Geriatric Nursing 55 (2024) 339–345

Contents lists available at ScienceDirect

Geriatric Nursing

journal homepage: www.gnjournal.com

Featured Article

Impact of information technology supported serious leisure gardening on the wellbeing of older adults: The Turntable project

István Vassányi, PhD[a,*], Benedek Szakonyi[a], Daniela Loi, PhD[b], Angelika Mantur-Vierendeel[c], João Quintas, PhD[d], Antonio Solinas[e], Bojan Blažica, PhD[f], Luigi Raffo, PhD[b], Marco Guicciardi, PhD[g], Andrea Manca[g], Balázs Gaál, PhD[h], Ferenc Rárosi, PhD[i]

[a] *Medical Informatics R&D Centre, University of Pannonia, Veszprém, Hungary*
[b] *Department of Electrical and Electronic Engineering, University of Cagliari, Cagliari, Italy*
[c] *EuroFIR AISBL, Brussels, Belgium*
[d] *Laboratory for Automation and Systems, Instituto Pedro Nunes, Coimbra, Portugal*
[e] *Abinsula Srl., Sassari, Italy*
[f] *Jožef Stefan Institute, Ljubljana, Slovenia/Proventus d.o.o., Ajdovščina, Slovenia*
[g] *Department of Education, Psychology, Philosophy, University of Cagliari, Cagliari, Italy*
[h] *GINF Systems Ltd., Veszprém, Hungary*
[i] *Bolyai Institute, University of Szeged, Szeged, Hungary*

ARTICLE INFO

Article history:
Received 11 October 2023
Received in revised form 18 December 2023
Accepted 19 December 2023
Available online 29 December 2023

Keywords:
IT-assisted gardening
Successful ageing
Field trial
Smart sensors
Mobile apps

ABSTRACT

Objective: The study presented in this paper aimed to assess the effect of an Information Technology enabled community gardening program for older adults, developed by an international consortium.
Methods: We have executed a quantitative, pre- and post-test field trial with older adult volunteers to test the proposed programme in two European countries, Italy and Belgium (n=98). We used standardized and ad hoc questionnaires to measure changes in the volunteers' mental and psychological state during the trial. The statistical data analysis sought for differences in the pre- and post-test values of the key scores related to the perceived quality of life and benefits of gardening via paired-samples t-tests, and also tried to identify the important factors of significant changes via logistic regression.
Results: We found significant improvements in the perceived benefits of gardening and also in the scores computed from the WHO Quality of Life instruments, especially in the social sub-domains. The improvements were associated with the country, age, marital state and education of the volunteers. Higher age or being widow, divorced or single increased the odds of a significant improvement in the scores in more than one sub-domains.
Conclusion: Though the two trial settings were different in some aspects, the observed significant improvements generally confirmed the positive effects of gardening concerning the perceived quality of life and benefits of gardening.

Introduction

Due to the long-term demographic trends and changes taking place in most developed countries, preserving or improving the quality of life among older populations has emerged as a pivotal concern. Projections indicate that by the year 2050, approximately 30 % of the European populace will surpass the age of 65.[1] It is vital to keep older adults healthy and active as this reduces the social and economic burden of ageing while conferring direct benefits to the individuals themselves. Thus, the concept of 'successful ageing' has been developed, encompassing both the physiological and physical well-being of individuals, along with their cognitive, psychological and social aspects.[2] Central to this paradigm is the notion of feeling actively engaged, productive, and integrally linked within the fabric of society.

A previous study has shown that spending time in green spaces has positive effects on older people, including a reduction in stress, and merely visiting urban green spaces could be considered a preventive measure to preserve cardiovascular health.[3] There are also successful completed and ongoing pilot projects that focus on nature-based health and social care or promoting 'green' living for older adults in urban areas.[4–6]

*Corresponding author at: Medical Informatics R&D Centre, University of Pannonia, H-8200 Veszprém, Egyetem u. 10., Hungary
E-mail address: vassanyi.istvan@mik.uni-pannon.hu (I. Vassányi).

https://doi.org/10.1016/j.gerinurse.2023.12.014
0197-4572/$ – see front matter © 2023 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/)

Gardening is an active form of contact with nature which has demonstrated efficacy in supporting successful ageing in a number of small or middle-scale studies across the globe.[7] A more recent review based on evidence from several trials proposes a logic model to explain the improved self-esteem, cognition, vitality, reduced stress and other positive effects of gardening on mental health.[8]

