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The Effect of Yoga on Balance in Community-Dwelling Older Adults With Knee Osteoarthritis

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Abstract
This study aims to assess yoga's potential to improve balance in older adults with knee Osteoarthritis (OA). The Hatha yoga intervention consisted of an 8-week, two 60 minutes in-person yoga sessions per week. Outcomes measured: Berg Balance Scale (BBS), Short Physical Performance Battery (SPPB), Single Leg Stance (SLS), 6 Minute Walk Test (6-MWT). The yoga group (n=12) statistically improved their 6-MWT mean of -67.92 ± 60.76 p = .003, SPPB score saw a median of 1 p = .010. SLS test left leg lifted the mean of -5.45 ± 5.63 p = .006 and with eyes closed mean of -0.88 ± 0.63 p = .001. Elements of the SPPB test were analysed further resulting in a statistical improvement: The 5 repeated timed sit-to-stand resulted in a mean of 3.30 ± 4.09 p = .017, and the 2.44 MWT saw a median of 0,22 p = .005. There was a slight improvement in the BBS median of 1.5 p = .42. SLS right leg lifted mean of -5.37 ± 9.33 p = .071, eyes closed mean of -0.96 ± 1.51 p = .049. The study's single pilot design indicated that the tailored 8-week yoga intervention positively influenced balance and functional mobility outcomes in older adults with knee OA.

Keywords: Knee Osteoarthritis, Yoga, Balance, Mobility, Older Adults

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Introduction

Osteoarthritis

The most common form of chronic joint disease in older adults is a clinical condition called osteoarthritis (OA), which is characterized by joint pain, swelling, stiffness and dysfunction brought on by the breakdown of tissue in and around the synovial joint (Buckwalter et al.,2004). Osteoarthritis is the most prevalent form of arthritis, affecting the knees, hips, hands, and spine. 1 in 3 people over the age of 60 years old are reported to suffer from this disease, studies show that prevalence is higher in women over the age of 50 years compared to men (Oliveria et al., 1995).

Living with knee OA can be challenging, as individuals often experience debilitating pain, stiffness, swelling and obstructed joint range of motion. These symptoms can lead to gait changes, functional decline, and loss of independence. The impact on physical functioning decreases a person's willingness and ability to ambulate, and experience fewer social interactions, while impeding their ability to perform activities of daily living (ADL) and notably a decreased perception of quality of life (Bradley et al., 2004).

According to the American College of Rheumatology, the clinical criteria for the diagnosis of Knee OA consists of being over 50 years of age and having three or more of the following conditions: Knee pain most days of the week, knee stiffness in the morning lasting no longer than 30 minutes, Joint crepitus, bony tenderness, or enlargement (Altman et al., 1986).

Both the American Geriatrics Society (AGS) and the American College of Rheumatology recommend physical activity as a key component in the prevention and management of knee OA. Exercise provides many benefits to people with knee osteoarthritis, however, physical activity is not entirely risk-free (Bennell et al, 2011). Therefore, an exercise prescription that is safe and well tolerated is essential for the treatment of knee OA. Unfortunately, there are reports from the 2001 Behavioural Risk Factor Surveillance Survey (BRFSS) that indicate 24% of adults with arthritis do not adhere to the recommended public health physical activity guidelines of 30 minutes of moderate activity a day on 5 or more days a week, or 20 minutes of vigorous activity on 3 or more day a week (Chmelo et al., 2013). Physical inactivity can lead to a decline in functional mobility, balance, muscle strength, muscle mass, endurance and cognitive function and can impact a person’s overall quality of life. Since most people with knee OA are over the age of 60, sedentary older adults may be at a higher risk of falling and developing comorbid conditions, which may further limit their functional abilities.

Yoga

Yoga is an ancient mind-body practice that originates in Indian culture and can be traced as far back as 2200 years ago (Singh, 2010). The word "yoga" is a Sanskrit word when translated to English meaning "yoke" referring to a union or connection. The union of the mind and spirit through movement (poses) brings balance and harmony to the body and promotes healing (Garfinkel et al, 2000).

Yoga is an exercise that emphasises mindful movement, integrating breathing, selfawareness, and muscular activity. In contrast to traditional exercise, yoga offers a foundation of static poses and dynamic movement that engages muscular activation to resist the force of gravity while maintaining alignment and stability (Singh, 2010).

Yoga is not well-researched as a physical activity for older adults with knee OA despite its popularity. Recent studies have shown yoga can benefit older adults with poor mobility and balance (Youkhana et al., 2016). An 8-week pilot study carried out by Cheung et al. (2014) specifically for women with knee OA demonstrated using the Western Ontario and McMaster University Osteoarthritis Index an improvement in perceived pain (p=.01), physical function and mobility performances (p=.03) compared to the waitlist control group. This demonstrated the favourable results that yoga has over a short period. Another 8-week study investigated the effects of a Hatha-based yoga program in adults with knee OA or rheumatoid arthritis compared to a waitlist control group. The yoga group demonstrated greater improvements in pain, physical function and quality of life compared to the control group. The improvement gained during the study could still be seen after nine months of finishing the study. This shows that yoga can have a prolonged and lasting positive effect on alleviating the symptoms associated with this condition (Moonaz et al, 2015).

Physiologically, yoga promotes joint movement which helps to decrease the inflammation at the joint by decreasing interleukin-1 involved in the process of cartilage breakdown. This leads to decreased fluid pressure in the joint which helps to preserve the cartilage tissue (Srivastava, et al., 2015). A 12-week yoga program designed to strengthen the quadriceps that focused on minimising the knee adduction moment (KAM) for women with knee OA showed an improvement in mobility performance during the walking (p=.001) and sit-to-stand (p=.006) tasks. The study focused on biomechanical loading using poses to minimising KAM while strengthening the quadriceps These postures included squats and lunge variations, while the study suggested the single-leg stance would produce lower muscle activation and higher KAM load (Brennerman et al., 2015).

There has been evidence that yoga increases strength, endurance, gait, and flexibility in the lower limbs (Cheung et al., 2016). A review of the literature also suggests that yoga can have a positive outcome on physical health, fitness, quality of life, pain, sleep, energy, and mood for people with arthritis (Cheung et al,.2014, Moonaz et al., 2015). No adverse effects were reported in the studies and practising yoga did not increase joint symptoms suggesting that yoga is a safe and effective intervention (Moonaz et al., 2015, Srivastava et al., 2015).

Materials and Methods

Recruitment

Recruitment took place in June 2023. Participants were recruited through poster advertisements around the community in places such as the local supermarkets, community hall, the GP'S office and the Killarney Sports and Leisure Centre. A social media post went out to the local community pages such as the sporting events Kerry, Killarney Sports and Leisure Centre and Killarney Today pages. Inclusion in the study required an individual to be between 60 to 75 years of age. Clinical diagnosis of knee OA within the last 6 months and not currently taking part in yoga or Pilates classes. In addition, no potential risk was identified in the PAR-Q. Participants were excluded if they had symptoms of joint locking or instability indicated by chronic use of a knee brace, cane, walker or wheelchair. Knee surgery or the use of corticosteroids, or hyaluronic acid injection within the last 6 months. Individuals with severe medical conditions that are contraindications to exercise such as uncontrolled high blood pressure or diagnosed high blood pressure within the last 6 months, acute systemic infection, uncontrolled metabolic disease, and unstable angina (ACSM, 2017).

Interested participants were sent via email an information sheet and a consent form which informed them about the nature of the research, inclusion and exclusion criteria, information regarding assessments and protocol procedure, information regarding the yoga intervention, the location and time commitment to the study, their obligations, insuring that all information kept is anonymous as they will be given a unique code, what the data is used for, how the data is being stored and for how long. Researcher information to get in contact if interested after which they were given the time (2 weeks) needed to consider if they wanted to take part in the study. When the researcher received the consent form, the researcher called the participants to cover the inclusion and exclusion criteria and according to the American College of Rheumatology guidelines the clinical presentation of knee OA (Altman et al. 1986), any concerns or questions they may have with regards the tests and study protocol. A time was allocated for the participant to do the pre-test measures at the Killarney Sports & Leisure Centre. A total of 15 participants volunteered for the study.

All data that was collected was non-identifiable using the participant's anonymized code, participants were allowed to withdraw from the study at any time. Anonymity and confidentiality were maintained throughout the research. The researcher followed the University of Galway's ethical procedure and data protection. Therefore, all the data that was collected was stored on a One Drive data storage by the University of Galway only accessed by the researcher and the supervisor. Research data will be stored for 5 years in line with the University of Galway data retention policy.

The single group hatha yoga study for 8 weeks with two 60-minute classes each week was approved by the University of Galway ethics committee, to assess the effectiveness of a specifically designed yoga program on balance performance in older adults with knee OA. Repeated measures were obtained at baseline and postintervention after 8 weeks.

The Killarney Sports and Leisure Centre provided the facility for this study, allocated within 5 minutes of the town with sufficient car parking. Data collection contained a health questionnaire form using the Physical Activity Readiness Questionnaire (PAR-Q), Outcomes measured the 6-minute walk test (6MWT), the Short Physical Battery Performance (SPPB) Single leg stance test (SLS) and the Berg Balance Scale (BBS) . The total collection time lasted 30 minutes per individual. The researcher collected all the data on each of the participants, the researcher was also involved in the yoga intervention and was not blinded.

Intervention

The yoga program consisted of two 60-minute Hatha-style yoga classes per week for 8 weeks. Time was given before the start of each class for an informal conversation on the well-being of each participant and how they are finding the level of difficulty, Attendance was also kept with reasons for missed classes. Sessions started with mindfulness meditation that focused attention to areas around the body, pranayama breathing techniques which were full belly breathing, 3-stage yogic breathing and alternative nostril breathing. Breath awareness was carried out throughout the class., Then moved into a seated series of movements to mobilise the joints called Pawanmuktasana, This sequence started with ankle rotation, leg extension, hip opening, spinal articulation, wrist and shoulder circles, arm circles, side stretch and forward fold. From there into standing poses that focused on balance (tree pose progressing to warrior 3), strengthening (Sit-to-stand, squats wide/narrow, high lunges, warrior 2) and stretching (leg extension, sitting/lying pigeon, supported bound angle) slowly progressing time and intensity each week.

When in the yoga poses attention was focused on proper alignment emphasis on reducing KAM with cueing from the instructor. When going from a seated position to standing, the focus is on the posterior chain of the body by placing the majority of the weight on the heels so as to engage the glutes and the hip abductors in order to stabilise the hips and knees. Attention is also drawn to the position of the knees, to keep them in line with the second and third toe so as not to let them fall inwards. If the participant cannot keep their knee's in line a yoga block is placed between the knees in order to try and engage the muscles needed to support this transition. When in a standing position attention was drawn to their feet, placing weight onto the four corners of the feet, to lift up through the inner arches activating the hip adductor muscles. Also, attention to the knee, keeping it in line with the second and third toe. Proper alignment targets the muscles that are needed in the pose while reducing the knee adduction movement placed on the knee.

Classes were designed by the researcher who is a registered yoga instructor using the knowledge gained from previous studies (strengthening quadriceps, hip abductors, stretching hamstrings and quadriceps muscles while reducing KAM). The yoga program designed was specifically for older adults with knee OA. The sample size of 15 participants was determined due to having only one yoga instructor to give each participant the individual attention needed to modify poses and on recruitment feasibility over the time frame for this study.

The postures were modified when needed using the props provided such as yoga blocks, chairs, yoga straps and blankets. The postures performed started with light intensity postures such as mountain pose (standing with feet side by side) with eyes open, slowly building confidence and proprioception awareness to standing with eyes closed. The single-leg balance with the support of the chair progressed to being able to place hands on the hips. The goal at the end of the 8 weeks was that all participants would be able to perform the balance postures with minimal upper body support.

Outcomes Measured

Balance was measured using the Berg Balance Scale, a commonly used and clinically relevant assessment tool that can be downloaded via online, it uses a 14-item physical performance measure of static and dynamic balance assessing functional balance. The tasks used involves sitting, standing and dynamic balance. The sitting task requires the participant to sit unsupported. The standing task requires a participant to stand unsupported, with eyes closed, with feet together, single leg balance, turning and looking behind them, being able to bend down and grab an object from the floor, reaching forward with arms out in front, balance with feet in tandem position. The last couple of tasks focus on dynamic balance, sitting to standing, standing to sitting, turning 360 degrees, transferring and stepping onto the step and back down. The task is marked on a 5 point ordinal scale ranging from 0 to 4. The score of 0 is when a participant is unable to do the task and the score of 4 is when they can do the task completely. Time is also a factor that can affect the points and if the participant needs assistance to complete it. The test scores were from 0 to 56, with the higher scores indicating better balance. A score of $\leq$36 is considered a fall risk (Maeda et al., 2009). Very little equipment is needed to administer the test. It requires a stopwatch, measuring tape, a step, a chair, and an object that can be picked up. The test usually takes between 15 to 20 minutes.

A single-leg stance test is used to assess postural stability and balance control. The test is performed with eyes open and with eyes closed. This test requires the participant to stand with one leg unsupported (hands on the hips). The timer starts when the foot lifts off the

ground and stops when the foot is back on the ground or if the participant uses their hand for support. The norms for this age group range from 29. 9 seconds to 18.3 seconds. Eyes closed norms range from 4.8 seconds to 2 seconds. It is reported (Bailey, 2022) that if the participant is unable to stand for more than 5 seconds, they are at a greater fall's risks. The equipment needed is a stopwatch.

Short Physical Performance Battery test is a performance mobility assessment tool testing lower limb strength and functional mobility, 5 repeated timed chair sit-to-stand done as quickly as possible, the timer starts as the participant is lifting off the chair and stops when they are back on the chair after 5 repetitions. and gait speed walking 2.44 meters at a normal pace, the participant walks to a mark on the floor. The three standing balance positions include standing with feet side by side, feet in semi-tandem and tandem position for 10 seconds each. The sum of time to stand in the three positions was up to a maximum of 30 seconds. The score ranges from 0 to 4, 0 indicates a longer time to finish the tasks while 4 indicates a fast time relative to the task. A final score is then calculated ranging from 0 indicating severe performance impairment to 12 which is optimal physical performance. A score of <7 can indicate a moderate to severe impairment. It was developed by the National Institute on Aging specifically for older adults (Guralnik et al., 1994). The equipment needed for this assessment is a chair, stopwatch, and measuring tape.

The 6 MWT was used to test mobility as it reflects activities of daily living. Data collected from this test is the participant's blood pressure, heart rate and oxygen saturation pre and post-test. Post-test Borg dyspnoea score where 0 represents no difficulty in breathing to 10 finding breathing very difficult. and the rate of perceived exertion (RPE) the numbers rate the difficulty they find the activity. 0 is nothing and 10 is very difficult. The participant is encouraged to walk as far as they can in 6 minutes. Cones are placed at either end of a lap which is a 30-meter stretch, with a chair positioned on either side along the walkway for if they need to rest. The average distance covered by a healthy older adult range from 514 ± 71 meters (Casanova et al., 2011). Equipment needed is a stopwatch, measuring tape, 30-meter walkway, two cones, chairs, pulse oximeter to measure SpO2, heart rate monitor to measure blood pressure and heart rate, Borg dyspnoea scale and rate of perceived exertion scale.

These outcomes are supported by the literature (A systematic review and meta-analysis by Youkhana et al. 2016, A systematic review and meta-analysis by Sivaramkrishnan et al. 2019)) for this cohort and were found to be reliable for measuring balance and mobility outcomes. Also, they are cost-effective and require no specialised equipment and no specialised training to carry out.

Statistical Analysis

Statistical analyses of data were performed using SPSS IBM version 27 for Mac OS. The data are presented as mean, standard deviation (SD) and median. A Shapiro-Wilks test was carried out to assess the normality of the outcomes.

In the comparison of the values obtained pre-and post-intervention, paired samples *t*-test was used if data showed a normal distribution, if there was skewness and the data does not fall within the normal distribution then a Wilcoxon signed-rank test was used and HodgesLehmann method to estimate the median differences and the 95% CI. The Wilcoxon signed rank test and the Hodges-Lehmann method were used for ordinal data variables. Cohens d was used to measure the effect size which ranged from small r = 0.2, medium r =

0.5 and large r = o.8 and greater. In all statistics, the gold standard *p* values less than .05 were accepted as statically significant.

Results

12 participants (1 male, 11, female) completed the follow-up assessments.

The Shapiro-Wilk test showed that data for the outcome measure of the Single leg stance, 6 minute walk test and the Short Physical Performance Battery test was normally distributed. The Berg Balance Scale was not normally distributed. Elements of the SPPB were further analysed such as the timed 5 repeated sit-to-stand was normally distributed and the 2.44meter walk which was not normally distributed.

Table 1: Summary of the Shapiro-Wilks test, change in score between baseline and 8 weeks. Difference (Post-test – Pre-test) and significance.

Variables	**Baseline (Mean ± SD)**	**8 week (Mean ± SD)**	**Mean Difference (Mean ± SD)**	**Significance P- Value**
6 Minute walk test (meters)	539 ± 2.83	595.5 ± 44.54	56.5 ± 47.37	.342*
BBS (0-56)	51 (85%)	53 (93%)	1.5 (8%)	.001
SPPB (0-14)	12 (91%)	13.5 (95%)	1 (4%)	.051*
5 repeated sitto-stand (seconds)	15.9 ± 14	10.85 ± 2.37	-5.07 ± 11.67	.158*
2.44 meter walk (seconds)	1.6 ± 0.02	1.61 ± 0.08	0.005 ± 0.06	.006
SLS Left leg lifted eyes open (seconds)	10.2 ± 12.94	8.70 ± 8.09	-1.54 ± 4.84	.836*
SLS Right leg lifted eyes open (seconds)	8.6 ± 11.11	9.32 ± 10.85	0.70 ± 0.26	.371*
SLS Left leg lifted eyes closed (seconds)	2.3 ± 1.62	3.38 ± 2.87	1.08 ± 1.24	.501*
SLS Right leg lifted eyes closed (seconds)	1.5 ± 0.68	3.52 ± 3.52	2.05 ± 2.84	.138*

Note: The Shapiro-Wilks test rejects the hypothesis of normality when the p-value is < 0.05. Significant comparisons are denoted with an asterisk (*).

Table 2: Summary of SPSS results

Variables	Mean ± Standard deviation, Median	Effect size (r)	P Value
6 Minute walk test (meters)	-67.92 ± 60.76	.79	.003*
BBS (0-56)	1.5		.042*
SPPB (0-14)	1		.010*
5 repeated sit-tostand (Seconds)	3.30 ± 4.09	.72	.017*
2.44 meter walk (seconds)	0.22		.005*
SLS Left leg lifted eyes open (seconds)	-5.45 ± 5.63	.78	.006*
SLS Right leg lifted eyes open (seconds)	-5.37 ± 9.33	.29	.071
SLS Left leg lifted eyes closed (seconds)	-0.88 ± 0.63	.81	.001*
SLS Right leg lifted eyes closed (seconds)	-0.96 ± 1.51	.33	.049*

Note: Significant comparisons are denoted with an asterisk (*)

Discussion

Current literature is deficient in research exploring the relationship between a yoga-based exercise prescription specific to balance outcomes for older adults with knee OA. The current study aimed to address this research gap by investigating the effects of a yoga-based exercise program for knee OA, designed specifically for strength, balance, and mobility and to minimise the KAM and consequently reduce the risk of falls in this population. It is important, however, for an older adult with knee OA to keep physically active, as discussed, an exercise prescription that does not progress the disease even further is a vital part of treatment. The following discussion elaborates on the findings, implications, limitations, feasibility, and conclusion of the study.

