, the intervention effect will be calculated by subtracting the post-intervention values from the baseline values. Due to the nature of these study designs, a control group will not be included.

Outcome

Eligible studies will include those that assess physical, psychological and social well-being using validated instruments, with outcomes measured both before and after the intervention. Physical well-being will be defined as perceived or objectively assessed physical functioning and health status, encompassing indicators of physical decline and functional capacity as assessed by validated instruments (eg, Katz Index of Independence in Activities of Daily Living, Barthel Index).[35] Psychological well-being will be defined as mental and emotional states operationalised through validated instruments (eg, Geriatric Depression Scale, UCLA Loneliness Scale).[36] Social well-being will be defined as participation in society and perceived social integration or support, operationalised through validated instruments (eg, Lubben Social Network Scale).[37] Outcomes measured in individuals other than direct recipients of the intervention, such as caregivers or staff, will be excluded. Functional evaluations of the intervention, such as assessments of usability, utility or adaptability, will not be considered.

Study design

All RCTs and quasi-experimental studies published in English or Korean, quantitatively assessing the impact of VAT interventions on older adults living alone, will be included. Publications such as study protocols, case reports, letters, books, opinion pieces, editorials, weekly reports, reviews and policy documents will be excluded.

Data sources and search strategy

The search approach will include both Medical Subject Headings terminology and free-text keywords to reflect the target population and themes of interest. We will systematically search international databases, including PubMed, Embase, Cochrane Library, CINAHL, PsycINFO, ProQuest and Web of Science, as these databases cover a broad range of literature in medicine, nursing and healthcare systems. For domestic literature, Korean databases such as RISS, DBpia and KISS will also be searched. Search terms included combinations of keywords such as 'living alone', 'aged' and 'voice activated'. The detailed search strategies adapted for each database are presented in online supplemental appendix 1. To optimise the search strategy, we will consult literature search experts. The search strategy will include studies regardless of their publication status or date.

Screening and selection procedures of eligible studies

Two reviewers will independently perform the study selection process. Titles and abstracts will be screened for eligibility, and duplicate records will be removed. Full-text articles will then be retrieved and assessed for inclusion. Any disagreements between the reviewers will be resolved through discussion and mutual agreement. A third reviewer will be consulted in cases where consensus cannot be achieved.

Assessment of risk of bias

Two reviewers independently will evaluate the methodological quality of the included studies using critical appraisal checklists provided by the Joanna Briggs Institute (JBI). For RCTs, the checklist included 13 items covering five domains of potential bias: selection and allocation, administration of the intervention/exposure, assessment and measurement of outcomes, participant retention and statistical conclusion validity.[38] For quasi-experimental studies, the JBI checklist comprises nine items reflecting seven domains of bias: temporal precedence, selection and allocation, confounding factors, administration of the intervention/exposure, outcome assessment and measurement, participant retention and statistical conclusion validity.[39] Each item was rated as 'yes', 'no', 'unclear' or 'not applicable'. Discrepancies will be resolved through discussion with a third reviewer. Additionally, to assess potential publication bias, if multiple quantitative studies with comparable designs and outcome measures are identified, we will apply quantitative synthesis methods, including the calculation of weighted effect sizes and the use of funnel plots.

Data extraction

Based on our review of existing studies in this area, study information (eg, publication year, publication type, study design, aim, setting), sample characteristics (eg, participants' age group, sex, sample size, country), intervention characteristics (eg, intervention duration, setting), details related to VAT, including the type of intervention (eg, device type, conversation availability) and effect size data for each included study will be coded in the current meta-analysis. For RCTs, standardised mean differences (SMDs) and 95% CIs will be extracted. For pre-post studies, SMDs will be calculated using means and SD of pre-intervention and post-intervention scores or derived from available test statistics, such as t or F values.

Data synthesis and analysis

All included studies will be required to quantitatively assess outcomes using validated measurement tools. Outcomes will be categorised into three domains—physical, psychological and social—and subsequently synthesised. For each outcome, we will extract the mean, SD and sample size for both intervention and control groups. When outcomes are assessed and reported at multiple time points, the final post-intervention measurement will be used for the primary meta-analysis.

Effect sizes will be presented as Hedges' g, a bias-corrected SMD that enables pooling results across studies using different but comparable measurement scales. Given the broad construct of well-being, we will conduct outcome-specific analyses (eg, depression, loneliness,

frailty, pain, quality of life) to identify which outcomes are most affected by VAT interventions.

Between-study heterogeneity will be assessed using the I^2 statistic, with values of 25–49% indicating low heterogeneity, 50–74% moderate and ≥75% high. When substantial heterogeneity is present, we will perform meta-regression or meta-ANOVA with prespecified moderators, including well-being domain, type of VAT intervention and participant characteristics. We will report the R^2 statistic to indicate the proportion of variance explained, as well as the Q statistic and its p value. Statistical analyses will be performed using R V.4.4.1.

DISCUSSION

Advancements in artificial intelligence and digital health technologies have accelerated interventions for vulnerable older adults.[19] Among these, VAT shows particular promise in enhancing well-being by enabling older adults to engage in leisure activities, supporting health monitoring and safety, and providing functions such as schedule management and conversational interaction.[20 25]

While digital interventions have demonstrated potential benefits for older adults, meta-analyses specifically examining VAT remain limited, particularly those focusing on older adults living alone, a group at heightened risk of poor health and well-being outcomes.[21 29 30 40 41] To address this gap, our study seeks to identify the potential benefits of VAT interventions for older adults living alone and highlight the importance of including this vulnerable population in future VAT intervention research. Our findings may contribute to the development of tailored and effective VAT interventions for this population.

This study will have some limitations. First, the application of VAT in home settings is relatively new; as a result, RCTs using this approach remain limited, although quasi-experimental studies will also be included to address this. Second, the literature search was limited to English and Korean, potentially resulting in language and publication bias owing to the exclusion of studies in other languages.

ETHICS AND DISSEMINATION

To the best of our knowledge, this will be the first study to examine the impact of VAT interventions on well-being outcomes in older adults living alone. The results are expected to support the development of targeted interventions for this vulnerable population, and strategies to improve their well-being. As this research is a systematic review and meta-analysis based entirely on previously published studies, it does not involve any human participants or new data collection; therefore, ethical approval from an institutional review board is not required. The findings will be disseminated through publication in a peer-reviewed academic journal to ensure broad accessibility and inform both academic and policy communities.

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