The spectrum of gardening activities spans from informal 'leisure gardening' on community spots or on the balcony with no organized framework to Horticultural Therapy (HT) with planned and facilitated community sessions in nursing homes. A comprehensive review encompassingof 20 HT studies, predominantly involving participants in residential care facilities for older adults, reported improvements in well-being, anxiety/depression and social relations,[9] and these findings are confirmed by another recent review with several studies from China.[10] Furthermore, evidence supporting the enduring impact of gardening emerges from longitudinal studies, particularly in the Far East, like the Taiwan Longitudinal Study on Aging with 5000+ older adults, that associated gardening with improved survival over 11 years.[11] In survey-based studies, members of gardening groups reported significantly more social and physical benefits than non-members,[12] and gardening was associated with a social and active lifestyle.[13]

However, as underscored in a recent review summarizing 41 studies,[7] more experimental evidence are needed for more reliable and consistent results. The Turntable project aims to address this problem, with three innovative elements. Firstly, we used an Internet of Things (IoT) platform, developed by the project consortium, to support gardening education, planning, logging and social networking. Secondly, we performed a trial in two European countries. To our best knowledge, except a small-scale study,[14] no qualitative studies have investigated the effects of leisure gardening in a European setting. Thirdly, while our inclusion criteria didn't exclusively target individuals in perfect health, our objective didn't center on therapeutic intervention following severe medical events, such as stroke rehabilitation. Nevertheless, we did organize thematic sessions for participants—particularly because a significant portion of the European population lacks gardening experience, making basic education essential. This places our approach somewhere in between free leisure gardening and HT.

Related work

In the following short review, we focus on recent, intervention-type trials that are most relevant to gardening interventions among older adults.

A study with a relatively small volunteer cohort and an indoor HT program found significant improvements in perceived loneliness and depression. These improvements were quantified through standardized assessments employing the Geriatric Depression Scale and the UCLA Loneliness Scale in Taiwan.[15] Also in Taiwan, a study[16] employed saliva samples to measure immune protein levels, and an improvement was found after some weeks of HT. The subjective feelings of life satisfaction, well-being and happiness also improved after each HT session.

According to a 3-month study in Taiwan,[17] significant improvements were observed in cortisol levels and in most of the standardized scores, while in the control group, no significant improvement was detected. This investigation involved older adults grappling with mental health issues, with physical functional ability assessed through the Senior Fitness Test score. Another study from Korea used a low number of volunteers and found an improvement in the nature-relatedness, psychological well-being, and pro-environmental behavioral intentions in a pre- and post-test design.[18]

The two studies that are most similar to Turntable are those of Sia[19] and Barello.[14] The study reported by Sia used pre- and post-test design and standardized scores for evaluation, but in a 6-month HT programme. The monitored features included perceived physical health, sleep hygiene, depression, anxiety, cognitive performance and social connectedness, many of which were also included in the Turntable design. The study found an improved momentary affect, cognitive function and reduced anxiety. The study by Barello et al. is relevant because this is the only European project we could find in this field. The difference is that their focus was on post-stroke healing and that they used semi-structured interviews within a qualitative phenomenological approach to explore the subjective experience of performing part of their rehabilitation program in a therapeutic garden. The findings unveiled a highly affirmative perception among patients, highlighting the profound impact on their overall well-being. This underscores the potential advantages of such interventions in augmenting the rehabilitation trajectory. Table 1 summarizes the key features of the above studies for the sake of comparison.

None of the trials in the review above reported the use of mobile/IoT technology. Information Technology (IT) solutions, however, can strengthen different telecare services and thus improve the quality of life of older adults.[20,21] As for the IoT/IT support for gardening, several innovative solutions have been proposed recently. Lekjaroen et al. developed a prototype with a 'mini garden' equipped with moisture, temperature, etc., sensors that report to an Android app.[22] In a similar cloud-based 'smart gardening' solution, sensor data was uploaded into the cloud for analysis, after which either an automatic action, e.g. starting a water pump, was performed, or the user was notified.[23] Therefore, extending the scope in this direction was a logical step in our project.

Our main hypothesis was that gardening with the Turntable support helps those over 60, with capacity and an interest in gardening, to remain engaged and productive, which improves their self-reported quality of life and enhances their social and psychological well-being. More specifically, we expected to observe an improvement between the pre- and post-intervention state of the participants in their quality of life, familiarity with gardening-related

Table 1
Features of recent intervention-type studies on gardening for older adults.