Adherence

A total of 15 people (1 male, 14 female) were initially screened for the study, and 12 participants (1 male, 11 female) completed the follow-up assessments. The study dropout was 20%, two participants dropped out due to having a fall at home and one participant dropped out due to hospital admission not relating to participating in the study. The number of classes

attended ranged from 10 to 16 with the mean class attendance 14 out of 16. Most of the participants (n=12) attended ≥ 81% of classes with common barriers during the summer months including going on holidays and family commitments. The average duration of the yoga session was 100 minutes out of 120 minutes each week. Participants did not report any related adverse events or injuries due to partaking in the yoga intervention.

Results

Following the 8-week hatha-style yoga program, participants experienced significant improvement in various outcomes related to balance, gait speed and functional mobility.

These findings are consistent with earlier research (Youkhana et al. 2016, Cheung et al.2014, Brennerman et al. (2015). The study observed substantial effect sizes (r-values) for these improvements, as evidenced by statistically significant improvement (p-values) between pretest and post-test results, SLS (*r*=.78), 5 repeated sit-to-stand (r = .72) and the 6-minute walk test (*r* = .79).

The effect sizes observed in this study surpassed those reported in comparable research. For instance, a systematic review and meta-analysis by Youkhana et al. (2016) who's results found a small effect on balance performance (r = 0.40), and a medium effect on physical mobility, gait speed and timed sit-to-stand (r = 0.50) and an 8-week study by Cheung et al. (2014) found a small effect size with the timed sit-to-stand (r =.37). In contrast to these studies, Brennerman et al. (2015) 12-week yoga program resulted in a statistical improvement in walking endurance p = .001 and sit to stand p = .006 compared to the current study p = .003, p = .017 respectively. These previous studies ranged in frequency, intensity, and duration, when compared to the current study it shows that 8 weeks of two 60-minute sessions at low to moderate intensity a week is an effective exercise prescription while also addressing the benefits of yoga as a physical activity.

The most significant improvements seen in the test performance were for the 6-minute walk test (595.5 ± 44.54, p .003) and the single leg stance (8.70 ± 8.09, p .001), previous research has determined (Bailey, 2022) that if the participant is unable to stand for more than 10 seconds, they are at a greater fall's risks and the 6-minute walk test can indicate a better functional ability (>514 ± 71 meters, Casanova et al., 2011). The improvement demonstrated in the sit-to-stand (10.85 ± 2.37, p .017) assessment suggests an improved functional balance and lower limb strength suggesting one can expect a decrease in the risk of fall's (Guralnik et al., 1994).

Overall, this study demonstrated significant findings in balance and mobility in terms of their ability to walk further during their 6-minute walk test.

The baseline assessment for SPPB overall score was 91% and this was due to the 3 balance tests (feet together, semi tandem, full tandem) where all participants reached 10 seconds, the BBS was 85% these results leave little room for improvement. This resulted in a ceiling effect and the reason there was very little change after the intervention. While mobility performance showed an improvement during the 6-minute walk test and the repeated chair sit-to-stand tasks, it is possible that this positive finding reflects training specificity as the participants completed squats, lunges, and chair sit-to-stand movements during the yoga sessions. Inconsistent with the alternate hypothesis, the single-leg stance with the right leg lifted did not demonstrate an improvement between baseline and follow-up (eyes open *r* =

.295, p .071 and eyes closed r = .33, p .049). This could be due to the left leg being weaker because of the severity of knee OA leading to a floor effect with the test.

Limitations

There are however several limitations to this study, the small sample size limiting generalisability as the study had only one male to twelve females. The study did not utilise a randomised controlled trial design with a control group, it cannot be ruled out that other confounding variables could be responsible for the statistical improvement observed between baseline and 8-week assessment. The study did not allow for blinding which may have resulted in attention bias. Since the study participants had to drive themselves to the study location, this may have ruled out the participation of less mobile elderly, making it difficult to translate the findings to frailer older adults with knee OA. Additionally, since yoga classes were provided to study participants at no cost, the high adherence rates may have been skewed by the cost-effectiveness of these classes, as the cost is one of the most common barriers to exercise adherence (Tiedemann et al., 2013), However, this study was intended as a pilot study to evaluate the feasibility of a yoga program for older adults with knee OA and to evaluate the impact on balance as the primary aim. The study has met these objectives.

The strengths of the study were well-defined inclusion and exclusion criteria, the yoga program was specifically designed by a highly qualified yoga instructor with over 15 years of experience working with older adults in the community. The yoga protocol can be easily followed by other qualified yoga teachers and researchers. The yoga poses included in the program were gentle and adaptable for older adults with knee OA who have functional limitations. Additionally, the participants that took part in this study were recruited from the community setting with various levels of knee OA symptoms and comorbidities, demonstrating the ability of the yoga program to meet the needs and demands of older adults with a range of abilities and medical histories. Furthermore, the outcomes measures included are validated measures of fall risk that are commonly used to assess mobility and balance in older adults. These measures were purposefully chosen to explore the potential for yoga to reduce the risk of falls.

Feasibility

The significant finding of this single-design pilot study was that this 8-week specifically designed yoga program was a safe, feasible and enjoyable exercise for older adults with knee OA. The yoga program's feasibility was demonstrated by its ease of recruitment over a short time. Participants attended 81% or more of the yoga sessions, demonstrating that the program was feasible. This indicates that the yoga program was appropriate to the abilities of the participants, enjoyable, and easy to follow, and the participants felt the physical and mental benefits after each session. The feasibility of the yoga program should not be underestimated as research states there is poor adherence to exercise among older adults.

Conclusion

The single-design pilot study highlighted the positive impact of the yoga intervention on various balance and functional mobility outcomes in older adults with knee OA. The improvements observed in walking endurance, balance control, physical performance, and specific functional tasks indicate the potential of tailored yoga interventions to enhance overall physical well-being in this cohort. However, with the small study group caution needs

to be applied when analysing these results. Finally, the intervention was limited to 8 weeks of yoga, which is below the recommended 50+ hours of balance exercise training according to clinical guidelines (Tiedemann et al., 2013), which has been shown to reduce fall risk in older adults. While the results are promising, further research with larger cohorts and refined methodologies will provide a more comprehensive understanding of the intervention's effectiveness at reducing falls and its implications for enhancing the quality of life in older adults with knee OA.

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Disclosing Statement

The author reports there are no competing interests to declare.

Appendices

Appendix A: Yoga intervention

Component	*Duration and description*
Check-in	
	5 minutes Participants asked how they have been that week and if
	they had any injuries, flare-ups, pain, or limitations.
Centering	
Seated	10 minutes
	Body scan, meditation, and Breathing exercises (pranayama)
Warm-up	
Seated poses	15 minutes
	Pawanmuktasana sequence joint freeing series
Standing poses	
	15 minutes
	Sit to stand x 3 very slow lifting and lowering.
	Mountain pose progressing to eyes closed.
	Toe to Heel raises x 5
	Tree pose – starting at 10 seconds.
	Squats – narrow to wide x 5
	High lunge
	Warrior 2,

Seated poses	Warrior 3
Cool down	10 minutes
	Single leg forward fold.
	Pigeon
	Supported bound angle
	Gentle twist
Savasana	5 minutes – Body scan and closing meditation.

Appendix B: Description of yoga poses, modifications, and progression

Participants will be asked to take the level that they can achieve with good posture and balance.

Yoga Pose description	Modification	Progression
Seated Poses		
Pawanmuktasana sequence - Ankle circles - Leg extension - Hip opening/ open leg to side - Cat/cow spinal articulation - Wrist circles - Shoulder shrugs - Arm circles - Side stretch - Forward fold	Using chair, strap	Level 1
Standing poses		
Sit to stand. Sitting on a chair, feet hip width apart, lean forward to stand	Use chair to help stand. Hands crossed in front of chest	Level 1 Level 2

Mountain Pose Standing with feet hip width apart	Use wall or chair to help balance. Standing without any aid Standing with eyes closed	Level 1 Level 2 Level 3
Toe to Heel raises Standing feet hip width apart, lifting heels to stand on balls of feet. Slowly lower back down. Lift toes to lean back on heels slowly lower.	Use wall or chair to help balance Standing without any aid	Level 1 Level 2

Tree pose Standing on one leg while placing the opposite foot on ankle or shin. Bending knee to side.	Using wall or chair for balance Without the use of aids	Level 1 – foot just off floor Level 2 – hands to hips Level 3 – Hands overhead
Squat Standing feet hip width apart, bending knees, sitting back into heels. Single leg squat	Using wall/ chair for support No support used	Level 1 – Knees at 30 degrees Level 2- hands on hips, knee 30 degrees Level 3 – Hand in prayer position n front of chest, knees at 60 degrees

High Lunge Standing in a forward position. Knee bends while stepping the opposite foot back, placing the ball of the foot on the ground	Using wall/ Chair for support No support needed, hands on hips Hands overhead	Level 1 Level 2 Level 3
Warrior 2 Standing in a forward position, bending knee while stepping opposite foot back parallel to the front of the mat	Using wall/ chair for support No support needed, hands on hips Hands out on either side	Level 1 Level 2 Level 3
Warrior 3 Standing in a forward position. Extend one leg back while leaning the body forward.	Using wall/ chair for support No support needed, hands on hips Arms extended forward	Level 1 Level 2 Level 3
Seated poses		
Single leg fold Feet hip width apart, extend one leg in front, foot dorsi flexed, fold from the hip hands to ward foot.	Using a chair.	Level 1

Gentle twist Hand to heart, twist to one side and the other	Using a chair	Level 1
Bound angle Soles of feet together, opening knees out to the side	Using a chair	Level 1
Pigeon Feet hip width apart and place ankle on top of opposite knee. Or cross ankles	Using a chair	Level 1

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"Familycare": Insights to Evaluation Results of a Mobile Dementia Coaching for Informal Caregivers

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Abstract
Familycare is an evaluation-project of the mobile dementia coaching, which is offered by a social organization in Carinthia, Austria. The aim of the program is to relieve the burden on family caregivers of people with dementia, to educate them through knowledge transfer and to prevent health risk factors. The research design of the evaluation is based on a mixed-methods approach: descriptive-quantitative questionnaires and qualitative interviews were conducted with the target group. This conference paper presents the research design and the evaluation results. The research results show, that half of the people surveyed feel very or extremely burdened by caring. This is accompanied by a lack of information about the clinical picture of dementia and possible support services. The use of the coaching shows that almost 95% of the people surveyed stated that they found the service helpful or very helpful. Just as many people would recommend the service to others. The results also show that the coaching enables family caregivers to better understand the clinical picture of dementia and to better take on their own role as informal caregivers. It is possible to turn to the coaching team with questions, which on the one hand provides security and on the other hand gives the feeling that caregiving relatives are not alone, as the data shows. Self-care and setting boundaries are further things that family caregivers were able to learn through this coaching. The evaluation results thus confirm positive effects, which include reducing loneliness and promoting recognition for informal caregivers.

Keywords: Caring Communities, Dementia, Dementia-Inclusiveness, Participatory Approaches

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Introduction

This document presents the findings from an evaluation project of a mobile dementia coaching program for informal caregivers in Austria. The study utilized a mixed-methods approach, including questionnaires and interviews, to assess the effectiveness of the program in providing relief, knowledge, and health risk prevention for family caregivers. The results highlight the high burden experienced by caregivers, the benefits of the coaching program, and the importance of continued evaluation to measure long-term impacts.

Recent studies in Austria have found that family caregivers, particularly those caring for individuals with dementia, experience high levels of stress and burden. This underlines the critical need for support services and interventions to alleviate the physical and emotional strain on these caregivers (Nagl-Cupal et al., 2018). The Diakonie de La Tour recognized this issue and initiated a project in 2022 to introduce relief services and other measures to support family caregivers in the home setting in Carinthia, in the South of Austria. The aim of the scientific evaluation is to show to what extent this intervention is effective and what effects can be recognized with regard to the target group (Diakonie, 2022).

Objectives and Methods

The Mobile Dementia Coaching aims to provide relief and support for family caregivers through a variety of measures, including counseling, home-based training, and social integration. A key objective is to improve caregivers' knowledge and understanding of dementia and their caregiving role by providing information and resources. The project also seeks to help to prevent health risks and burnout among family caregivers by addressing their physical, emotional, and social needs (Diakonie, 2022).

To assess the effectiveness of this outreach-oriented intervention, the evaluation team is conducting a formative evaluation using an integrative research design. This mixed-methods approach includes three key modules: Descriptive-Quantitative Surveys, Caregiver Interviews and Result Reporting. Two questionnaires are being used to gather data from individuals who have accessed the Mobile Dementia Coaching service, both at their first and second appointments. Semi-structured interviews are being conducted with a sample of caregiving relatives participating in the program to gain deeper insights into their experiences. The integrative findings from the quantitative and qualitative data will be compiled into a comprehensive report to assess the overall effectiveness of the Mobile Dementia Coaching.

The first step was to carry out comprehensive research and review relevant survey instruments in the field of carers/caregiving relatives in order to record the current state of research. A comparison of existing instruments was also done. This provided important insights for the content and design of the questionnaire. As a result of this research, the questionnaire design was based on the following sources:

The Berliner Inventar zur Angehörigenbelastung-Demenz (BIZA-D) (Schacke & Zank, 2009) was developed as part of a large German longitudinal study on the burden on carers of relatives of dementia patients. It differentiates between objective and subjective stress as well as primary and secondary stressors. It also asks about the long-term consequences of care, coping strategies and support (Schacke & Zank, 2009).

The Zarit Burden Interview is a well-known instrument for self-reporting by family carers. The quality criteria of this instrument are suitable about a comprehensive view of the situations of family carers; it is used internationally to record the stress/burden of family carers. The number of items varies between the different versions of the instrument, which means that it can be customised to the research question (Mosquera et al., 2016).

The questionnaire for recording the situation of family caregivers (Nagl-Cupal et al., 2018) was created as part of research for the Federal Ministry of Labor, Social Affairs, Health and Consumer Protection in Austria and covers all important dimensions, such as socio-demographic characteristics, resources, prevalence, negative and positive aspects of care, etc., which are relevant in the course of the subject area of this evaluation research.

An initial version of both questionnaires for this accompanying evaluation was derived from the instruments listed above and adapted to the research question. The first version of the questionnaires was discussed with the client at the start of the accompanying evaluation in 2022 and adapted accordingly. In addition to content-related aspects, the focus was on making the questionnaires as inclusive and barrier-free as possible so that they could be completed by family carers, some of whom are under a great deal of strain, and so that they would not be overwhelming. The final version includes the following dimensions: Questions about the current care or caring situation, effects of care, offers, questions about the offer (only in questionnaire 2), as well as socio-demographic questions.

The quality of the questionnaire was tested by a pre-test and was available both in online format in Limesurvey and in paper-pencil format. The questionnaires were distributed to the clients by the staff of the service and returned to the research team.

The interview guide for the evaluation of the "Mobile dementia coaching" project was designed based on a comprehensive literature review on the topic of caring relatives and was based on the previously developed questionnaire.

The method "collect", "check", "sort" and "subsume" (Helfferich, 2011, p. 182ff.) was used. In the first step, all questions that could be relevant for the evaluation of the project were collected. This included literature research on the topic of family carers of people with dementia, a reference to a pool of questions that were formulated in the course of creating the questionnaire but not used in it, as well as feedback and assessments from the client. In the second step, this collection of questions was reviewed and reduced according to its applicability and feasibility: Factual questions and monosyllabic questions were removed, the questions were checked for their openness and compared with the content of the quantitative questionnaire (Helfferich, 2011, p. 182ff).

In the third step, the questions were sorted according to the topics relevant to the monitoring evaluation and the identification of effects. These include the current care situation, effects of care and questions about mobile dementia coaching. Thus, the four topic blocks recommended in the literature were not exceeded in the interview guide used. In the last step of the guideline creation, the topics were subsumed: The topic blocks each begin with open questions in order to provide a narrative impetus and to be able to give space to new aspects. This is followed by optional questions, which are only asked in greater depth or provide help for the interviewer if the open question alone does not lead to sufficient answers or important aspects are not mentioned in the context of the open question (Helfferich, 2011, p. 181ff).

After pre-testing the employees of the programme provided access to the field to clients of the Mobile Dementia Coaching. The interviews were audio-recorded and then transcribed. The evaluation was carried out using Maring's summarising content analysis (Mayring, 2022 & 2015).

Results

The first questionnaire, completed by 38 individuals accessing the Mobile Dementia Coaching service for the first time, revealed some key insights. Participants had varying levels of knowledge about dementia, with some reporting good awareness of the disease and available support services, while others had more limited understanding (Figure 1).

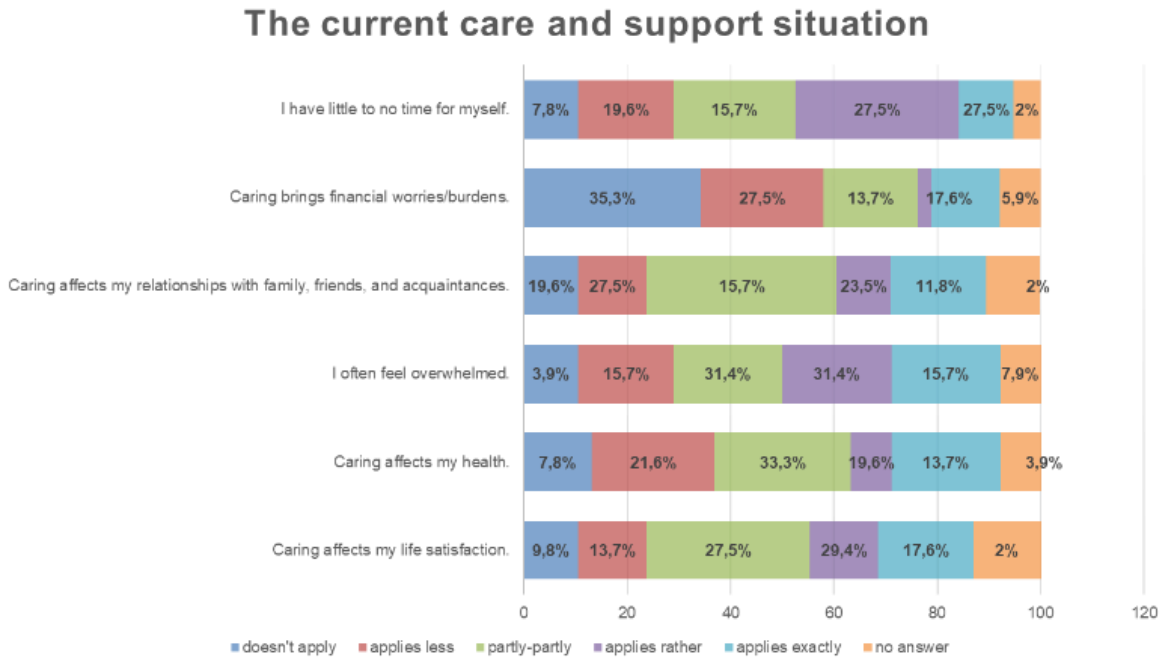

Figure 1: The current care and support Situation
(Questionnaire 1 (n=38) Evaluation Mobile Dementia Coaching)

Nearly all participants (95%) rated the Mobile Dementia Coaching service as very helpful, and 100% said they would recommend the service to others. The coaching sessions helped participants gain a better understanding of dementia and their role as a caregiver, which was seen as a significant benefit (Figure 2).