Author, year	*Country*	*Study population (age)*	*Study design*	*Evaluation methods*
Chen et al., 2015 [15]	Taiwan	*n*=10 (avg. 75.3)	10-week indoor HT program, pre- and post-test	Interviews plus standardized forms/scores
Barello et al., 2016 [14]	Italy	*n*=22 (60–88)	10 bi-weekly sessions, keeping a diary	Semi-structured interviews
Han et al., 2018 [17]	Korea	*n*=28 (avg. 80.1)	3 months HT, pre- and post-test with control group (*n*=14)	Saliva samples, standardized forms/scores
Sia et al., 2020 [19]	Singapore	*n*=47 (avg. 77.5)	6 months HT, pre- and post-test with 5 time-points	standardized forms/scores
Shen et al., 2022 [16]	Taiwan	*n*=23 (70–93)	6 weeks of HT, pre- and post-test	Saliva samples, standardized forms/scores
Jo et al., 2022 [18]	Korea	*n*=12 (60–70)	5 months gardening, pre- and post-test	ad hoc or adapted standard forms
Turntable (this study, 2022)	Italy, Belgium	Italy *n*= 41 (avg. 68.8) Belgium *n*= 60 (avg. 85.2)	3 months gardening with IT support, pre- and post-test	Ad hoc and standardized forms/scores

topics, and their attitude and familiarity in the use of modern information technologies. We also expected a generally positive acceptance of the Turntable solution.

Material and methods

Components of the Turntable system

The Turntable system has been developed by an international consortium in the framework of a European Horizon AAL programme. The system consists of one or more Agrumino wireless soil sensors, an Android mobile phone app and a backend framework (see Fig. 1). The sensor measures the light, ambient temperature and soil moisture and it can even control a small water pump. The mobile app reads data from the sensor and stores it in both a backend database and the cloud. The app is integrated from two parts, the Tomappo app that acts as a gardening diary and advisor for gardening activities and garden design, and the Lifely app that connects with the sensors and exposes the state of the plants in an intuitive graphical interface, e.g., "I'm thirsty" etc. Both apps contain educational materials about the plants and recommended cultivation practices. The backend supports user management, messaging, and event logging. We refined the functionality of the system in cooperation with small end-user groups before the implementation phase of the project.[24] For more information on the system, see the project web page.[25]

Study design

We have executed a quantitative, pre- and post-test field trial with older adult volunteers to test the proposed system in two European countries, Italy and Belgium. A small-scale trial was also started in Portugal, but it was not completed successfully.

Sample

The study used convenience sampling to recruit older adults and included volunteers aged over 60, familiar with touchscreen technology and having an interest in gardening, and did not include those with any relevant impairment or motor disability that would interfere with the execution of gardening activities and those unable to give an informed consent.

The volunteers were first informed about the goals and the methods of the trial, the data management scheme, etc., and they signed an informed consent. In Belgium (BE), the trial protocol was approved by the KU Leuven Social and Societal Ethics Committee in April 2021 (No. G-2021 04 2054). In Italy (IT), the protocol was approved by the Ethics Committee of the University of Cagliari in March 2021 (No. 0073531). We designed the trial according to the principles of the Helsinki Declaration of 1975, as revised in 2000.

Recruitment strategies included online posts on social media platforms, appeals for participation in local newspapers, dissemination of paper-based flyers at strategic public venues and shared with professional connections/retirement homes, and finally direct contact with several social care/supported living homes. In Italy, most of the volunteers responded to the recruitment flyer and initiated contact with the trial manager, and also several of them were recommended by associations of older adults. The recruitment resulted in 63 persons signing the informed consent, but only 41 of them finished the trial successfully in two groups (see Table 3). The groups consisted of 19 and 22 volunteers, respectively, including 8 men and 33 women, with an age average of 69 ± 4.50 years. In Belgium, a social care/supported living home confirmed their willingness to participate with 60 volunteers. Here we had 60 volunteers signing the informed consent, of which 57 completed the trial successfully, including 15 men and 42 women, with an age average of 85.4 ± 9.24 years.

Table 2 summarizes the changes in group sizes in the different phases of the project.

Intervention

Throughout the intervention period, volunteers were granted access to the app and were encouraged to visit the garden independently. Additionally, they actively participated in weekly gardening sessions conducted under the supervision of an instructor, each session spanning approximately two hours. These activities encompassed structured sessions on installing and utilizing the Turntable system, planning the garden, getting the soil ready, sowing the seeds of vegetables, watering and cultivating plants, among others, culminating in the harvesting of seasonal vegetables.

Participants not included in the data analysis were those who spent less than one month during the intervention period or exhibited low motivation by using the app fewer than two times a week for two consecutive weeks. Recruitment commenced in May 2021 and concluded in April 2022. The intervention phase terminated in September 2022.

In Italy, two consecutive groups, Autumn-Winter (AW) and Spring-Summer (SS), denoting respective seasons, were assembled. Most volunteers resided in their homes and utilized their personal smartphones. The gardening sessions were held at the Botanical Garden of the University of Cagliari, situated on the island of Sardinia. Conversely, in Belgium, participants lived together in a supported living facility catering to older adults. They utilized shared Android tablets pre-equipped with the Turntable app pre-installed. The facility provided access to a shared garden in Brussels.

Measures

We used standardized questionnaires, proven in several other studies, to measure changes in the volunteers' mental and psychological state during the trial, and also and an additional questionnaire to measure their attitude towards gardening.

The WHO Quality of Life (QOL_BREF) and the WHO Quality of Life in Older Adults (QOL_OLD) are two similar self-report questionnaires that measure the perceived quality of life. The QOL_BREF consists of 24 questions in 4 topics, Physical Health (7 questions), Psychological Health (6 questions), Social Relationships (3 questions) and

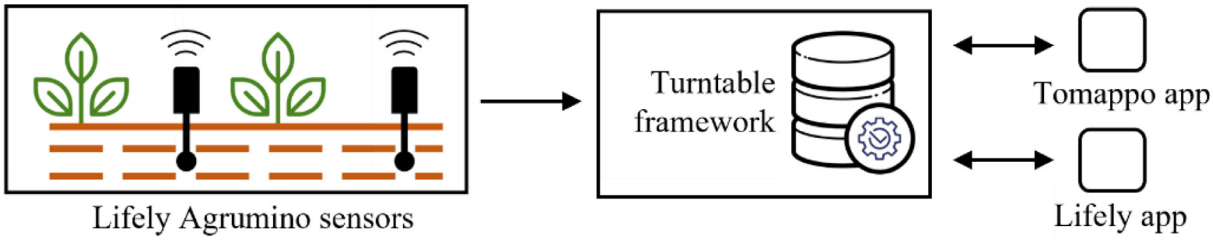

Fig. 1. The components of the Turntable system

Table 2
Dropouts during the execution of the trial protocol.

Trial phase	*No. of persons* (IT)	*No. of persons* (BE)	*No. of persons* (total)
Number of volunteers who signed the informed consent	63	60	123
Dropouts before the start of the intervention:			
. . .due to health conditions of the volunteers or their family members	−5	0	−5
. . .due to increasing number of Covid-19 cases in February 2022	−5	0	−5
. . .due to the obligation to have a Green Pass to visit the botanical garden	−7	0	−7
. . .due to the delay in the execution of the trial	−5	0	−5
Number of volunteers starting the intervention:	**41**	**60**	**101**
Dropouts due to lack of motivation	0	−3	−3
Number of volunteers successfully completing the trial:	**41**	**57**	**98**

Environmental (8 questions), plus two questions for assessing overall quality of life and general health. The questions are to be answered on a 5-point scale ranging from 'very dissatisfied' to 'very satisfied'. While QOL_BREF is a more general purpose instrument, the QOL_OLD focuses on the quality of life related to aging. It has 24 questions in a similar scheme, but with the domains Sensory Abilities, Autonomy, Past Present and Future Activities, Social Participation, Death and Dying and Intimacy, each supported by 4 questions. Finally, the Gardening Benefits Questionnaire includes 36 attitude statements in 8 factors (topics), rated on a 5-point Likert-type scale ranging from 1 = 'strongly disagree' to 5 = 'strongly agree'.[12] The objective is to measure the perceived benefits of gardening, i.e., volunteers' opinions and attitudes of gardening relative to purpose, feelings, and social engagement. The factors are Restoration benefits (8 statements), Attachment (5 statements), Physical benefits (5 statements), Spirituality benefits (6 statements), Social benefits (3 statements), Identity benefits (4 statements), Purpose (3 statements), Shared experience (2 statements). The above instruments are summarized in Table 3.

Prior to the commencement of the trial, demographic information was gathered, encompassing the participants' country, age, gender, marital status, and educational background. Age and education were considered as independent scale-type variables, while the remaining factors were classified into categories. The questionnaires were administered via SurveyMonkey web forms.[28] All questionnaires were taken in the control period i.e., before the start of the intervention and then repeated during the intervention period after 2 months of using the system. These two times will be referred to as T0 and T1, respectively. The trial was concluded with a final interview.

Data analysis

The data analysis aimed to address two questions: firstly, whether a significant change, either positive or negative, occurred between T0 and T1 concerning the key scores (dependent variables) within the entire cohort; and secondly, whether any independent variables can be linked to any observed significant changes. For each test in the statistical analysis, the relevant assumptions, including missing values, univariate/multivariate normality of distributions, univariate/multivariate outliers, multicollinearity, etc., were verified, and appropriate corrections were applied.