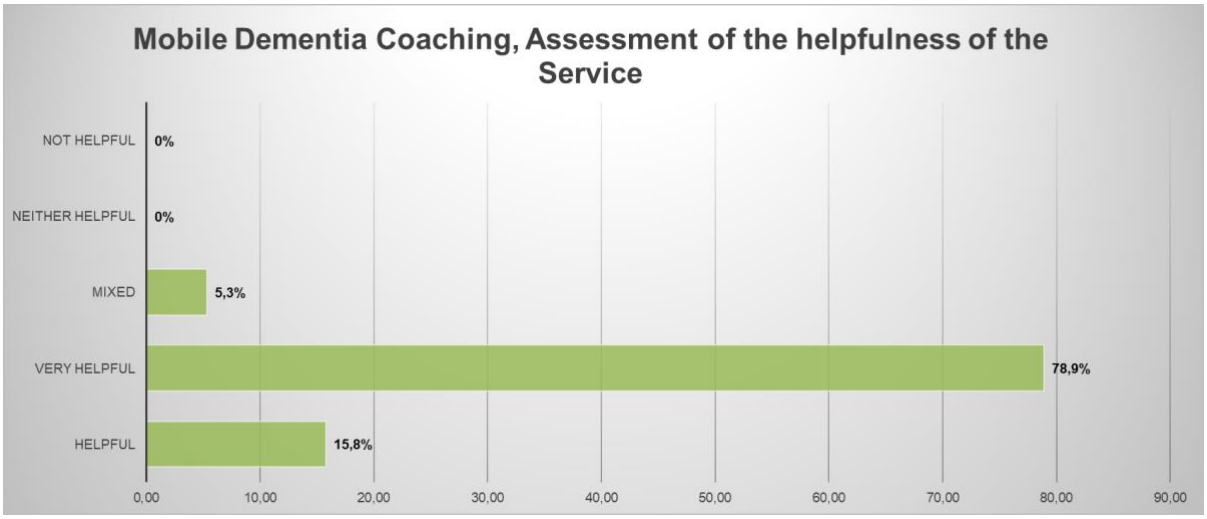

Figure 2: Mobile Dementia Coaching, helpfulness of the Service
(Questionnaire 2 (n=19) Evaluation Mobile Dementia Coaching)

The second questionnaire, completed by 19 individuals who had made use of the Mobile Dementia Coaching service for a second time, provided additional insights: Participants reported that the coaching helped them better cope with the challenges of caregiving, with 89% indicating it had a positive impact on their ability to manage the care situation. Nearly three-quarters (74%) of participants said the coaching had reduced their overall burden and stress as a caregiver, highlighting the program's effectiveness in providing relief. The coaching also boosted participants' confidence in their caregiving role, with 84% reporting increased self-assurance in managing the demands of caring for a loved one with dementia (Figure 3).

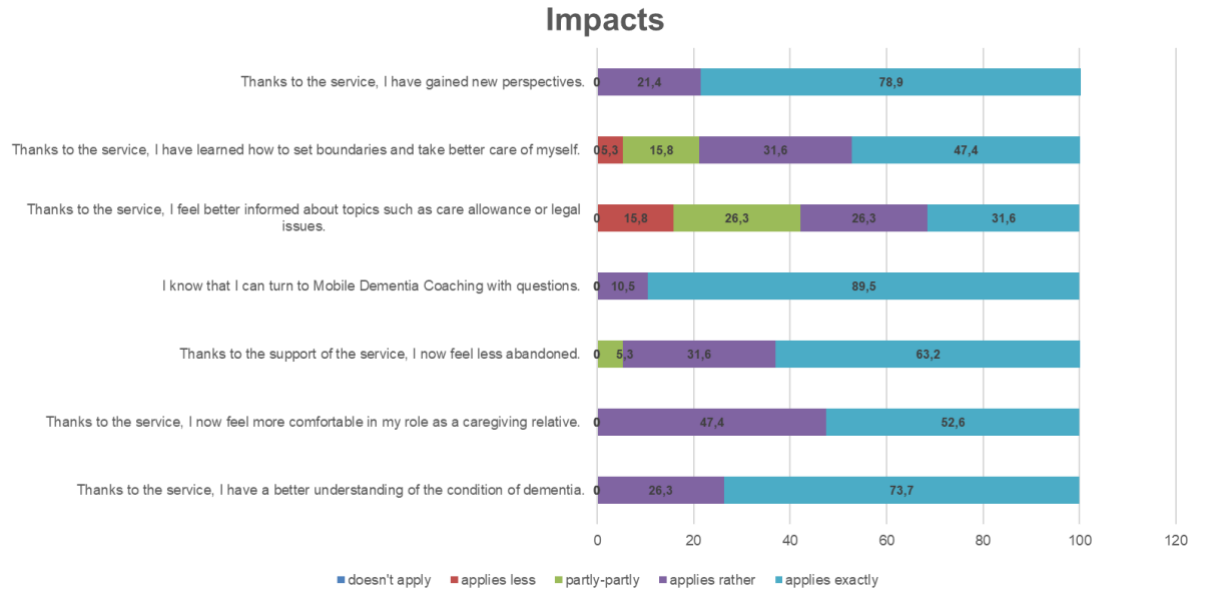

Figure 3: Impacts
(Questionnaire 2 (n=19) Evaluation Mobile Dementia Coaching)

Interviews with three caregiving relatives revealed the significant burden and responsibilities they faced in caring for parents with long-term dementia, with varying levels of strain reported. Participants appreciated the diagnostic tests and psychological discussions provided through the Mobile Dementia Coaching, which they found to be highly valuable in

understanding the disease and their role as a caregiver. Caregivers highlighted the importance of the coaching's flexible and outreach-oriented nature, which made the support more accessible and tailored to their individual needs. While caregivers were willing to pay for the coaching service, they expressed concerns about the lack of financial support from the government for their caregiving responsibilities, and the need for increased visibility of the Mobile Dementia Coaching intervention.

Discussion

The study findings confirm the significant burden and stress experienced by family caregivers of individuals with dementia, underscoring the critical need for support services. The Mobile Dementia Coaching program was highly effective in improving caregivers' knowledge and understanding of dementia and their caregiving role. Caregivers expressed a high level of satisfaction with the mobile coaching service, praising its accessibility, flexibility, and the valuable information and relief it provided. The mixed-methods approach used in the evaluation was beneficial, and the researchers recommend continuing the program with long-term follow-up to measure its sustained impact.

Conclusion

The evaluation of the Mobile Dementia Coaching intervention has demonstrated its effectiveness in providing relief, knowledge, and health risk prevention for family caregivers of individuals with dementia. The positive feedback from participants, particularly regarding the program's accessibility and the valuable information and support it offered, highlights the importance of such outreach-oriented services. Based on the findings, the researchers recommend that the intervention should be continued to offer, with ongoing evaluation to measure its long-term impacts on caregiver well-being and the sustainability of the support provided. To reach more caregivers in need, the researchers suggest increasing the visibility and promotion of the intervention, particularly in light of the financial concerns expressed by participants regarding the lack of governmental support. Additionally, from a scientific point of view it would be relevant to explore the opportunities to expand the intervention’s services and resources to further address the diverse needs and challenges faced by family caregivers of individuals with dementia.

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Research on Mental Health Service Design for the Elderly Based on Smart Home Environment

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Abstract
Because of rapid global aging, more than 14% of older people face psychological problems such as depression and anxiety, which directly affect their physical health and quality of life. To deal with these problems in time, we propose a design scheme of mental health services for the elderly based on smart home technology. The rapid development of smart home technology offers an unprecedented opportunity to improve the health of older adults. Our design is designed to meet the needs of the elderly for intelligent health care, through a comprehensive understanding of the psychological state of elderly patients, to provide timely diagnosis and treatment support and medical services. In the smart home environment, we use non-contact sensing technology to collect the mental state data of elderly users in real time while using machine learning methods to predict and evaluate. With the elderly users as the centre, we have established a dynamic monitoring mechanism for the mental health of the elderly. This system not only provides elderly users with real-time mental health monitoring and professional psychological guidance, depression prevention and management, remote consultation and safety monitoring and other all-round services, but also effectively reduces the cost of traditional psychological diagnosis and treatment services, and solves the problem of shortage and inequality of medical resources. By proposing this service design scheme, we hope to improve the mental health problems of the elderly, thereby optimizing the quality of life of the elderly, so that they can enjoy a healthier and happier old age.

Keywords: Smart Home, Elderly People, Mental Health, Service Design

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Introduction

The global population is aging rapidly, and the number and percentage of elderly people are increasing significantly. Population aging is becoming a worldwide trend. Mental health problems like depression have increasingly become a focus of attention among elderly people. This issue not only greatly affects the individual's physical and mental health but also brings tremendous challenges and burdens to social pension systems, healthcare systems, and community healthcare systems. For example, with almost 20 years of development in China, urbanisation and population aging trends are becoming more apparent, and medical services have become one of the urban residents' most rapidly growing demands. The residents prefer large hospitals since China's family healthcare service institutions are still in their early stages. They seldom choose community healthcare hospitals/centres, which puts great pressure on general hospitals and has increased medical contradictions. The increasing number of senior citizens in China who live independently prefer staying at home rather than in hospitals or nursing homes, which means they either live alone or with a partner. As they age, their physical, auditory, visual, and cognitive abilities decline, and long-term care becomes crucial for them. However, due to various reasons, many older people prefer to age in place. Therefore, there is a need to develop technologies and services that enable older people to live at home and improve their quality of life. Nevertheless, the uneven distribution of medical resources, shortage of elderly service personnel, and high costs have resulted in home care services failing to fully meet the health, safety, and well-being needs of older persons. Moreover, there is a lack of mental life support services for the elderly, who often experience negative emotions such as loneliness and sometimes cognitive decline. Emotional problems can lead to mental problems, which in turn affect physical health, creating a vicious cycle that has a devastating impact on the physical and mental health of the elderly. Additionally, depression in the elderly is characterized by low detection rates and difficulty in sustaining treatment. As the population ages, these related problems will become more prominent.

Depression is a serious human mental disorder, because of its high incidence and high harm in the elderly population, depression has been widely concerned by the world. The disease is generally manifested as low mood, depression, slow thinking and cognitive impairment, impaired physical activity and other symptoms, and these symptoms usually last for a long time. With the rapid aging of society, the risk of depression in the elderly is increasing. Studies have shown that subjects with severe depression may even show suicidal tendencies and self-harming behaviors,[1] which puts a great burden on the patients and their families and the whole human society. Depression is also characterized by a high recurrence rate, and according to statistics, patients have a recurrence rate of more than 50% even after treatment and recovery. According to the World Health Organization, the number of people suffering from depression worldwide has reached 980 million. Depression has become a major typical disease with a wide range of patients, seriously affecting human physical and mental health and social development and progress. Therefore, the timely diagnosis and rehabilitation of depression has gradually become a hot topic of widespread concern in human society. In clinical practice, doctors first identify the symptoms of depression through face-to-face clinical consultation, to measure and evaluate the severity of depression. The doctor will understand the patient's medical history through communication and observation. Symptoms and daily living conditions, etc., and standardized questionnaires or scales were used to assess the severity and frequency of depressive symptoms.[1] During these visits, clinicians assess both verbal and non-verbal indicators of depression symptoms: including monotone pitch, reduced speech speed, reduced volume, fewer gestures, and less eye contact, and if these

symptoms continue for two weeks, the patient can be considered to be having a major depressive episode. This is a large number of people with the disease. According to data published by the World Health Organization in 2018, the prevalence of depression in older people over the age of 65 is conservatively estimated at 10%-15%, and even some estimates range as high as 45%. Although geriatric depression has become a serious public health problem, it is rarely concerned by public opinion, and this group of elderly depressed patients is also in a state of "aphasia". At present, the identification rate of geriatric depression is low, and the treatment is inadequate, and with the deepening of the aging population, the problem will become more prominent. With the continuous development of smart homes, various household appliances have become intelligent and Internet-based,[2] and artificial intelligent-related intelligent algorithms are emerging in an endless stream. Then, mental health services for the elderly are implanted in smart homes, non-contact sensors are adopted to collect daily elderly data, and artificial intelligence methods are used to conduct real-time data analysis. Determine whether the elderly is in the stage of depression; Then according to the results of the judgment analysis, the corresponding processing, while supporting the safe monitoring function, at any time to ensure the safety of the elderly, to achieve a full range of intelligent protection. Therefore, based on the smart home environment, this paper will design and study the mental health services for the elderly, and propose a smart home service design that pays attention to the mental health of the elderly.

Related Research

1. Service System Based on IoT and Digital Twins

Service System based on IoT and Digital Twin for remote smart home-device control with HMI-driven user interaction aims to improve home healthcare. The main objective is to build an integrated smart home system that merges the physical and virtual ranges via the IoT, VR, AR, and MR technologies to enhance the lifestyle of old users. Implementing smart home device control with digital twin technology, using multiple data sources, helps bridge the physical and the virtual world effectively and enables all-around monitoring and dynamic management of home devices at any time.

In addition, using VR, AR and MR technology can enhance the user experience of the interaction of smart devices, making remote control more engaging and accurate. The investigation results demonstrate that the system is quite pronounced for the teleoperation of smart home systems and interconnection of devices and can considerably improve these devices' operational reliability and safety.

Based on IoT and Digital Twin, this service system can access AI technologies such as algorithms, computing power, and big data, and it can use non-invasive monitoring methods to understand the health status of the elderly.

2. Non-invasive or Contactless Monitoring

Mental health monitoring is one of the most potent tools for treating psychological problems. The sensing methods that can be used are invasive (contact) or non-invasive (contactless), depending on how each method interacts with the subject.[3]

It is important to note that contactless methods represent a new emerging trend. Their application scope is expanding due to the advantages they offer. These advantages include the

fact that they can collect real-time data such as physical signs in the form of facial expressions, gestures, and activities, as well as physiological signs in the form of heart rate or respiration. Furthermore, a modern-day Smart home is a typical example of implementing a contactless sensing method for the early detection of a depressive episode with the timely provision of services and subsequent intervention.

Muhammad Nouman and his colleagues published a paper in 2022 introducing three ways of monitoring mental health, especially focusing on non-invasive methods to monitor mental health. The research is a detailed review of current technologies and approaches working with non-invasive monitoring based on mental health problems like depression, anxiety, and stress. Various studies are compared to demonstrate the effectiveness and reliability of different contactless sensing techniques. Contactless Sensing and Its Benefits (i.e., collecting physical and physiological signal data in real-time without interfering with the subject) make the body sensor data analysed by applying machine learning techniques for behavioural pattern inferences indicating a corresponding user's mental health states.[3]

Based on previous studies, it is important and necessary to use contactless monitoring technologies which are used for monitoring mental health with smart home service systems. These technologies are potentially useful and crucial in mental health monitoring because they directly link sensing methods to the identification and monitoring of mental health conditions. Non-contact sensing techniques for checking facial expressions, gestures and vital signs can detect the mental health conditions of individuals.

3. Artificial Intelligence Technology

Signs of depression are mainly divided into biological signs and behavioral signs. Although some biological signs have been considered to be closely related to depression, they are not specific signs of patients with depression. In addition, because the experimental conditions of different studies are difficult to achieve unity, the conclusions obtained are inconsistent or even contradictory. With the rapid development of the Internet and the continuous improvement of computing power, artificial intelligence has become increasingly mature in speech recognition, computer vision, natural language processing and other technologies, and has been applied more widely in the medical field. It can help doctors to make diagnosis more scientifically and efficiently by learning various forms of knowledge such as patient behavior and text.[2] Based on this, a large number of studies have proposed behavioral signs of depression, including visual signs and verbal signs.

Visual signs include body movements, gestures, subtle expressions, and periodic muscle movements. Girard et al. proposed a social withdrawal hypothesis to explain the non-verbal behaviors of depressed individuals,[4] arguing that depression is characterized by the reduction of communicative behaviors and the increase of non-communicative behaviors, in other words, the signals expressing accessibility should be reduced, while the signals expressing hostility should be increased. Through the facial action coding system, it is found that people with depression produce fewer affectionate expressions (e.g., raised lip corners), head movements and more non-affectionate facial expressions (e.g., contempt, tight lips).

Language signs include phonetic, grammatical, and semantic aspects. As a way of expression, language can express an individual's inner thoughts. By systematically analyzing a person's language, we can understand how depression affects his feelings and mental state. In terms of speech, people with depression tend to show a slowdown in their speech speed, they may

express their ideas more slowly and obtusely, or they may pause for a long time while speaking; The tone of voice may become monotonous and dull, lacking natural variation and emphasis: the volume of speech may also be relatively low,[5] the voice may become low or soft, and the voice may even be weak or unclear. Patients with depression will also over-focus on negative thoughts and emotions, lack interest and confidence in positive things and possibilities, and use more negative evaluation words when expressing. To sum up, it is necessary and promising to introduce artificial intelligence technology to screen behavioral signs of depression.

Based on the universal law of machine word learning, Wang extracted the features of the sample data set, and then choose the appropriate classifier model based on the guide. IveJ et al. proposed an RNN architecture that incorporates attention mechanisms to predict potential depression patients: due to the combination of attention mechanisms, this model can extract important text elements and make effective predictions.[6] Coppersmith et al. used LSTM network to quantify the text signal of suicide attempt in their study on whether there was suicide attempt in the text of social network, and captured the context information between the text contents through the model, so as to obtain the text content related to suicide. Chlasta et al proposed an ensemble learning method based on convolutional neural networks,[6] which achieved good performance on AVEC2016 dataset. Lu Xiaoyong et al. proposed a model combining residual idea and attention mechanism to solve the problem of structural complexity and low recognition rate of the deep neural network method. The accuracy of the model reached 76%. Li Jinming et al. studied feature design and network architecture, proposed a multi-scale audio difference normalization (MADN) feature extraction algorithm, and based on this algorithm, proposed a depression recognition regression model DRAudioNet.[6] The mental state of patients with depression is related to the changes of their facial expressions, and the common features of patients' facial vision are dullness, depression, desolation and stuttering eyes. In a study of psychomotor disorder related to bipolar disorder, people with depression had longer reaction times on swords-looking tasks. In addition, depression identification, deep learning technology and diagnosis methods of facial visual features for the elderly are generally divided into two categories. One is the visual local method, which is based on previous studies on facial features of patients with depression and seeks one or more types of local features related to depression as the data input of the deep learning model. The number of features required by this method is small. In the training of the model, it is easier to converge. Another method is the visual whole method. In order to avoid the information loss in the process of feature extraction, the whole face information is used as the input of the model to achieve automatic feature extraction. However, this method requires training through large amounts of video data, as well as building complex deep learning models.