First we used a standard paired-samples t-tests to compare the dependent variables at T0 and T1 to check for significant changes. If a variable had any sub-scores, we repeated the test also on each of the sub-scores. In the second step, we built logistic regression models to find the predictor independent variables of the significant changes. For these tests, we binarized the target score using a range and distribution dependent threshold (cutoff) value such that a score above the cutoff should fall into the 'improved' category. When building the model, we used the forward likelihood (stepwise) variable selection method that terminates when the accuracy of the model improves no longer.

Throughout the analysis *P*-values $p < 0.05$ were regarded as statistically significant.

Table 3
The most important questionnaires used in the Turntable project.

Short name	*Name*	*Notes*
QOL_BREF	WHO Quality of Life	Measuring the general perceived quality of life[26], Cronbach's alpha: 0.91. Range: 24–120
QOL_OLD	WHO Quality of Life in Older Adults	Measuring the quality of life related to aging[27], Cronbach's alpha: 0.85. Range: 24–120
GARDEN	Gardening Benefits Questionnaire	Measuring the perceived benefits of gardening, i.e., volunteers' opinions and attitudes of gardening relative to purpose, feelings, and social engagement. Cronbach's alpha: 0.61–0.91. Range: 36–180

Results

Table 4 shows the demographic characteristics of the whole study population and the sub-groups for easy comparison.

In the first step, we performed a paired-samples t-test on the whole study population (n=98) for the scores listed in Table 3, and found six significant changes between the T0 and T1 values, each showing an improvement. In the case of GARDEN, we found a significant increase of 17.90 points ($p < 0.001$, 95 % Confidence Interval 15.23–20.56). For QOL_BREF, there was a significant increase of 2.27 points ($p = 0.012$, 95 % CI 0.51–4.26). We also performed the test on the sub-scores of QOL_BREF, and found a 0.75 point increase on the Physical Health domain (QOL_HEALTH, $p = 0.006$, 95 % CI 0.22–1.28,) and a 1.01 point increase on the Social Relationships domain (QOL_SOC, $p < 0.001$, 95 % CI 0.43–1.59). We must note that the value range of the QOL_BREF sub-scores, and also those of QOL_OLD, is only 4–20 points, so a 1-point increase means much more than on the full score with a range of 20–120 points. Finally, the QOL_OLD sub-scores Past Present and Future Activities (OLD_PPF) and Social Participation (OLD_SOP) also increased significantly (by 0.69 points, $p = 0.005$, 95 % CI 0.21–1.17 for the former, and 0.68 points, $p = 0.010$, 95 % CI 0.17–1.20 for the latter).

In the second step, we used a cutoff value of 20 points for the GARDEN score and found that the only significant predictor of the model was the Country variable ($p < 0.001$, odds ratio = 5.606, 95 % CI 2.29–13.66). This means that being a volunteer in the Belgian trial increases the odds of improvement by a factor of 5.606. The QOL_BREF, with a cutoff of 4 points, was linked to two predictors, Education ($p = 0.050$, odds ratio = 0.546, 95 % CI 0.29–1.00) and Marital ($p = 0.04$, odds ratio = 2.88, 95 % CI 1.04–7.96). Thus, having higher education (university degree) *decreases* the odds of improvement by

Table 4
Basic characteristics of the study population and the sub-groups.

	Italy, AW group	Italy, SS group	Belgium	Whole cohort
Age	69.0 ± 4.74	68.4 ± 4.02	85.4 ± 9.24	78.2 ± 11.10
Gender	16 women, 3 men	17 women, 5 men	42 women, 15 men	75 women, 23 men
Marital status (married/partnership; widowed/divorced/single)	12 m/p, 7 w/d/s	9 m/p, 13 w/d/s	3 m/p, 54 w/d/s	24 m/p, 74 w/d/s
Education level (primary school/lower secondary school; upper sec. school/high school diploma; univ. degree)	5 ps/lss, 9 uss/hsd, 5 ud	4 ps/lss, 7 uss/hsd, 11 ud	6 ps/lss, 24 uss/hsd, 27 ud	15 ps/lss, 40 uss/hsd, 43 ud
Garden type (large garden/back garden; balcony/terrace; no garden)	9 lg/bg, 9 b/t, 1 no garden	6 lg/bg, 11 b/t, 5 no garden	(retirement home with a shared garden)	N/A
Persons living together	12	9	(retirement home)	N/A

a factor of 0.502, while being widow, divorced or single increases the odds by 2.88. We used the same cutoff value of 1 point for the subscores of QOL_OLD and QOL_BREF. The QOL_SOC improvement was associated with Age (p = 0.003, odds ratio = 1.061, 95 % CI 1.02–1.10). Since the age was measured in years, the odds of improvement was found to improve by a factor of 1.061 by every year of age. For the QOL_HEALTH, no significant predictors among the demographic variables could be found. The OLD_PPF improvement had a single predictor, Age (p = 0.033, odds ratio = 1.042, 95 % CI 1.00–1.08). Finally, the OLD_SOP had no significant predictors.