The Elderly Mental Health Problem Identification Algorithm Design

1. Diagnosis Methods Based on Text Features

With the development of science and technology and online social platforms, people use online social networks (OSNs) more frequently to express opinions and emotions. It provides researchers with a novel and effective way to detect individual patterns of emotion, communication, activity, and social behavior. Existing research has shown that various types of information on online social networks (OSNs) can help predict the early stages of depression.[7] However, studies using machine learning methods to complete depression detection tasks still do not have high classification performance, suggesting that there is a lot

of potential for improvement in its feature engineering. Therefore, combining the automatic feature extraction function of deep learning technology and the characteristics of Chinese text, this paper proposes a classification method of Chinese depression.

1) Construction of Emotional Dictionary of Depression

In natural language processing tasks such as text classification and sentiment analysis, sentiment dictionaries usually play a major role and can influence the performance of the task. However, in the research of emotion dictionaries in the field of depression, the construction of emotion dictionaries is still in the preliminary stage, and there are few related emotion dictionaries. Therefore, by using web crawler technology to obtain the relevant depression text data, and combining the characteristics of the basic emotion dictionary and the data of depression patients, the English depression emotion dictionary is constructed and expanded. The specific steps are shown in Figure 1:

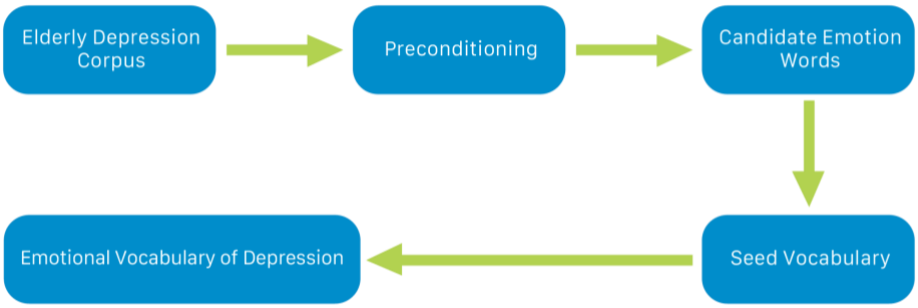

Figure 1. Construction of emotional vocabulary in the elderly with depression.

2) BERT-Based Word Recognition Model for Depression in Elderly People

BERT-W model is based on the depression domain emotion dictionary recognition model, which has stronger domain generalization ability and understanding ability, so it has more prominent advantages in depression tendency recognition task of online social texts. The elderly mental health service design designed in this paper will use this model to identify depressed words of the elderly,[8] as a basis for the mental health of the elderly. The workflow structure of this model for classifying depression in the elderly is shown in Figure 2.

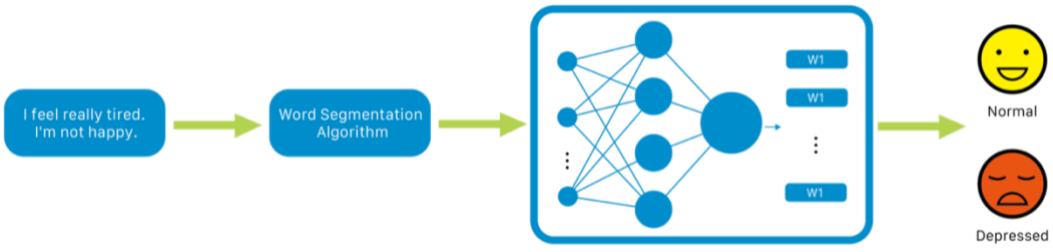

Figure 2. Workflow of depression classification in the elderly people.

2. Diagnostic Methods Based on Acoustic Features

1) Speech Feature Extraction

For the recognition of depression in the elderly, voice is an important feature. Based on the smart home system, the speech of the elderly can be obtained at any time, and the mental health problems of the elderly can be predicted in advance through the recognition and judgment of the speech by the machine learning algorithm. The extraction of speech features refers to the process of removing redundant information from the original data and extracting features with obvious distinguishing ability, which can realize the compression of feature dimensions and improve the computational efficiency and generalization ability of the model. Before the multi-modal feature fusion, the features of each mode should be extracted accurately and richly to make full use of the information contained in each mode.[8] The process of feature extraction is shown in Figure 3.

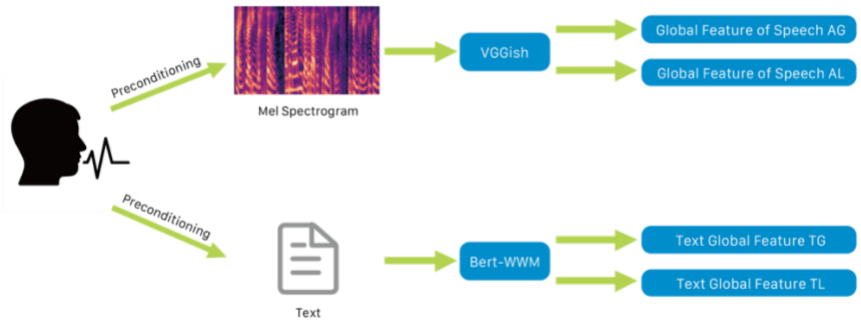

Figure 3. Speech global feature extraction.

2) Speech Recognition Model

The attention global awareness gating architecture consists of a feature extraction module and a Multi-mlp module. In the feature extraction module, we use the VGG16 model to extract high-dimensional depth spectral features. Multi-mlp is the backbone network module of the model used in this paper,[9] which is composed of multiple parallel MLPS. Figure 4 below shows the overall framework of the system.

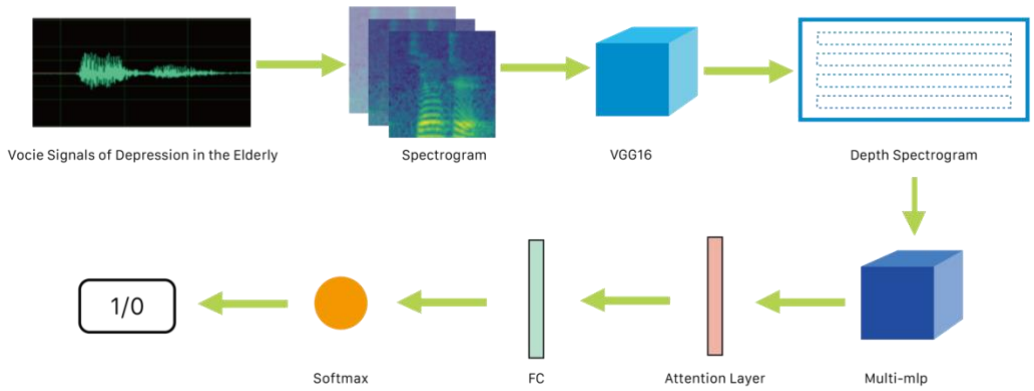

Figure 4. Speech recognition model of depression in the elderly people.

First, we convert the original speech signal after noise reduction into a spectral graph, which contains two dimensions of information, the horizontal axis represents the time information, and the vertical axis represents the frequency information. The spectrogram is then input into the pre-trained VGG-16 model to extract the 4096-dimensional depth spectral features of its penultimate layer: After that, the extracted features are input into the Multi-mlp module for mutual communication between features, and then connected to the attention layer to obtain the global key information. Finally, the output features are sent into the fully connected network and activated by SoftMax for depression classification recognition.

3. Diagnostic Methods Based on Facial Visual Features

1) Data Collection

In recent years, facial video-based depression recognition tasks have attracted much attention in the fields of computer vision and deep learning. Depression is a common psychological disorder, and research on efficient automatic depression recognition methods can help doctors better diagnose and treat patients. The overall process of depression recognition task based on face video is shown in Figure 5, which includes depression data acquisition, facial data preprocessing, data set analysis, model building, depression feature extraction, regression analysis and result prediction, etc. In the depression data acquisition segment, a large amount of facial data is usually collected on both depressed and non-depressed patients. This is the first step in completing the task of identifying depression. Then, in the process of facial data preprocessing, the data collected in the first step is usually cleaned and normalized for subsequent learning and recognition.[10] The third step is data set analysis, which usually analyzes the collected data, its validity, and the characteristics of the data set. The fourth step is model building and depression feature extraction, which usually uses machine learning algorithms or deep learning algorithms to build models and extract facial features from facial data according to the characteristics of the data. Finally, the extracted facial features are analyzed and processed to realize depression recognition.

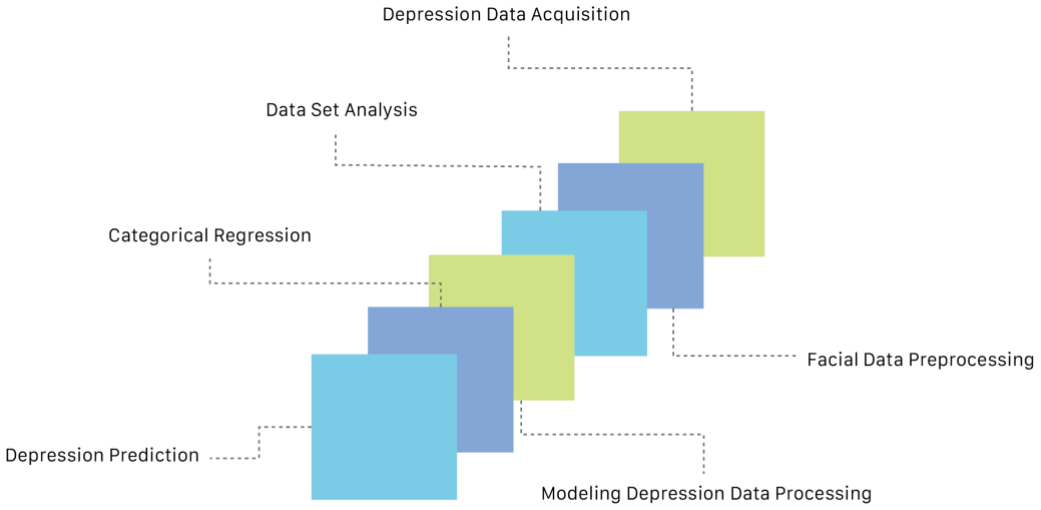

Figure 5. Task flow of depression recognition based on facial video.

2) Model

Depression is a long-term mental illness, and the emotions expressed by the subjects during the interview are gradually accumulated. Therefore, depression cannot be accurately identified only through short-term fragment features, and it is necessary to integrate the learned short-term features to further capture the long-term dependence relationship. In this paper, the LSTM model is used to fuse the short-term facial depressive features extracted by IC-STDM to capture the remote structure of motion features.

The fusion process is shown in Figure 6, where multiple short-term features are entered into the LSTM as input sequences. The principle of LSTM is to add three gate controllers based on recurrent neural networks, namely input gate, forgetting gate and output gate. These gate controllers can help the network better process sequence information while also avoiding problems with disappearing or exploding gradients.

In LSTM, each time step represents a short-term feature. The trained LSTM model is used to make predictions about the new data. Then, the hidden layer of LSTM is used for feature fusion and information transfer, and long-term motion features in short-term feature sequences are learned. The relationship between facial expressions and depression degree is analyzed. The prediction result of depression degree is calculated by the fully connected layer.

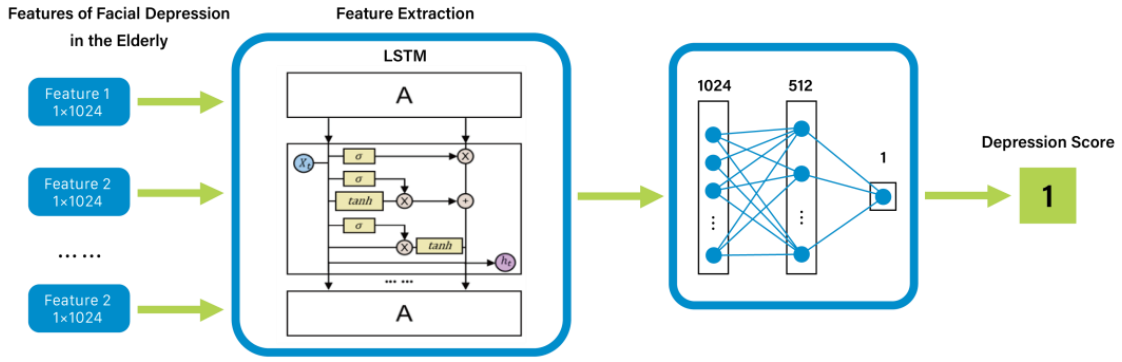

Figure 6. Feature fusion prediction architecture based on LSTM.

Design of Elderly Mental Health Service Scheme Based on Smart Home

In the context of a smart home environment, this paper applies the current advanced machine learning algorithm to analyze and process the text, voice and facial expressions related to depression of the elderly, which can predict the psychological well-being of the elderly in advance. Based on smart home, the text information typed online by the elderly is captured for word segmentation processing and training, and artificial intelligence is used to predict whether there is a tendency of depression through the online chat information typed by the elderly. In addition, the smart home collects the voice information of the elderly at home, adopts the voice conversion method,[11] and runs the artificial intelligence model to predict the mental health state of the elderly. Finally, the expression information of the elderly at home is collected, and the mental health of the elderly is judged through the inference of the neural network. Finally, the mental health service plan for the elderly in this paper includes the above three non-contact prediction methods, the combination of which can help prevent the mental health problems of the elderly in a more comprehensive way. The prediction

results will be timely notified to their families through phone calls and short messages, and at the same time, a big data system will be established in the design of the plan. Big data analysis is used to predict the mental health tendency of the elderly, and at the same time, some music to relieve stress and ease mood will be recommended according to the mental health of the elderly, which can guide the elderly out of the risk of depression to the greatest extent. The design process of mental health services for the elderly in this paper is shown in Figure 7.

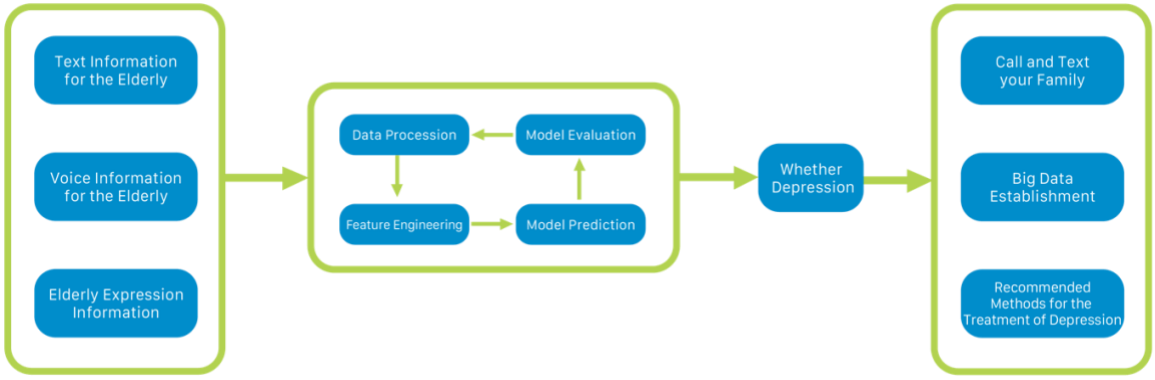

Figure 7. Design process of mental health service for the elderly.

Conclusion

With the intensification of global aging, the mental health of the elderly is a very important issue. Based on the smart home platform, this paper designs a scheme that can help predict the mental health problems of the elderly in advance. The scheme applies the current advanced machine learning algorithm to the platform. The text information, voice information and facial expression information of the elderly in their daily life are collected by non-contact sensors, and the mental health status of the elderly is identified and predicted in advance through the pre-processing of algorithms and the prediction of machine learning models. In combination with the predicted results, the program will notify the elderly's family members of these information and screen treatment methods. Help the elderly out of the risk of depression. The mental health service design for the elderly based on the smart home environment proposed in this paper is expected to help the elderly spend their old age peacefully.

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Supercentenarians – The Conquerors of Aging

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Abstract
Supercentenarians are people who have lived past their 110th birthday. While supercentenarians are not a recent phenomenon, the number of supercentenarians has increased over time. Previous research on supercentenarians has had a smaller scope which necessitated the present study. The aim of this study was to validate deceased supercentenarians and analyze them concerning number of supercentenarians, sex differences, regional differences, and seasonality. The results indicate that the number of supercentenarians has increased quickly over time, that 90% of validated supercentenarians are female and that most come from a limited number of regions, with most supercentenarians coming from the Northern hemisphere and either USA & Canada or Europe. About 56% of supercentenarians were born and died between the months of October to March. A mortality plateau of 50% might exist at ages up to 113, whereafter an acceleration towards 60% occurs. This study provides a better insight into supercentenarians than has previously been known but there are still gaps in the data which need to be addressed.

Keywords: Demography, Mortality Plateau, Seasonality, Supercentenarians

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Introduction

A supercentenarian is a person who has lived to at least 110 years of age. Based on a mortality plateau at 50% for centenarians aged 100 (Modig et al., 2017), approximately one in every 1,000 centenarians would be expected to reach 110 (Maier et al., 2010). With an estimated 575,000 and 700,000 living centenarians living worldwide (Gondo & Ishioka, 2021; United Nation, n.y.), it can be deduced that there are approximately 700 living supercentenarians in the world. Researchers have become increasingly interested in studying supercentenarians, due to their impressive ability to delay or escape age-related illnesses (e.g., dementia, cardiovascular diseases) when compared to people who die at younger ages (Andersen et al., 2012; Schoenhofen et al., 2006). Determining how genetic and environmental factors influence this characteristic is pivotal to understanding health outcomes associated with extreme longevity (Passarino et al., 2007). A validated supercentenarian database would provide information on sex disparities, country statistics, socioeconomic influences, and mortality rates.

Prior studies have found sex disparities among centenarians, with over 80% of reported centenarians being female (Poulain, 2010). Given the proportion of female centenarians, a prediction can be made that most supercentenarians are also female (Perls. 2017). Research has also indicated that which season a person is born in might influence their lifespan (Gavrilov & Gavrilova, 2011).

To validate data on supercentenarians, a rigorous set of guidelines must be established (Poulain, 2010). There are numerous supercentenarian claimants, but not all are accurate or verifiable due to a variety of factors such as lack of documentation, fraud (i.e., identity theft, pension fraud), misremembering age, or being unknown to researchers at study initiation (Poulain, 2010). Without a robust supercentenarian validation process, false claims remain undifferentiated from true claims, thus skewing the data and resulting in conclusions unrepresentative of real-world demographics. Previous research on supercentenarian age validation by other organizations, while commendable, has been demonstrated by us to contain inaccuracies, which necessitates a further review, especially given the increasing number of supercentenarians over time.

Aim

The aim of this study was to validate deceased supercentenarians and analyze them concerning number of supercentenarians, sex differences, regional differences, and seasonality.

Methods

Age Validation

The basis for the validation methodology originated from the established methodology of prior extreme-longevity researchers (Poulain, 2010; Gondo et al., 2017; Robine et al., 2019). Deceased supercentenarian claims born between 1788 and 1913 identified from sources such as media reports and death indexes, were included. Some of the included supercentenarians were previously verified by other groups researching supercentenarians but were re-checked to comply with our validation criteria and falsely validated supercentenarians were filtered out during review. Claims were examined by four reviewers. After evaluating a defined set of

biographical and documentation requirements, reviewers reached consensus on whether to accept or reject the claim as validated. Information collected included media reports, interviews, and photos. Family contact was initiated when necessary to obtain clarification of biographical details. For a supercentenarian to be considered "validated," documentation dating from the period of birth until their time of death needed to exist. The documentation collected fell into three categories: early-life (i.e., original birth or baptismal certificate or equivalent), mid-life (i.e., marriage record, social security applications, or census records), and proof of death (death registration or extensive obituaries). Delayed birth registrations were not an acceptable substitute for original documentation. Name changes required documentation. Family tree reconstruction was performed, when possible, to decrease the possibility of identity swapping (i.e., sibling-sibling, parent-child). Claims were accepted once the review panel found that the documents corroborated life events from birth to present-day, thus supporting a lifespan of 110+ years.