Discussion

According to the statistical analysis, the perceived quality of life (QOL_BREF, QOL_SOC, QOL_HEALTH, OLD_PPF, and OLD_SOP) improved significantly in the whole study population during the intervention. Though the improvement of the main QOL_OLD score was not statistically significant, we found no significant worsening in any of the QOL-related sub-scores. Since the social domain improved both in the general (QOL_SOC) and the age related (OLD_SOP) sense, we may conclude that according to the results, better social connections may be related to IT-supported gardening. These positive changes seem to confirm our initial hypothesis concerning the quality of life. Since the GARDEN score measures the perceived benefits of gardening, an improvement in this aspect was also a naturally expected outcome of the project, meaning that most volunteers liked gardening with the Turntable support and in general appreciated gardening more after the trial. The strong improvement (17.9 points on a 180-point scale) confirms this expectation.

The logistic regression models emphasize the importance of the age, marital state, education and the country among the independent demographic variables. It may be surprising that higher age is linked with more improvement in two QOL sub-domains, QOL_SOC and OLD_PPF. This effect may be due to a less satisfied mental startup condition of these volunteers that could improve more, compared to younger participants, during the trial. Similarly, those without a spouse may naturally find more reward in gardening than those living in partnership, especially since the Turntable apps actively try to impersonate the vegetables planted by the user. This may be reflected in the appearance of the Marital variable as a predictor of the QOL_BREF improvement. We should note that the demographic variables may have influenced the dependent variables in other ways as well, which the relatively small group sizes have prevented from emerging in this trial.

The location (Country variable) also exhibits a strong effect on the main QOL_BREF score, emphasizing the importance of the differences between the two setups. The Belgian group was quite different, as it could be characterized by a higher average age (above 85) and a living arrangement in a retirement home. Gardening and using mobile devices at this age may prove a much more challenging task than in the 60s. Another difference was that the volunteers shared the same daily routine and meals furthermore, volunteers had no mobile devices of their own and had access to shared tablets only for periods of time, while Italian volunteers used their own devices without any limitation. The effect of these differences is clearly reflected in the statistical analysis, calling for an extended, country-wise elaboration of the changes as an extension of this analysis.

According to the final interviews, most notably in Italy, an important indirect impact of the project was the improvement of digital literacy for some volunteers. Another effect on volunteers was the development of a sense of belonging to a community. During trial activities, volunteers organized various moments of conviviality, through which they shared homemade food and coffee and came into contact with each other. Many of these social interactions developed into friendships that outlasted the end of the trial.

Limitations

Due to the design of the trial with no dedicated control groups, any T0–T1 change that we experienced in the scores might have been influenced by external factors that we could not control in the trial. The two most important such factors could be the quickly changing Covid-19 situation, which could have an impact on our volunteer's perceived quality of life, via the restrictions and also via the so-called 'Covid-depression', especially for volunteers with a higher age, and the changing of the seasons and weather conditions in general, which gains specific importance due to the outdoor gardening focus of the Turntable solution. It should be noted, however, that though there was a big change both in the Covid situation during the trial in Italy and also in the season, between the 'Autumn-Winter' and 'Spring-Summer' groups, we did not experience a considerable difference between the performances of these two groups. This fact adds to the reliability of the findings.

In lack of a gardening control group with no IT support, we could also not separate the presumably positive effect of community gardening from the pure (presumably positive) effect of using the Turntable solution as a gardening support.

Comparison of the results to related work

It is hard to directly juxtapose the score variations we have observed with those reported in the extant literature. This difficulty arises primarily from the substantial disparities in cultural contexts, with a majority of pertinent studies having been conducted within vastly different cultural settings such as Taiwan, Korea and Singapore (see the 'Related work' for more details), alongside the utilization of standardized scoring systems that diverge from those adopted in Europe.

The study with the most similar setup in terms of settings and activities is the one conducted by Barello.[14] However, there are still significant differences that limit direct comparisons. Firstly, there is a distinction in the method of guiding patients during gardening activities. In Barello et al., specialized therapists actively guided and adapted gardening tasks based on patient abilities, while in our study, participants used a mobile application as a self-guided tool for engaging in gardening activities. The choice of guidance method (therapist-led vs. app-guided) can result in divergent outcomes in terms of participant experience. Secondly, Barello et al. present the outcomes of their qualitative phenomenological investigation into patients' perceptions of therapeutic gardening, focusing on subjective representations and meanings related to interactions with nature, the therapeutic gardening experience, and its potential to enhance patient engagement in their care management. In contrast, our study specifically examined changes in the mental and psychological states of the volunteers using quantitative approaches. The setup of our trials made it possible to track the individual changes in the mental or psychological state of the volunteers, which led to stronger evidence than studies using no intervention, though with considerably more volunteers.[12,13] Furthermore, compared to other studies based on the introduction of gardening activities at an older age,[28] a strength of our study is the use of multiple and standardized instruments for measuring the effect of the intervention.

Conclusion

The paper presented the design and the results of a multi-center community gardening trial for older adults in Italy and Belgium. Though the two trial settings were different in some aspects, the observed significant improvements generally confirmed the positive effects of gardening concerning the perceived quality of life and benefits of gardening.

Declaration of Competing Interest

None declared.

CRediT authorship contribution statement

István Vassányi: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation. **Benedek Szakonyi:** Methodology. **Daniela Loi:** Writing – review & editing, Visualization, Supervision, Methodology, Investigation, Data curation. **Angelika Mantur-Vierendeel:** Methodology, Investigation, Data curation. **Antonio Solinas:** Software, Project administration, Funding acquisition, Conceptualization. **Bojan Blažica:** Software, Funding acquisition, Conceptualization. **Luigi Raffo:** Conceptualization. **Marco Guicciardi:** Conceptualization. **Andrea Manca:** Investigation, Conceptualization. **Balázs Gaál:** Software. **Ferenc Rárosi:** Formal analysis.

Acknowledgements

The authors wish to thank all involved project partners and the volunteers for contributing to the field trial.

This research has been co-funded by the European Commission and National Funding Authorities of Italy, Belgium, Hungary, and Portugal (AAL-2018-5-163-CP), and has partially been funded by the Slovenian Research Agency (research core funding No. P2-0098). Project no. 2019-2.1.2-NEMZ-2019-00003 has been implemented with support from the National Research, Development and Innovation Fund of Hungary, financed under the AAL-2018-5-163-CP funding scheme.