Statistical Analysis

Linear regression was performed to investigate potential increases in the number of supercentenarians. Chi^2-test was used to compare sexes regarding seasonality and a log-rank-test was used to compare sexes regarding survival.

Results

Number of Supercentenarians

3,011 deceased supercentenarians born between 1788-1913 were validated as of December 31st, 2023. Of these, 2,740 (90%) were female and 271 (10%) male. It was observed that the number of supercentenarians increased over time with close to zero being born prior to the 1850s and the number steadily increasing thereafter (Figure 1) ($p < 0.001$).

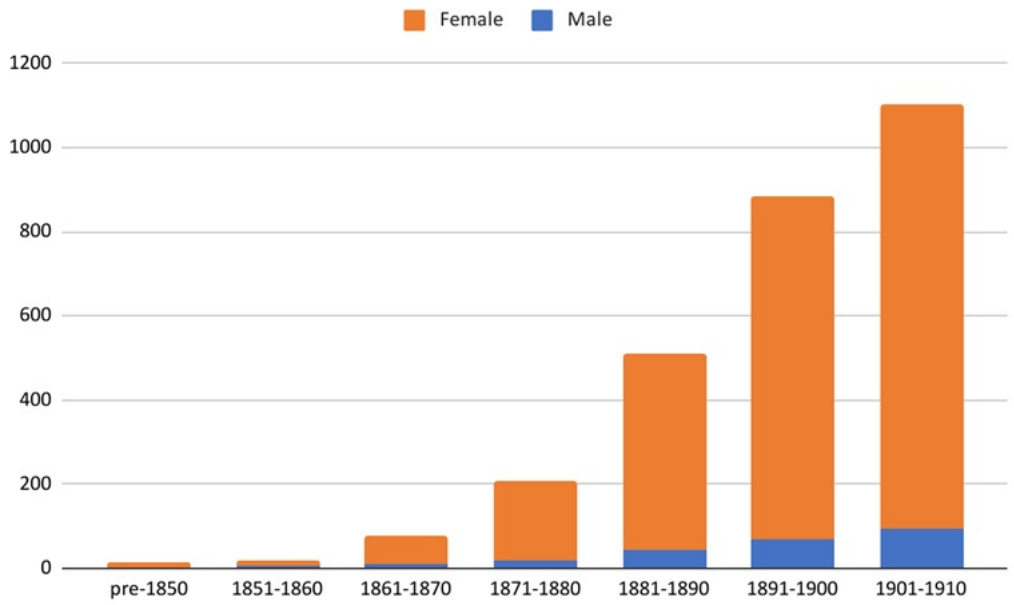

Figure 1. Number of validated supercentenarians per decade

Supercentenarians came from a limited number of regions, with the region USA & Canada (1,247), as well as Europe (1,092) representing over three quarters of all validated supercentenarians. Asia (456), with almost exclusively Japanese representation, was the third-largest region. Few supercentenarians came from the rest of the Americas (166), Oceania (51) and only one validated supercentenarian came from Africa.

Age	*Female SC*	*Male SC*	*Total SC*	*One-Year-Mortality (%) **
110	2174	209	2383	45.0
111	1208	103	1311	47.3
112	651	40	691	49.2
113	333	18	351	52.1
114	162	6	168	63.1
115	59	3	62	56.5
116	26	1	27	63.0
117	10	0	10	60.0
118	4	0	4	25.0
119	3	0	3	66.7
120	1	0	1	0.0
121	1	0	1	0.0
122	1	0	1	100.0

* Table 1 describes the mortality rate at each age for supercentenarians (SC). For Age 110 row: 1,311 of the 2,383 validated supercentenarians born between 1788-1906 that reached age 110 survived until age 111 or higher.

Table 1. Supercentenarian mortality

Due to not all cohorts for validated supercentenarians being extinct at the time of the study, a mortality table was only constructed for the deceased cohorts (1788-1906). It was observed that the one-year-mortality-rate increased with age, especially after age 113. A low proportion of supercentenarians survived past their 117th birthday, indicating that the one-year-mortality-rate could be less accurate past this age. Female supercentenarians had a lower mortality-rate than male supercentenarians up to age 114, after which the number of remaining male supercentenarians was extremely low.

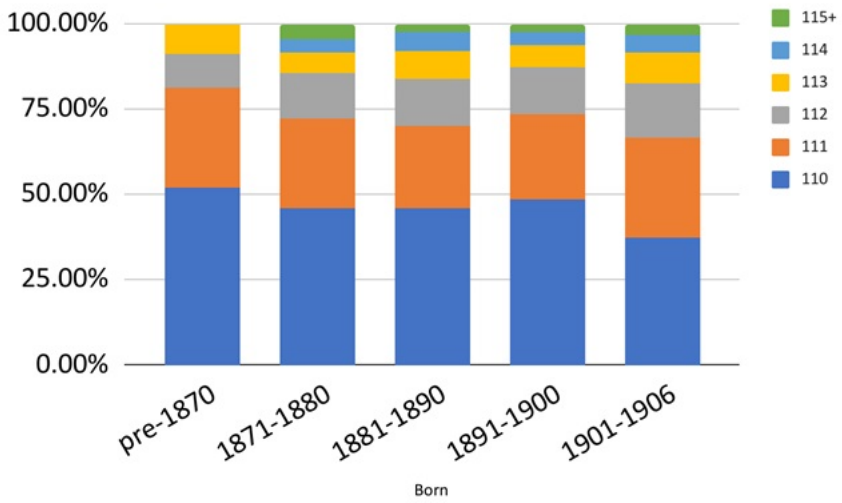

Figure 2. Age distribution of supercentenarians over time

It was noted that the age distribution of supercentenarians changed over time (Figure 2). Prior to 1870, no supercentenarian achieved an age of over 114 years, which was first achieved by a person born in 1871. The proportion of supercentenarians who lived to be 110-111 years decreased over time, with more supercentenarians reaching higher ages. Only a small proportion lived past their 115th birthday.

Seasonality

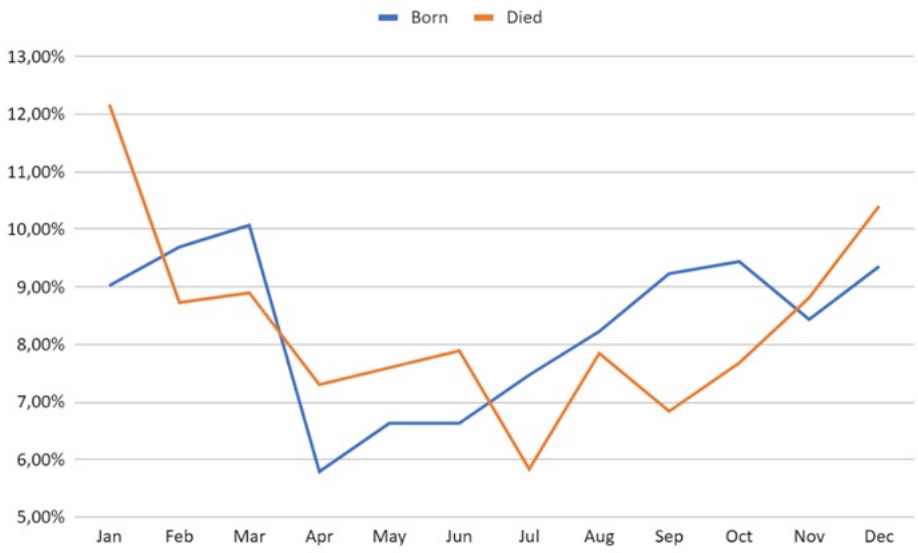

Figure 3. Supercentenarian seasonality (%) based on how many were born and died each month

The study found that a significant majority of supercentenarians, 56.4%, were born during the colder months of the year (October to March), with the highest birth rate occurring in March at 10.1% (Figure 3, Table 2). No significant differences were observed between female and male supercentenarians regarding their season of birth ($p = 0.675$). Similarly, mortality patterns for supercentenarians followed a comparable trend, with 55.8% dying during

October-March, peaking in January at 12.2%. There were no significant differences in the season of death between female and male supercentenarians (p = 0.777).

It was observed that seasonality varied by region (Table 2). Four out of five regions with more than one supercentenarian had most supercentenarians being born between October-March, the exception being The Americas except the USA & Canada. Likewise, three out of five regions with more than one supercentenarian had most supercentenarians dying between October-March, with the exceptions being The Americas except the USA & Canada (equal amount) and Oceania (majority died April-September).

	Born			***Died***		
	Oct-Mar N (%)	**Apr-Sep N (%)**	**p ***	**Oct-Mar N (%)**	**Apr-Sep N (%)**	**p ***
Total	**1697 (56.4)**	**1314 (43.6)**		**1680 (55.8)**	**1431 (44.2)**	
Sex			**0.675**			**0.777**
Female	1541 (56.2)	1199 (43.8)		1531 (55.9)	1209 (44.1)	
Male	156 (57.6)	115 (42.4)		149 (55.0)	122 (45.0)	
Region						
Europe	610 (55.9)	482 (44.1)		621 (56.9)	471 (43.1)	
USA & Canada	694 (55.7)	553 (44.3)		717 (57.5)	530 (42.5)	
Asia	285 (62.5)	171 (37.5)		240 (52.6)	216 (47.4)	
Rest of America	73 (44.5)	91 (55.5)		82 (50.0)	82 (50.0)	
Oceania	35 (68.6)	16 (31.4)		19 (37.3)	32 (62.7)	
Africa	0 (0.0)	1 (100.0)		1 (100.0)	0 (0.0)	

* Seasonality in birth divided by sex and continent. Chi^2-test was used on dichotomous variables.

Table 2. Supercentenarian season of birth

Survival

Survival past age 110 for the supercentenarians was plotted and it was noted that 50% of the supercentenarians were deceased by 111.17 years. 25% were alive at 112.15 years and 10% at 113.42 years. Female supercentenarians were noted to have a higher survival rate past age 110 than male supercentenarians (p < 0.001).

Discussion

Apart from it being the first time such a large set of supercentenarians has been researched, the main findings of this study are also that the majority (90%) of all supercentenarians is female, that the number of supercentenarians born each year has increased over time, and that there appears to be a seasonal aspect to when supercentenarians are born and when they die. Given this, certain findings need to be discussed.

First, while recent research included more than double the number of SCs recognized by longstanding organizations such as the International Database on Longevity, IDL, (1,161 validated supercentenarians as of April 2022) (Ined, n.y.), the results are in no way exhaustive. We at LongeviQuest are aware of a substantial number of known, partially documented supercentenarians (as of December 2023 over 1,000 supercentenarians) and

validation efforts are ongoing. Even considering this, it is likely that there is some degree of selection bias in the data. For supercentenarians to be researched and validated, researchers must know of them. Given that the researchers that participated in the validation of supercentenarians come from a limited number of areas it is possible that some supercentenarians from other regions go unnoticed. Further, not all supercentenarians are reported on in the media, meaning that if they do not have any proof of death, they cannot be fully validated, or potentially even known by researchers.

Second, most deceased validated supercentenarians resided in a handful of developed, wealthy countries. A clear Western bias existed, with certain countries (e.g., USA, France, United Kingdom, and Italy) being well-represented. Japan, with one of the highest life expectancies in the world (Tsugane, 2021), was the Asian country with most validated supercentenarians. Notably, several regions and countries with a significant proportion of the global population had little or no representation. China and India, the two most populous countries with a combined 2.8 billion people as of 2023 (~35% of the global population) (Hertog et al., 2023), had only two validated deceased supercentenarians in total. While these two countries have many supercentenarian claims, the lack of validated cases may be due to a combination of several factors: poor record keeping, language barriers, poor socioeconomic conditions for many non-metropolitan residents, and a lack of knowledge about longevity research organizations, thus limiting participation. There was only one validated deceased supercentenarian from Africa, which has a population of approximately 1.4 billion people (Abramova, 2022). This finding can potentially be attributed to insufficient record-keeping for most African countries, as well as poor media coverage for potential claimants.

Third, approximately 90% of the validated supercentenarians are female, in line with previous findings that 85 - 90% of centenarians are female (Andersen et al., 2012; Kestenbaum, 2021). This can partially be explained by the differences in life expectancy, with females on average living for 2 to 3 years longer than males (Thorslund et al., 2013; Ginter & Simko, 2013). Notably, the ages of the individuals from age 111 and upward indicate an annual mortality rate of approximately 50%, which remains consistent with the theory of a mortality plateau (Barbi et al., 2018). The limited number of individuals validated at age 110 that could result in a lower mortality rate in this dataset may be attributed to several factors, most likely selection bias of which supercentenarians the researchers devoted their time to validating and a potential bias in media reports to emphasize longer-lived individuals. There appears to be an acceleration in mortality towards 60% after age 113. After age 116 or 117 there is insufficient data for any conclusions to be drawn.

Finally, that there was a seasonal component to when supercentenarians were born and died is tangentially related to previous research, which has found that centenarians are born to a higher extent in the Fall and Winter months (Gavrilov & Gavrilova, 2011; Doblhammer et al., 2005). Access to nutrition for expectant and nursing mothers has been put forward as a potential explanation for their children living longer (this period follows the harvest in several areas of the world). Research from 1936 found that in New York and Belgium, children born in the Spring and Summer had a higher mortality following the first year of their birth (Huntington, 1936). For season of death the colder months have been linked to a higher risk of death from infection and environmental exposure (Rau, 2007). Since the exceptionally old are likely to be frail towards the end of their lives it is possible that the cold weather affects their mortality. Specific diseases such as chronic obstructive pulmonary disease and the flu are both associated with excess mortality during the winter months (McCormack et al., 2018; Pebody et al., 2018), both of which are known as causes of death

among the oldest old. In the present study, it was noted that the pattern in seasonality for birth and death was most apparent for people born in the Northern hemisphere, potentially indicating that previous explanations on this phenomenon are accurate.

Conclusion

The number of supercentenarians has increased over time and the majorities are female. A potential mortality plateau might exist at younger ages, but a potential acceleration occurs after age 113. There also appears to be a seasonal aspect to longevity, with most supercentenarians, especially from the Northern hemisphere, being born and dying between October to March. While this study helps provide a better understanding on the number of supercentenarians there are still gaps in certain areas of the world that need to be addressed to provide a full picture about mortality and seasonality patterns of supercentenarians.

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Data Availability

Data used in this study (and other, more recent, validations) are continuously being added and available at https:///longeviquest.com.

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The Effect of Virtual Zen Garden on Quality of Life and Affect of Residents in Long-Term Care Home

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Abstract

Background: Increasing attention has been paid to the therapeutic effect of garden in long-term care home. However, problems on set up and reliability of implementation were still of concern in studies. Virtual Zen garden is an innovative intervention that transfers the beneficial effect of garden into long-term care home.

Objectives: To examine the effect of virtual Zen garden on quality of life and affect of long-term care home residents in Hong Kong.

Methods: A single blinded randomized controlled trial with repeated measure and convergent mixed methods design was adopted. Participants were randomly allocated to received virtual Zen garden intervention(IG) or activity control(CG). Each participant received bi-weekly session for 3 months. Quality of life and affect before(T0), after(T1) and 3-month post-intervention(T2) were measured. Semi-structured interview were conducted to explore the experience of participants in virtual Zen garden.

Results: Significant interaction effect in quality of life ($F = 17.806$, $p < 0.001$), depression ($F = 12.684$, $p < 0.001$), anxiety ($F = 15.909$, $p < 0.001$), pain ($F = 10.640$, $p < 0.001$) and neuropsychiatric symptoms ($F = 20.795$, $p < 0.001$). Significant differences in post hoc analysis were only found in IG instead of CG. The improvement in quality of life and affect in IG sustained for 3 months after intervention. Four themes were drawn from thematic analysis, including influence of virtual Zen garden on (1) physical health; (2) psychological health; (3) social relationship; and (4) environment.

Keywords: Quality of Life, Virtual Reality, Garden, Zen Garden, Long-Term Care

1. Introduction

Quality of life is a broad and complex concept influenced by physical, spiritual and social situations of individuals, personal, faith, as well as relationship with the environment (WHO, 1998). A variety of interventions have been developed to promote quality of life in long-term care home residents. One of these interventions is the use of garden (Chalfont, 2007; Tyson, 2002; Zeisel, 2007). Quantitative studies showed small yet consistent effect of outdoor garden as a multisensory environment on improving affect and wellbeing in older persons (Cox et al., 2004; Detweiler et al., 2008; Hernandez, 2007). Given that there is a limitation of space, recent studies have begun to put emphasis on the use of virtual reality to evoke some of the beneficial effects of garden in a more feasible way (Kim, 2017; Liszio, 2018).

Virtual reality resembles real-life situations in which users can have close-to-reality experiences (Baus & Bouchard, 2014). As a mean to improve accessibility of older persons to nature, past studies have shown that virtual nature is beneficial to reduce stress, heart rate and blood pressure while it can increase restoration, vitality and positive affect (Mattila et al., 2020; Yu, 2018). These effects often attribute to two influential theories, namely the attention restoration theory and stress recovery theory (Brown et al., 2013; Gladwell et al., 2012). The attention restoration theory proposed that voluntary attention depletes in urban environments and cognitively demanding tasks, and restores in natural environment (Kaplan, 1995). The stress recovery theory claims that natural environments influence affective states and hence facilitate recovering from stressors (Ulrich et al., 1991). However, virtual reality experience and its therapeutic effect are affected by the design of content being represented which might lead to unwanted effects such as motion sickness and boredom (Moyle et al., 2018; Reese et al., 2022). Therefore, careful consideration on the type and design of virtual garden is needed to optimize its effectiveness.

Zen garden from Asian culture is specifically developed to calm one's mind by viewing miniaturized scenery (Goto et al., 2014). The word 'Zen' signifies its use in meditation. For example, the world-famous Zen garden is composed with only fifteen small stones on white sand and it is used by practitioners of meditation in Ryoan-ji Temple (Goto et al., 2018). Previous studies have shown that viewing Zen garden improves quality of life of older persons (Goto et al., 2013; Goto et al., 2018). Unlike other gardens that facilitate physical interaction with the elements of nature, Zen garden requires no direct physical contact with, or movement of person within the garden (Gonzalez & Kirkevold, 2014). It is a pictorial representation of nature to be viewed from certain specific viewing points. Viewers being still in the process puts Zen garden to advantage of minimizing unwanted effect of motion sickness when being virtually represented. Therefore, Zen garden can be readily transformed to a virtual intervention with desirable effect on quality of life.

The design of Zen garden emphasizes on the principles of naturalness, simplicity, and austerity. The sparse and seemingly random composition of rocks and empty rectangle of raked gravel form a beloved landscape. A good design of Zen garden is based on two aspects (Gyoba et al., 1985). One is the spatial structure that refers to the perceptual attributes of stimuli. While the rocks have irregular and asymmetrical shapes, natural patterns formed by them are often self-similar and contribute to implicit regularity of Zen garden. Another aspect of good design is the integrated impression that refers to the synthesized evaluations mad by viewers (Gyoba et al., 1985). The rocks abstractly represent natural elements such as islands in ocean, mountain top above the clouds or strokes of the Chinese character meaning 'heart' or 'mind'(Gyoba et al., 1985). A well-designed Zen garden induces a sense of harmony and

imagination during the inexhaustible process of engagement. These distinctive features should be incorporated when developing virtual Zen garden.

Virtual Zen garden is a virtual representation of Zen garden that has potential to improve quality of life of residents in long-term care home. A feasibility study has shown that residents in long-term care were satisfied with virtual Zen garden and its positive benefit on affect and social relationship (Yuen & Kwok, 2024). Compared with another study on virtual vegetable garden in Taiwan which evoked positive emotions by stimuli related to participants' experience of garden in the past, effect of virtual Zen garden was less dependent on viewers' characteristics (Hsieh et al., 2022). This suggests latent factors contributing to consistent effect of virtual Zen garden on residents with various background in long-term care home. While virtual garden yielded a range of effect, studies on its effect on quality of life is limited (Hsieh et al., 2022; Reese et al., 2022). The present study aimed to examine the extent of effect of virtual Zen garden on quality of life and to explore the process and experience of residents in virtual Zen garden in long-term care home.

2. Methods

2.1 Participants and Procedure

A single blinded randomized controlled trial with repeated measure and convergent mixed methods design was adopted. Inclusion criteria were age 65 or above, length of residence of more than 3 months and informed consent obtained. The exclusion criteria included blindness, severe hearing impairment that could not be resolved by hearing aid, recent change in psychoactive medication and medical emergency. The research was approved by the Survey and Behavioural Research Ethics Committee of the Chinese University of Hong Kong. Informed consent was obtained from residents without dementia and guardian of residents with dementia before data collection started.

One hundred and seventy participants were recruited from local two long-term care homes. There were 10 residents (5.9%) excluded due to meeting the exclusion criteria or refusal reasons, including 3 residents hospitalized, 4 residents' guardians not reachable, and 3 residents' guardians declined to participate. A total of 160 residents completed baseline measurement and were randomized into intervention group (n = 80) or control group (n = 80). The structure and format of two groups were designed to parallel each other in terms of their duration (i.e., 1 hour per session) and frequency of sessions (i.e., 2 times per week), number of facilitator and group size. Quantitative measurements were conducted by trained assessors blinded to group allocation in periods of preintervention (T0), post-intervention (T1) and post 3-months follow up (T2). For semi-structure interview, trained interviewers were independent from facilitation of intervention period and quantitative measurements of the trial.

2.2 Measures

2.2.1 QUALIDEM-C

The QUALIDEM-C will be used to measure the primary outcome as quality of life of participants. It is a 37-item proxy-rating questionnaire which has been found applicable to all stages of dementia based on observations of participants in the past 7 days (Arons et al., 2018), with Cronbach's alpha of 0.895 in our validation study. It consists of 37 items categorized into care relationship, positive affect, negative affect, restless tense behavior,

positive self-image, social relations, social isolation, feeling at home, and having something to do. Each item was rated on a 4-point scale ranging from never (0), rarely (1), sometimes (2) to frequently (3). Higher scores indicate higher level of quality of life.

2.2.2 Rating Anxiety in Dementia Scale

The Rating anxiety in dementia scale was used to rate the level of anxiety of participants based on observation of the past 14 days, with Cronbach's alpha of 0.83 (Creighton et al., 2019). It includes 18 items being scored on a 4-point scale and 2 items not included in scoring, marked as present or absence with described observation. Higher scores indicate higher level of anxiety.

2.2.3 Cornell Scale for Depression in Dementia

The Cornell scale for depression in dementia was used to rate the level of depression of participants based on observation in the past 7 days (Kørner et al., 2006). It includes 19 items being scored on a 3-point scale. Higher scores indicate higher level of depression.

2.2.4 Chinese Neuropsychiatric Inventory, Nursing Home Version

The Chinese Neuropsychiatric Inventory, Nursing Home version, was used to evaluate the neuropsychiatric symptoms of participants. The Cronbach's alpha was 0.84 (Leung et al., 2001). Higher scores indicate higher frequency and severity of neuropsychiatric symptoms.

2.2.5 Abbey Pain Scale

The Abbey pain scale was used to rate the level of pain of participants based on observation before and after each session (Lovell et al., 2015; Ludvigsson et al., 2020). It includes 6 items being scored on a 4-point scale. Higher scores indicate higher level of pain.

2.3 Data Analysis

Analysis were performed by SPSS. A 2-tailed P value $P < 0.05$ was considered statistically significant. The baseline demographic and clinical characteristics and outcome variables of continuous data among IG and CG were verified for normality. For between group comparison of continuous variables, independent t-test was used. For within group comparison of continuous variables, paired t-test was used. For categorical variables, Chi-squared test was used. Intention-to-treat analysis was used for the analysis. Missing value were not imputed to avoid possible bias. Two-way repeated measures multivariate analysis of variance with post-hoc analysis was used to evaluate significant main and interaction effects of group allocation and time of measurements.

3. Results

Significant interaction effect in quality of life ($F = 17.806$, $p < 0.001$), depression ($F = 12.684$, $p < 0.001$), anxiety ($F = 15.909$, $p < 0.001$), pain ($F = 10.640$, $p < 0.001$) and neuropsychiatric symptoms ($F = 20.795$, $p < 0.001$). Significant differences in post hoc analysis were only found in IG instead of CG. The improvement in quality of life and affect in IG sustained for 3 months after intervention. Four themes were drawn from thematic analysis, including influence of virtual Zen garden on (1) physical health; (2) psychological health; (3) social relationship; and (4) environment.

4. Discussion

The present study examined the effect of virtual Zen garden on improving quality of life and affect. The results showed that virtual Zen garden, when compared with the activity control, significantly improve quality of life, depression, anxiety, pain, neuropsychiatric symptoms and staff distress. Besides, the effect of virtual Zen garden sustained for 3 months after intervention. The current findings support that virtual Zen garden is effective in improving quality of life and affect in long-term care home residents. Despite the encouraging findings of virtual Zen garden for improving quality of life and affect in long-term care home residents, the results of this study can only be generalized to long-term care home populations. Further studies with recruitment of community and residential populations are needed to improve the generalizability of the study.

5. Conclusion

Virtual Zen garden demonstrated positive beneficial effect on quality of life in physical, psychological, social and environmental perspectives. The findings were encouraging for introduction of virtual Zen garden, as an innovative intervention, into long-term care home. This offers a possible mean of easy and reliable delivery of garden intervention in long-term care home. Besides, the type and design of virtual garden should be considered to deliver promising therapeutic effect.

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Note

1. Virtual Zen garden indicates the potential of virtual nature intervention to improve quality of life in older persons.
2. Virtual Zen garden is a feasible option of intervention to improve older persons' quality of life in limitation of space.
3. Type and design of garden should be considered to deliver promising effect of intervention.

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An Investigation Into the Health Workers Perceptions on the Adoption of Chatbots in Medical Treatment: A Case of Bulawayo Hospital

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Abstract
The utilisation of chatbots in medical treatment has demonstrated significant potential and advantages, with numerous healthcare facilities incorporating this technology into their patient care strategies. Nonetheless, there exists a scarcity of literature focusing on the perspectives of healthcare professionals regarding the incorporation of Artificial Intelligent Chatbots in diagnosing patients' illnesses and delivering medical care, particularly within hospitals in developing countries. Consequently, there is a pressing necessity to comprehend the perceptions of healthcare workers concerning the utilization of chatbots in medical care within the distinctive context of a developing nation. Grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT), this investigation delves into healthcare workers' perceptions of the implementation of chatbots in medical care. Drawing upon qualitative data from a singular hospital case in Bulawayo, Zimbabwe, a developing country in Southern Africa, this study reveals that the effectiveness of chatbots in medical care is impacted by perceived usability, social values and facilitating conditions. These discoveries contribute to the existing knowledge by offering comprehensive insights into healthcare workers' viewpoints on chatbots in medical care. Such crucial findings are valuable for policymakers and key stakeholders in hospitals, aiding them in making well-informed decisions regarding the integration of innovative technologies within the critical domain of medical care. The advancement of technologies like chatbots relies on a thorough understanding of healthcare workers' perceptions and anticipations, thereby enabling hospitals to reap benefits from such advancements and similar innovations.

Keywords: Chatbots, Artificial Intelligence, Medical Treatment, Perceptions, Patient Care, Unified Theory of Acceptance and Use of Technology (UTAUT)

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1. Introduction

Chatbots are dialogue systems that serve as intelligent mediators, capable of engaging in genuine conversations with humans (Parviainen & Rantala, 2022). They are commonly referred to be computer apps that simulate human interactions with the use of natural language processing and machine learning (Shahsavar & Choudhury, 2023). The utilisation of chatbots in the medical domain has demonstrated significant promise and advantages, as some hospitals have included this technology in their patient care methods. Chatbots have been developed as conversational systems that employ different levels of intelligence to help understand user inquiries (Cis & Capstone, 2021). In the medical field, these previous systems have demonstrated their potential to offer solutions based on pre-established labels derived from training data, a continuous service, and readily accessible data. Therefore, they enhance health literacy and promote awareness (Shahsavar & Choudhury, 2023). Chatbots have been realised in the educational sector Dube et al. (2024) however, in the health space there is limited scholarly literature about the perspectives of healthcare professionals regarding the use of chatbots in medical treatment inside the hospitals of underdeveloped countries. The incorporation of emerging technologies, such as Quantified Self devices and chatbots, within the healthcare sector has garnered increasing attention from researchers. A previous research endeavor delved into the determinants affecting the acceptance of QS technology for monitoring diabetes (Ndlovu et al., 2024) and put forth a framework for steering the creation of Quantified Self-centered interventions for chronic disease management (Mutunhu et al., 2024) thus offering valuable insights into the capacity of technology-driven remedies to improve medical care and patient self-management. Correspondingly, recent research has scrutinised the possibilities presented by conversational AI platforms like chatbots in augmenting healthcare provision and patient involvement (Shahsavar & Choudhury, 2023). Building upon this groundwork, the current investigation aims to explore the perspectives of healthcare practitioners on the integration of AI chatbots, with Mpilo Central Hospital being the primary focus of the study. Being a prominent referral hospital in the Matabeleland area, the hospital faces difficulties in providing high-quality healthcare services. The issues encompass extended patient waiting lists and a scarcity of medical personnel (Nyakutombwa et al., 2021). Mpilo Central Hospital is now facing issues as its infrastructure is unable to cope with the increasing patient load. Originally established in 1958 to accommodate 250,000 people, the hospital today serves over one million patients without any substantial changes to its equipment. Therefore, doing research in a setting with limited resources offers useful insights into the contextual elements that impact the adoption of chatbots (Laranjo et al., 2018).

1.1 Aim and Objectives

This research aimed to investigate the healthcare workers; perceptions of the adoption of chatbots in medical treatment.

Objectives :

- To establish opinions of healthcare workers on the use of chatbots for medical treatment
- To assess the factors that influence the adoption of chatbots in medical treatment
- To identify challenges faced by healthcare workers in adopting chatbots to assist in medical treatment

2. Literature Review

This section analyses previous literature on Chatbots in healthcare.

a) Implementation Challenges

Literature has suggested that the integration of chatbots into the healthcare environment has faced several hurdles. The primary obstacle has been recognised as the imperative for chatbots to successfully interact and resolve intricate issues (Parvianian et al., 2021). Chatbots have demonstrated a restricted knowledge base in situations that necessitate human expertise. Another obstacle is guaranteeing the safety and security of patient data while utilizing chatbots for medical therapy. The reference is from a study conducted by Salimi and Shahir in 2020. Healthcare workers exhibited reluctance to use chatbots due to concerns over the preservation of patient confidentiality (Nardazinky et al., 2019). Chatbots suffer from a lack of standardization in their development, making it difficult to regulate and ensure the reliability and correctness of medical information provided during therapy (Abd alrazaq et al., 2020). Integrating chatbots into existing healthcare systems might be particularly challenging because of constraints on technological resources and opposition to change among medical practitioners (Yunus et al., 2024). Addressing the aforementioned problems will optimize the advantages of chatbots to enhance healthcare delivery.

b) Benefits of Adoption of Chatbots in Healthcare

The incorporation of technology in the healthcare sector has garnered significant attention in recent studies, particularly with the emergence of innovations like the Internet of Things (IoT) which exhibit potential in the management of chronic diseases, as exemplified in a prior investigation (Mutunhu et al., 2022). In contrast to IoT devices that furnish immediate data, chatbots present a promising avenue for engaging with patients and providing assistance, underscoring the complementary functions of these technological solutions in the provision of healthcare services. Existing literature demonstrates the advantageous outcomes of employing chatbots in the medical field. Chatbots have enhanced accessibility and support for health care information by providing a 24/7 service (Shahsavar & Choudhury, 2023). Furthermore, this has enhanced patient involvement and heightened their contentment. Adopting chatbots in healthcare has been found to result in increased efficiency, according to Parviainen et al. (2021). Chatbots can execute administrative tasks, such as booking appointments, allowing healthcare practitioners to allocate more time towards addressing the intricate requirements of patients. Chatbots are highly advantageous in the monitoring of chronic illnesses due to their ability to offer personalized assistance and reminders (Zhou et al., 2019). Thus, using chatbots in healthcare will offer a favorable chance to improve patient care outcomes and delivery.

c) Healthcare Provider Perspectives

Overall, the findings reflect a positive outlook on AI chatbots in the healthcare sector among the participants. The chatbots' contributions to enhancing healthcare services are recognised for their provision of personalized assistance, assistance in diagnosing conditions, and facilitation of access to medical information. This mindset exhibits a proactive attitude towards embracing and utilizing technology to improve patient outcomes and operational efficiency in healthcare settings. Adamopoulou and Moussiades (2020) found that healthcare practitioners are familiar with most medical chatbots, including Alexa.

3. Methodology

A qualitative study was undertaken to acquire a comprehensive grasp of the perspectives of healthcare professionals on the implementation of chatbots in medical care. A purposive sample cohort of 10 healthcare professionals was selected from Mpilo Central Hospital in Bulawayo, which is one of the major institutions in the area offering a comprehensive range of medical services (Manzira, 2021). The researcher employed purposive sampling to pick individuals who were actively engaged in decision-making and had prior expertise in interacting with chatbots (Coy, 2019). Open-ended Interviews were used as the method for gathering data in this study. These interviews were performed either in person or online, depending on the participants' preferences. A comprehensive interview guide was developed, encompassing many aspects such as respondents' knowledge of chatbots, their attitudes towards using chatbots in patient care, perceived advantages and obstacles, and suggestions for effective implementation. The researcher utilised the UTAUT model to create these questions, using its four primary constructs: performance expectancy, social impact, effort expectancy, and enabling circumstances. The likelihood of accepting technology is influenced by these factors, and the impact of predictors is mitigated by gender, age, voluntariness of usage, and experience (Thomas et al., 2013). Therefore, the researcher utilised these structures in the study, allowing for the capture of crucial information.

The data obtained from the interviews was analysed using the thematic analysis methodology. This method was employed to find repeating patterns, themes, and insights. The interviews were transcribed verbatim.

4. Results

4.1 Demographic Data of Respondents

Table 1: Demographics of Respondents.

Participant	Age	Marital status	Speciality	Profession	Workplace
P1	28	Single	Junior Doctor	Doctor	Mpilo
P3	48	Married	Gynaecologist		Mpilo, Private Surgery
P6	48	Married	Paediatrics	Doctor	Mpilo, Private surgery, Mater Dei, Corporate 24
P7	36	Married	General practitioner	Doctor	Mpilo
P8	45	Divorced	Dentist	Doctor	Mpilo
P9	40	Single	General practitioner	Doctor	Mpilo
P10	40	Married	General practitioner	Doctor	Mpilo, Private Surgery
P2	37	Married	Paediatrics	Doctor	Mpilo, Private Surgery
P4	45	Married	General practitioner	Doctor	Mpilo, Private Surgery
P5	38	Married	General practitioner	Doctor	Mpilo, Private Surgery

Based on the information presented in Table 1, Participants' ages ranged from 28 to 48 years old, with most falling between 36 to 48 years old. This suggested a relatively experienced group of medical professionals. The majority of participants seven out of ten are married, indicating a stable demographic pattern in terms of family commitments and potentially differing perspectives compared to single individuals. Information on the number of children was not consistently provided for by all participants, but marital status suggested that many likely have children, impacting their lifestyle and decision-making. All participants are healthcare professionals, predominantly doctors, with one dentist. This ensures a homogeneous group in terms of their background and expertise in medical practice. Specialties include Gynaecology, Paediatrics, General Practice, and Dentistry. This diversity indicates varied clinical perspectives and experiences among the participants. Participants work primarily at Mpilo Central Hospital, with several also involved in private surgeries and other medical facilities such as Mater Dei and Corporate 24. This suggested exposure to different health-care settings and potentially varying patient populations. The participants represent a diverse range of medical specialties and practice settings, enhancing the richness of perspectives in the study.

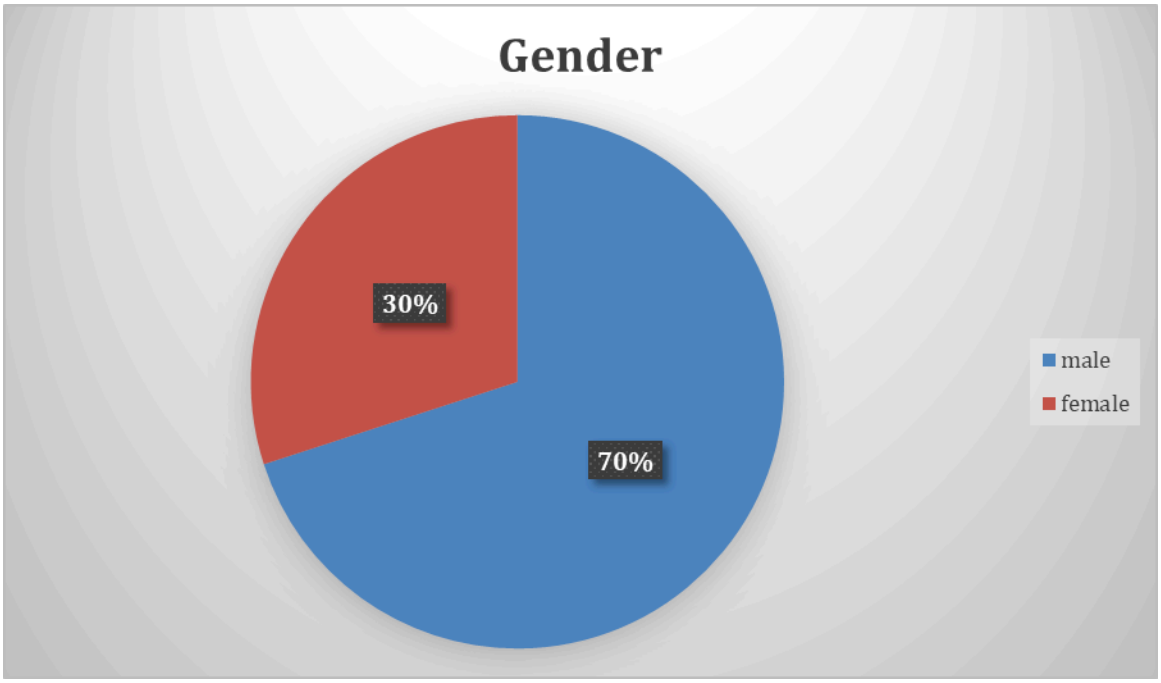

Figure 1: Gender of Respondents.