References

1. European Council. *The Impact of Demographic Change in a Changing Environment* (Report).; 2023. https://commission.europa.eu/system/files/2023-01/Demography_report_2022_0.pdf.
2. Urtamo A, Jyväkorpi SK, Strandberg TE. Definitions of successful ageing: a brief review of a multidimensional concept. *Acta Biomed*. 2019;90(2):359–363. https://doi.org/10.23750/abm.v90i2.8376.
3. Kabisch N, Püffel C, Masztalerz O, Hemmerling J, Kraemer R. Physiological and psychological effects of visits to different urban green and street environments in older people: a field experiment in a dense inner-city area. *Landsc Urban Plan*. 2021;207: 103998. https://doi.org/10.1016/j.landurbplan.2020.103998.
4. Zhong Y-Q, Tu H-M. Horticultural activity type, psychological well-being, and fruit and vegetable intake. *Nutrients*. 2020;12(11):3296. https://doi.org/10.3390/nu12113296.
5. Green4c P. Green4C Knowledge Alliance. 2020. https://www.greenforcare.eu/ Accessed 1 December 2023.
6. GRAGE P. Grey and green in Europe. Elderly living in urban areas. 2016. https://www.academia.edu/39994238/Grey_and_green_in_Europe_Elderly_living_in_urban_areas. Accessed 1 December 2023.
7. Gagliardi C, Piccinini F. The use of nature – based activities for the well-being of older people: an integrative literature review. *Arch Gerontol Geriatr*. 2019;83:315–327. https://doi.org/10.1016/j.archger.2019.05.012.
8. Howarth M, Brettle A, Hardman M, Maden M. What is the evidence for the impact of gardens and gardening on health and well-being: a scoping review and evidence-based logic model to guide healthcare strategy decision making on the use of gardening approaches as a social prescription. *BMJ Open*. 2020;10(7): e036923. https://doi.org/10.1136/bmjopen-2020-036923.
9. Nicholas SO, Giang AT, Yap PLK. The effectiveness of horticultural therapy on older adults: a systematic review. *J Am Med Dir Assoc*. 2019;20(10):1351.e1–1351.e11. https://doi.org/10.1016/j.jamda.2019.06.021.
10. Wang M, Wu J, Yan H. The effect of horticultural therapy on older adults in pension institutions: a systematic review. *Geriatr Nurs (Minneap)*. 2023;51:25–32. https://doi.org/10.1016/j.gerinurse.2023.02.006.
11. Wang J-D, Lêng CH. Daily home gardening improved survival for older people with mobility limitations: an 11-year follow-up study in Taiwan. *Clin Interv Aging*. 2016;11:947–959. https://doi.org/10.2147/CIA.S107197.
12. Scott TL, Masser BM, Pachana NA. Positive aging benefits of home and community gardening activities: older adults report enhanced self-esteem, productive endeavours, social engagement and exercise. *SAGE Open Med*. 2020;8: 205031212090173. https://doi.org/10.1177/2050312120901732.
13. Cheng E, Pegg S. If I'm not gardening, I'm not at my happiest": exploring the positive subjective experiences derived from serious leisure gardening by older adults. *World Leis J*. 2016;58(4):285–297. https://doi.org/10.1080/16078055.2016.1228219.
14. Barello S, Graffigna G, Menichetti J, et al. The value of a therapeutic gardening intervention for post-stroke patients' engagement during rehabilitation: an exploratory qualitative study. *J Particip Med*. 2016;8:e9.
15. Chen Y-M, Ji J-Y. Effects of horticultural therapy on psychosocial health in older nursing home residents. *J Nurs Res*. 2015;23(3):167–171. https://doi.org/10.1097/jnr.0000000000000063.
16. Shen J-L, Hung B-L, Fang S-H. Horticulture therapy affected the mental status, sleep quality, and salivary markers of mucosal immunity in an elderly population. *Sci Rep*. 2022;12(1):10246. https://doi.org/10.1038/s41598-022-14534-x.
17. Han A-R, Park S-A, Ahn B-E. Reduced stress and improved physical functional ability in elderly with mental health problems following a horticultural therapy program. *Complement Ther Med*. 2018;38:19–23. https://doi.org/10.1016/j.ctim.2018.03.011.
18. Jo J-H, Shin S, Son Y-G, An B-C. Seniors' participation in gardening improves nature relatedness, psychological well-being, and pro-environmental behavioral intentions. *J People Plants Environ*. 2022;25(3):297–309. https://doi.org/10.11628/ksppe.2022.25.3.297.
19. Sia A, Tam WWS, Fogel A, Kua EH, Khoo K, Ho RCM. Nature-based activities improve the well-being of older adults. *Sci Rep*. 2020;10(1):18178. https://doi.org/10.1038/s41598-020-74828-w.
20. Akbar MF, Ramadhani NA, Putri RA. Assistive and wearable technology for elderly. *Bull Soc Inform Theory Appl*. 2018;2(1):8–14. https://doi.org/10.31763/businta.v2i1.101.
21. Macis S, Loi D, Ulgheri A, et al. Design and usability assessment of a multi-device SOA-based telecare framework for the elderly. *IEEE J Biomed Heal Inform*. 2020;24(1):268–279. https://doi.org/10.1109/JBHI.2019.2894552.
22. Lekjaroen K, Ponganantayotin R, Charoenrat A, Funilkul S, Supasitthimethee U, Triyason T. IoT planting: watering system using mobile application for the elderly. *2016 International Computer Science and Engineering Conference (ICSEC)*. IEEE; 2016:1–6. https://doi.org/10.1109/ICSEC.2016.7859873.
23. Sharma S, Sharma A, Goel T, Deoli R, Mohan S. Smart home gardening management system: a cloud-based internet-of-things (IoT) application in VANET. *2020 11th International Conference on Computing, Communication and Networking Technologies (ICCCNT)*. IEEE; 2020:1–5. https://doi.org/10.1109/ICCCNT49239.2020.9225573.
24. Szakonyi B, Vassányi I, Mantur-Vierendeel A, Loi D, Correia G, Blažica B. Co-creating digital services to promote active lifestyle among older adults: the turntable project. In: *Proceedings of the 7th International Conference on Information and Communication Technologies for Ageing Well and E-Health*. SCITEPRESS - Science and Technology Publications; 2021:213–220. https://doi.org/10.5220/0010474902130220.

25. Turntable Project. Turntable: a platform supporting vitality and ability of elderly. 2020. https://www.aalturntable.eu/ Accessed 1 December 2023.
26. De Girolamo G, Rucci P, Scocco P, et al. Quality of life assessment: validation of the Italian version of the WHOQOL-Brief. *Epidemiol Psichiatr Soc*. 2000;9(1):45–55. https://doi.org/10.1017/S1121189×00007740.
27. Power M, Quinn K, Schmidt S. Development of the WHOQOL-Old module. *Qual Life Res*. 2005;14(10):2197–2214. https://doi.org/10.1007/s11136-005-7380-9.
28. Momentive. SurveyMonkey online platform. 1999. https://www.surveymonkey.com/ Accessed 1 December 2023.