According to Figure 1, three females participated in the interviews while on the other hand seven male participants were interviewed.

The findings derived from the empirical data collected during the research process were divided into sections corresponding to each research objective:

4.2 Objective 1 - Opinions of Healthcare Workers

This section presents the diverse viewpoints and perspectives expressed by healthcare professionals regarding the adoption of chatbots for medical treatment. It explores themes such as perceived benefits, concerns, and expectations towards integrating chatbots into healthcare delivery. The themes that relate to the opinions of participants include the use of

the latest medical applications, familiarity with chatbots, multiple benefits of chatbots in medical treatment, and proficiency in skills and learning use of chatbots.

Theme 1: Use of the Latest Medical Applications

Participants highlighted the use of the latest healthcare application utilised at Mpilo Central Hospital, providing access to current medical findings and recommendations.

> Participant 4 (P4): "*Yes. There is an application that we use at Mpilo and it is compulsory and it's called UpToDate. It is a health care application that is dedicated to providing modern medical findings and recommendations on medical practices*."

> Participant 6 (P6): "*Yes. There is an application that we use at Mpilo that is recommended by the hospital and it's called UpToDate. It is a healthcare application that is dedicated to providing information on what is happening in the medical field. Provides information on the latest inventions that can be used to care for patients. It also provides suggested ions on medical solutions*."

The findings suggested reflecting a positive acknowledgment of the role of technology in health care, specifically in enabling healthcare professionals at Mpilo Central Hospital to access and utilise the latest medical information efficiently.

Theme 2: Familiarity With Chatbots

The participants demonstrated familiarity with AI chatbots such as Florence, Ada, and Alexa, and highlighted their roles in medication reminders, symptom diagnosis, and general information assistance.

> Participant 4 (P4): "*I know of Florence who is a personal nurse who works on Facebook and reminds patients to take their medication. There is also another one called Ada which is a diagnostic tool for checking symptoms. And there is ChatGPT that everyone talks about.*"

> Participant 6 (P6): "*I know of Alexa which was designed to be a personal assistant that provides general information. There is also Ada which is used for diagnosis. It checks for symptoms and suggests what the problem is*."

In general, the results emphasize a favorable perspective on AI chatbots in the field of healthcare among the participants. They acknowledge the chatbots' contributions to improving healthcare services by providing individualized help, aiding in diagnosis, and granting access to medical information. This consciousness demonstrates a proactive approach to embracing and exploiting technology to enhance patient outcomes and operational efficiency in healthcare environments. According to the research conducted by Adamopoulou and Moussiades (2020), healthcare professionals are now well-acquainted with the majority of chatbots, such as Alexa, that are used for medical purposes.

Theme 3: Multiple Benefits of Chatbots in Medical Treatment

Participants outlined the multiple benefits of chatbots including quick access to medical information, convenience for patients, and cost-effectiveness compared to traditional health care services.

> Participant 4 (P4): "*Chatbots provide medical information and advice for minor conditions. They are convenient as patients can use them in the comfort of their homes and they are also cheaper compared to frequent visits to the doctor or even hiring a nurse for home-based care.*"

> Participant 6 (P6): "*They are fast as they provide solutions instantly. At times our work comes with a lot of pressure so having an application that helps with information on the go to make decisions makes our work very easy, which is what these chatbots do*."

Findings reflect a favourable view among participants regarding the benefits of chatbots in health care. They see chatbots not only as tools for quick and convenient access to medical information but also as cost-effective solutions that can enhance patient care and operational efficiency in healthcare delivery. This recognition underscores a growing acceptance of digital health technologies and their potential to transform healthcare practices by making them more accessible, efficient, and patient-centered.

Theme 4: Proficiency in Skills and Learning in Using Chatbots

Participants described their proficiency in using chatbots as average, learning primarily through colleagues or self-exploration, highlighting the straightforward nature of these tools.

> Participant 4 (P4): "*I can say I am average because a colleague of mine is the one that taught me how to use the chatbots but I discovered there is nothing complicated about using these chatbots."*

> Participant 6 (P6): "*I can say I am average because a colleague of mine is the one that taught me how to use the chatbots but I discovered there is nothing complicated about using these chatbots*."

Findings suggested that participants described their proficiency in using chatbots as average, learning primarily through colleagues or self-exploration, highlighting the straightforward nature of these tools.

The majority of participants recognised the potential of AI chatbots in health care, primarily for providing quick access to medical information, assisting in decision-making processes, and improving efficiency in patient care. They appreciate the convenience and cost-effectiveness of chatbots, especially in contexts where immediate information and decisions are necessary. Their familiarity with specific chatbot applications like Ada and their ease of use suggested a positive outlook toward integrating these technologies into medical practice in Bulawayo.

These summaries and verbatim responses collectively illustrated the participants' opinions on medical applications and AI chatbots, emphasizing their integration into medical practice, familiarity among healthcare professionals, perceived benefits, and ease of use.

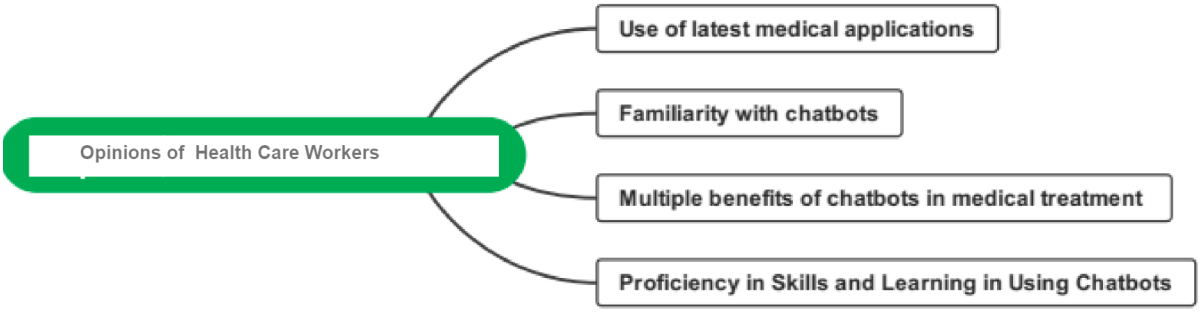

Figure 2: Summary of themes of opinions of healthcare workers

4.3 Objective 2 - Factors Influencing Adoption

Here, the focus shifts to the examination of key factors influencing the adoption of chatbots in medical settings. Factors identified through the research are discussed in detail, highlighting their significance in shaping healthcare workers' readiness to embrace this technology.

a) Perceived Usability

In terms of perceived usability, the sub-themes were very skilled use of chatbots and learning process and installation challenges.

Theme 1: Very Skilled Use of Chatbots and Learning Process

This theme refers to participants' self-assessed proficiency in using chatbots and the methods they employed to acquire these skills, whether through self-teaching or assistance from others. Results showed that participants were very skilled in the use of chatbots in the learning process.

> P3: "*I can say well skilled. I self-taught myself on how to use them without the assistance of anyone.*"
>
> P5: "*I can say very skilled because there is nothing complicated about using chatbots. Anyone can use chatbots you don't need any training*."
>
> P7: *"I can say well skilled, I taught myself how to use them and they are quite simple to use."*

The findings underscore participants' proficiency, ease of learning, and positive experiences with chatbots, indicating their readiness to utilise these tools in various aspects of medical practice and beyond.

Theme 2: Installation Challenges

This theme involves the difficulties participants encountered when installing chatbot applications, such as technical issues or subscription requirements, and how they resolved these challenges. Results showed that participants faced installation challenges such as technical issues and subscription requirements.

> P3: "*For the ChatGPT, I was required to pay premiums to have full utility of the application so I ended up not installing it*."

> P7: "*The challenge I faced with ChatGPT was the requirement to pay a subscription fee to use it so I did not follow through with installing it*."

These findings emphasise the real-world obstacles participants encountered during the installation of chatbots, underscoring the importance of addressing technical issues and subscription requirements to optimize usability and adoption in healthcare and other fields.

b) Social Values

With regards to social values, sub-themes are community and colleague reactions and expectations as well as experiences.

Theme 1: Community and Colleague Reactions

This theme describes the perceptions and attitudes of the broader community and colleagues toward the use of chatbots in medical treatment, including skepticism, acceptance, or concerns about accuracy and reliability. Results showed that most participants had mixed feelings such as skepticism, concerns, and acceptance of chatbots in medical treatment.

> P6: "*Many people seem skeptical about seriously relying on chatbots for medical treatment. They have fear of the accuracy of information provided*."

> P7: "*People find it difficult to accept information from chatbots because they worry that it may not originate from reputable or trustworthy sources*."

Findings show the diverse range of attitudes participants hold towards chatbots in medical treatment, encompassing scepticism, concerns, and acceptance. This complexity reflects the need for careful consideration of ethical, practical, and technical aspects in the development and deployment of AI-driven technologies in health care. The majority of medical personnel accepted the use of chatbots with slight reservations whilst the older participants had a negative attitude towards their use among their peers. The results suggested that social influences have contributed to the use of AI chatbots.

Theme 2: Expectations and Experiences

This theme encompasses participants' initial anticipations when first using chatbots and whether these expectations were met, along with any specific encounters or observations that influenced their ongoing usage. The results showed that participants had doubts and different experiences about the use of chatbots.

P3: "*When I first started using these chatbots I just wanted to see whether these applications work if they give the correct information*."

P5: "*I started using chatbots with the expectation that they would make work easier and if they lived up to the hype that everyone was talking about*."

The findings highlight the nuanced perspectives participants have towards chatbots, ranging from doubts and scepticism to varying degrees of acceptance and optimism. Understanding these diverse experiences is essential for developing chatbot technologies that align with healthcare professionals' needs and expectations while addressing their concerns effectively. The results indicated that medical students expressed concerns about their usability in practice despite the hype given about their benefits. In the same study, some also showed high expectations and acceptance for use in administrative purposes.

c) Facilitating Conditions

In terms of facilitating conditions, there are enjoyment, voluntary use, privacy, and security concerns as identified themes:

Theme 1: Enjoyment and Voluntary Use

This theme reflects participants' subjective satisfaction or lack thereof in using chatbots, and whether their usage is based on personal preference or driven by external factors like professional requirements or patient expectations. Results showed that participants enjoyed and voluntarily used chatbots in medical practice.

P5: "*Yes, so far so good*."

P6: "*I can't say I enjoy. But it's alright*."

Findings suggested that participants not only found chatbots enjoyable to use but also voluntarily incorporated them into their medical practice, indicating perceived utility and positive user experience. This positive reception is crucial for the continued adoption and integration of AI technologies like chatbots in healthcare settings.

Theme 2: Privacy and Security Concerns

This theme focused on participants' apprehensions regarding the confidentiality and security of data handled by chatbots, including uncertainties about data sources and potential risks associated with information storage and usage. Findings showed that participants had privacy and security concerns about the use of chatbots in medical practice.

P3: "*I don't trust chatbots as there is a third party involved and their source of information is not known*."

P7: "*Well, we do not know where these chatbots derive their information or where they keep it. So security is an issue when it comes to these chatbots*."

Findings reveal that while participants recognise the potential benefits of chatbots in medical practice, their concerns about privacy and security remain significant barriers that need to be addressed to foster greater acceptance and integration of AI technologies in healthcare.

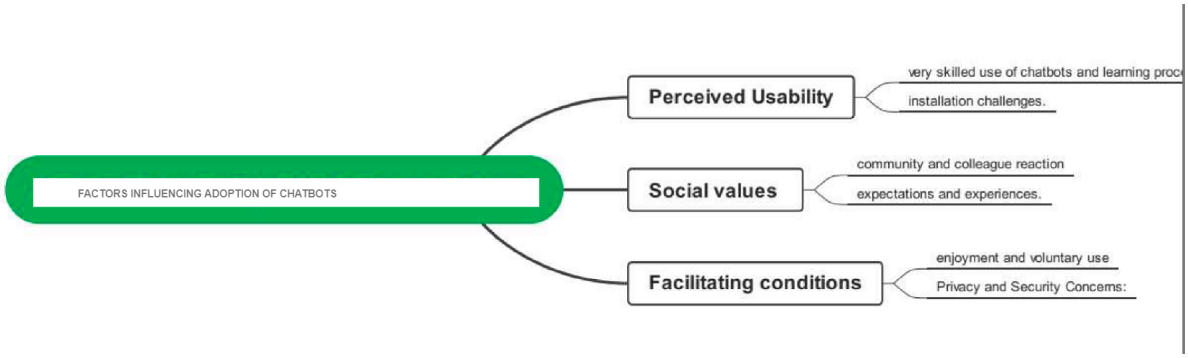

Figure 3: Summary of themes of factors influencing adoption of chatbots

4.4 Challenges in the Adoption of Chatbots

The final section examines the challenges faced by healthcare professionals when adopting chatbots for medical treatment. It synthesizes qualitative data to delineate barriers, constraints, and ethical dilemmas encountered in the process of integrating chatbots into clinical practice. Based on the responses provided by participants regarding challenges encountered when using chatbots in healthcare practice.

Theme 1: Limitations in Handling Complex Cases

Participant P10: *Chatbots struggle to handle complex cases and cannot provide emotional support, which is crucial in patient care. They cannot substitute for the human experience necessary in such situations*.

Participant P7: *Echoes a similar sentiment that chatbots cannot adequately address questions or issues that require human experience or nuanced understanding beyond factual information*.

Participant P3: *Notes that chatbots have limitations in handling complex cases and can give incorrect answers when faced with questions that are not straightforward or require context*.

Theme 2: Limitations in Medical Decision-Making

Participant P5: *Specifically mentions the Ada chatbot's inability to perform complex diagnoses or provide treatment plans such as issuing prescriptions. This limitation hinders its utility in more advanced medical scenarios*.

Theme 3: Response Delays and Inaccuracy

Participant P9: *Highlights challenges with chatbots getting overwhelmed or delayed in responding, especially during periods of high demand. This can result in annoyance and reduced effectiveness in providing timely information*.

Chatbots' inherent limitations—inability to manage complexity, medical decision support limitations, and operational issues—are the main challenges in healthcare. The results showed that Chatbots struggle with complex situations that need human discernment, emotional understanding, or delicate decision-making beyond information retrieval. Certain chatbots cannot dispense drugs or perform complex medical diagnoses or treatment plans. Participants often notice operational issues like answer delays and errors that might influence these systems' therapeutic usefulness. These issues demonstrate chatbot technology's limits in healthcare and provide ways to improve their integration and use alongside human healthcare professionals.

Theme 4: Installation Challenges

Participant P8: *Didn't use ChatGPT due to the requirement of a subscription fee. Meta AI, integrated with WhatsApp, posed no installation challenges since WhatsApp was already on the phone.*

Participant P7: *Encountered no installation issues with Pi, as it came integrated with WhatsApp. However, noted that Pi can get overwhelmed with commands, leading to delays in responses. Did not install ChatGPT due to the subscription fee requirement*.

Participant P10 (at 4:05): *Installed applications from the Google Play Store without significant issues. ChatGPT required a subscription fee for full functionality, which deterred installation. Meta AI was embedded in WhatsApp, hence no separate installation was needed.*

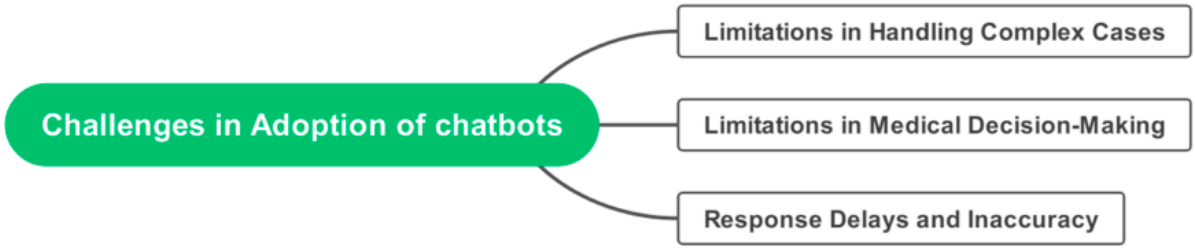

Figure 4: Summary of themes in challenges of adoption of chatbots

5. Discussion

The study conducted at Mpilo Central Hospital reflected broader trends in the literature regarding the adoption of chatbots in health care and hence the researcher explained how the research findings confirm with existing literature. Shown below is how the researcher linked findings from the study to other existing literature.

a) Lack of Trust in the Source of Chatbots

The data analysis showed that the ten Mpilo Central Hospital health staff use current apps to help them with their work. The chatbot source was not trusted by these participants. The 10 participants show a complicated acceptance-skepticism landscape. This is consistent with studies on healthcare chatbot dependability and trustworthiness. Healthcare chatbots are becoming more popular, but trust and dependability remain major impediments (Grassini et al., 2024).

b) Limited Use in Complex Cases and Medical Decision-Making

According to the findings, the participants also believe that chatbots cannot handle complex cases and scenarios requiring human experience. Participants noted that while chatbots could manage routine tasks, they fell short in scenarios that required nuanced understanding and decision-making. The foregoing is also supported by existing literature. Chatbots are not yet mature enough to replace human judgment in complex medical situations, (Parviainen et al, 2021).

c) Chatbots as an Efficient Tool and Source of Support

Despite the mentioned concerns by participants and existing literature; the researcher also found that chatbots could play a supportive role in health care by automating routine processes and providing timely information. This is consistent with the literature, which suggests that chatbots can enhance efficiency and reduce the burden on healthcare professionals by handling administrative tasks and providing basic patient support (La, 2024). Chatbots have been successfully used to schedule appointments, remind patients of medication, and provide general health information, thereby freeing up healthcare workers to focus on more complex tasks (Parviainen et al, 2021). Chatbots have dual roles as both a tool for efficiency and a potential source of support which highlights their value in the healthcare ecosystem, despite the existing reservations (Grassini et al, 2024).

d) Enjoyment and Voluntary Use

The results data analysis confirm with data reported by Sweeney et al. (2021) who noted that medical health personnel had satisfactory experiences with chatbots in the mental health sector. The similar level of enjoyment points out to the seamless ease with which chatbots are used.

e) Privacy and Security Issues

The findings support Saglam et al. (2021)'s usage of personal data and chatbot data recovery failure. Medical staff were also wary about chatbots due to privacy issues (Nadarzinky et al., 2019). Given the multitude of activities in healthcare institutions, chatbot monitoring is tough. These subthemes organize participants' views on AI chatbots in medicine, including abilities, installation, social perceptions, user expectations, usage delight, and security.

f) Installation Challenge, Response Delay, and Inaccuracy

The results agree with Yunus et al. (2024), who found installation difficult, especially for first-time chatbot users due to gadget difficulties. The results concur that AI might make ChatGPT incorporation into medical practices and healthcare environments difficult due to biased or erroneous information and ethical violations in patient safety (Yunus et al,2024). AI-generated information mistaken for human knowledge raises ethical difficulties. The similarities indicated that chatbots were still in development and needed extra steps before adoption. Participants reported subscription and slow response issues when installing and using chatbots.

6. Implications

This study will advance understanding theoretically and practically. In practice, it will improve healthcare by assessing health professionals' impressions, making services more accessible and efficient. Knowing health professionals' opinions can help create chatbots that are easier to use and improve patient care and workflows (Abd-Alrazaq et al., 2021). Chatbots may optimize resources, reduce healthcare professional workload, and reduce costs if good perceptions are found (Palanica et al., 2019). The findings can help create health worker training programs and policies. The findings can help governments create supportive frameworks for chatbot integration in healthcare settings, resolve concerns, increase acceptance, and educate health workers to utilise chatbots. The review's findings will illuminate healthcare technology adoption and influence future AI-based solution integration decisions. The study showed how cultural and infrastructural variables affect healthcare technology adoption. Academic research relies on theoretical contributions to bridge the literature gap between technology and health care in underdeveloped places (Wilson & Marasoiu, 2022).

7. Limitations

Selection bias, restricted generality, and lack of longitudinal data limit the study of health workers' views on chatbots in medical care at Mpilo Central Hospital. Participants were chosen based on chatbot experience and decision-making position. The findings may have been biased and not applicable to all Mpilo Central Hospital health personnel. The study was done at one hospital, which may limit its applicability. Depending on the institution and culture, health personnel may see chatbots in medical care differently. The investigation's one-time evaluation of health professionals' perspectives limited its capacity to track changes in attitudes and opinions. Chatbot perspectives in medical therapy should be better understood with longitudinal data.

8. Recommendations

The researcher suggests using random sampling instead of specific criteria to select participants in future studies to reduce selection bias and improve generalizability to the hospital's health workers. To examine health professionals' impressions over time, a longitudinal study design is needed. This allows a more dynamic examination of attitudes and preferences for medical chatbots and an understanding of how medical practitioners' attitudes toward chatbots are changing.

9. Conclusion

In conclusion, Mpilo Central Hospital health workers' views on chatbots in medical care have illuminated the various aspects that affect acceptance and attitudes toward this developing technology. A comprehensive survey of health workers revealed a range of viewpoints and concerns about chatbots in medical care. Context-specific factors including institutional resources, organizational culture, and technology infrastructure influence health professionals' chatbot adoption perspectives. This study lays the groundwork for future research and activities to boost chatbot adoption in health care, improving patient care and medical treatment at Mpilo Central Hospital and beyond.

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Designing a Social Robot to Support Older Adult Homecare: Qualitative Study of Testing Results

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Abstract
Social robots may be a solution to the growing number of elderly and thus the demand in homecare. Previous work shows good acceptability for robotic tools in homecare. The Guardian project associates a social robot, used by the senior, with an application to be used by caregivers. The objective of this testing phase was to assess whether the Guardian system would be helpful and well accepted within the real conditions of a homecare environment. The Guardian system was tested in a real-life homecare environment during an early testing phase. Data was gathered through questionnaires and comments formulated by the participants. 30 participants were recruited across Italy, the Netherland and Switzerland: 10 older adults, 10 formal caregivers, and 10 informal caregivers. The collected data was then analyzed through thematic and qualitative method. The results of this test show that users were ready to accept robotic solutions into a homecare environment. Most users found the Guardian system easy to use, but it appears older adults' expectations were not met regarding helpfulness in everyday tasks. Caregivers saw some benefit in using it to facilitate cooperation between caregivers but found human-robot interaction and application functionalities limited. The most common comment was that users want vocal commands for an easier and more natural interaction with the robot. Social robotics may very well be a relevant field to explore regarding homecare but users' expectations are growing fast. In this regard, accessibility is key and must remain a primary focus when considering tool development for elderly.

Keywords: Older Adults, Elder Care, Early Testing, Daily Coaching Solution, Evaluation in Natural Environment, Social Robot

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Introduction

Background

According to the United Nations World Population Prospect, "by 2050, one in four persons living in Europe and Northern America could be aged 65 or over" (Department of Economic and Social Affairs & Population Division, 2022). In fact, between 2015 and 2050, "the proportion of the world's population over 60 years will nearly double from 12% to 22%" (WHO, 2022). Mainly due to increased life expectancy (Department of Data and Analytics, 2020; Eslami, 2016) and declining fertility in both developing and developed countries (Beltrán-Sánchez et al., 2015; Eslami, 2016; Nargund, 2009), the world population is definitely aging (Beltrán-Sánchez et al., 2015; Department of Economic and Social Affairs & Population Division, 2022; Keyfitz & Flieger, 1991; Spasova et al., 2018).

With the increasing proportion of older adults in most countries (Department of Economic and Social Affairs & Population Division, 2022; WHO, 2022), a proportional increase in the need for long-term care is observed as well (Spasova et al., 2018). Long-term care can be defined as "medical and non-medical care provided to people who are unable to perform basic activities of daily living" (*Long-Term Care - Glossary*, n.d.). In the United States for example, the Administration for Community Living estimates that people aged 65 in 2020 had a 69% chance of requiring long-term care (1 year or more) during their remaining years (ACL Administration for Community Living, 2020).

For the majority older adults, in the event of a long-term care requirement, a clear preference toward home care over senior communities or nursing homes was observed in an American study (Malato, 2016). Moreover, presently in all regions in Europe, the availability of residential care (e.g., nursing homes) is insufficient and demand exceeds supply in many countries (Spasova et al., 2018). This situation calls for innovative solutions in terms of long-term care and especially home care.

One of many possible solutions to the elder care crisis our society is facing (Abel, 2022; Drummonds, 2007; Greene et al., 2005; Haubner, 2020; Lancet, 2014) may very well be found in the development and use of digital tools such as apps and home automation tools. As automation appears to be underutilized among older adults (Pal et al., 2018), it could facilitate everyday activities, thus alleviating some aspects of the home care process.

Prior Work

Various studies were conducted on the subject of automation and more precisely the use and acceptance of robotic tools with older adults (Cesta et al., 2016; Fasola & Matarić, 2013; Fischinger et al., 2016; Koceski & Koceska, 2016; Pino et al., 2015; Wu et al., 2016). One study in particular provides promising results toward the acceptability by seniors of robotic tools within home care systems (Cavallo et al., 2018). As for professional caregivers, experimental results seem to be less positive toward the implementation of robots, mainly due to the idea that current robots may not be able to recognize and integrate individual perspectives of care (Busse et al., 2021).

Different versions of social robots for the elderly were designed and tested during the last two decades. However, it seems that none of these prototypes managed to make it to the commercial phase. This might be due mostly to three distinct reasons according to an article

from the International Journal of Social Robotics (Bardaro et al., 2022): “the intrinsic complexity of the tasks the robot has to achieve (Alterovitz et al., 2016), the unpredictability of a domestic environment (Bodenhagen et al., 2019), and the unstructured interaction with the users (Coronado et al., 2017)”. The search for the perfect social robot continues, in part with the Guardian Project.

The Guardian System

The Guardian system is composed of three elements: a social robot, which is installed in the older adult’s living room, and two mobile applications for the older adult and their caregivers respectively. The caregiver application gives the ability to plan different types of reminders (medication, meals, and activities), self-reports requests (sleep quality, global wellbeing); It can also be used to set appointments and offer personalized messages. Once the older adult reports or answers to a reminder, the caregiver can see the results on their application.

As for the older adults, they receive vocal notifications from the robot and can then interact with it using their application. With the application, seniors can self-report on their sleep or well-being, confirm or infirm reminders with additional information. They can also consult planned appointments.

Goal of This Project

The Guardian Project aims to explore and develop possibilities in the field of robotic-assisted home care by designing a social robot that is helpful to both the older adults and their caregivers, namely health professionals or close relatives. Using a Misty II robot (*Misty Robotics*, n.d.), paired with a mobile application linking the senior with their caregivers, the Guardian system offers various digital tools to alleviate the homecare process. Through the mobile app, caregivers can manage meal and medication reminders, ask for wellbeing and sleep quality reports, suggest personalized activities, add appointments to the senior’s calendar, and have an overview of the senior’s answers (Lewis, 1995).

Early Testing

After promising usability tests conducted in a controlled environment (Villaverde Naveira et al., 2022), the early testing phase was designed to evaluate the Guardian’s system operation in real-life conditions and allow for a more comprehensive user-centered approach.

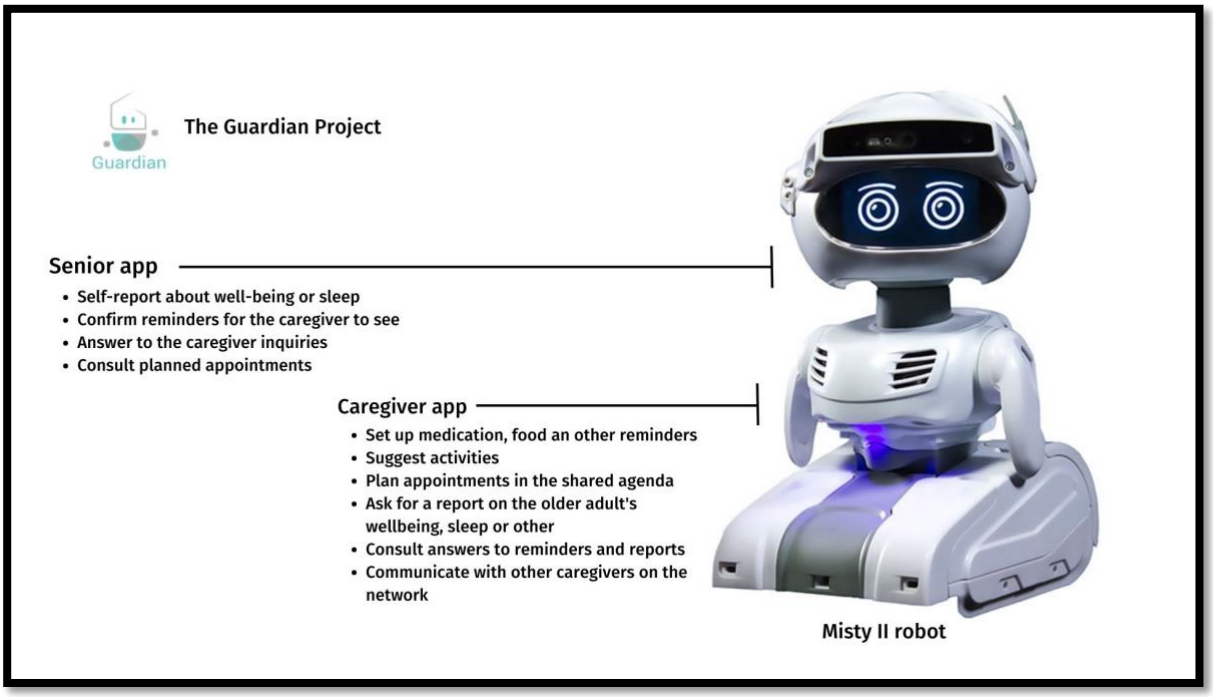

Figure 1: Functionalities of the Guardian System

Methods

The early testing stage of the evaluation process was mainly focused on the usability of the Guardian system in real life conditions. The aim of this evaluation was to observe how the robot would fit into the everyday life of an older adult receiving homecare, and how much help it could provide to the caregivers. To this end, questionnaires were given and filled out by the participants at the end of the testing period.

Recruitment

Groups of three participants were enrolled for this trial: an older adult, a professional caregiver, and an informal caregiver. The adults were chosen to be older than 65, and recognized as *frail* according to the Frailty Index (Rockwood et al., 2005) or to a SF-12 survey (Ware et al., 1996). The formal caregivers were health professionals involved in the care of the recruited senior and must have had at least a year of experience in the field. As for the informal caregivers, they had to be relatives or close friends of the senior, providing frequent care and aged 18 or older. All groups needed to display good written and oral comprehension of the local language and be available during a two weeks period. Furthermore, an open mindset towards technology was asked of the caregivers.

The recruitment process took place in Switzerland, Italy, and the Netherlands; it aimed to include 15 participants from each country. Even though the desired number of 45 participants was not reached – partly due to logistic problems during the recruitment phase – 35 participants interested in testing the robot in a home environment were enrolled. 30 participants in total fully completed the test: 10 seniors, 10 formal caregivers, and 10 informal caregivers. Of those who participated in the two weeks long testing phase, only certain participants were able to fill out the required questionnaires. The number of collected questionnaires is presented on each corresponding table in the Results section.

Procedure

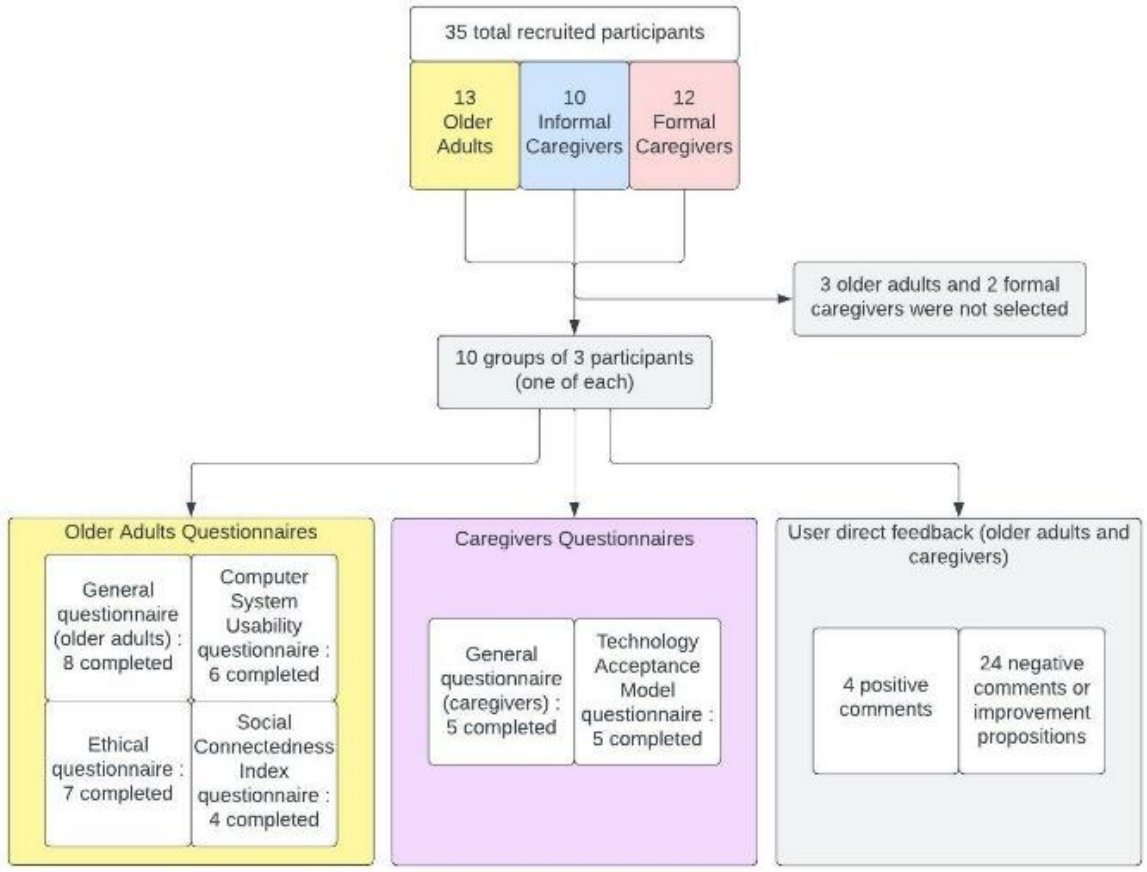

Figure 2: Collected data

The trial period for each group lasted two weeks, during which the robot was installed inside the older adult's home, in the room where they spent the most of their time. Caregivers were asked to set up regular reminders and requests during the installation and then adapt them as required during the testing period. Daily interaction through Guardian was asked of every participant, whether to self-report and interact with the robot or check results and adapt reminders. Participants' feedback on the Guardian system was then collected using various questionnaires detailed in the Material section below. These questionnaires were filled out by seniors and their caregivers after the testing period. Participants were also invited to share comments and suggestions for improvements that were recorded and can be seen in the Results section. As the number of total collected questionnaires was fairly low, a thematic analysis was conducted on the qualitative dataset to better represent the collected data.

Material

In order to get relevant feedback from the seniors and their caretakers, different questionnaires were submitted to them. First, the seniors had to fill out a general questionnaire (Table 1) about a variety of subjects relating to the Guardian system's helpfulness in regard to the everyday activity of the older adult. A Computer System Usability Questionnaire (Lewis, 1995) (Table 2) was then used to evaluate how easily and efficiently the system could be used by the older adults. Both of these questionnaires were rated from 1 (*strongly disagree*) to 7 (*strongly agree*). To those were added an ethical

questionnaire (Table 3), mainly focused on safety aspects. A Social Connectedness questionnaire (Table 4) was also filled out to better understand how Guardian helped the older adults feel connected to their caregivers. The items of this second set of questionnaires were rated from 1 (*strongly disagree*) to 5 (*strongly agree*).

The caregivers were submitted two different questionnaires, without distinction between formal and informal caregivers. The first is also a general questionnaire (Table 5), with questions regarding the subjective helpfulness of Guardian to the caregivers; it uses the usual item rating system from 1 to 5. The second caregiver questionnaire used the Technology Acceptance Model (Lai, 2017) (Table 6) to assess the accessibility and usability of Guardian; items were rated 1 to 7 by the participants.

For each questionnaire, the mean (either "3" for 5-points questionnaires or "4", for 7-points questionnaires) represents "neither agree nor disagree".

The particular items relative to each questionnaire can be found in the tables of the Results section.

Results

Senior's Point of View

Helpfulness.
The data recovered from the general questionnaire submitted to the seniors (Table 1) seems to indicate that the efficiency expectations were not met. Seniors did not find Guardian to be helpful in most surveyed everyday activities such as being more active (M=2.875/7), taking medication on time (M=3.375/7), and eating and drinking enough (M=2.25/7). Most seniors did not find Guardian to be helpful in feeling less lonely (M=3.625/7), feeling more independent (M=1.875/7) or following a daily routine (M=2.75). Some seniors did find Guardian to be helpful in informing caregivers about their wellbeing (M=4.375/7).

Usability.
The answers given to Computer System Usability Questionnaire (Table 2) show that seniors were mainly satisfied with the accessibility Guardian (M=4.7/7), and appreciated the organization of the information on screen (M=5.3/7) as well as the clarity of the information provided with the system (M=5.2/7). The main problem seems to be the error messages which did not clearly tell the seniors how to fix problems when they occurred (M=2.8/7).

Ethical Concern.
The ethical questionnaire results (Table 3) show that the seniors felt safe using Guardian (M=5/5) and thought the data collected by Guardian well protected (M=5/5). Most seniors agreed that the robot was not time consuming and saved time (M=4/5) but most seniors still found Guardian not to be in line with their expectations (M=2/7).

Social Connectedness.
Seniors were also asked to evaluate their social connection to the caregivers through a Social Connectedness Index questionnaire (Table 4). The collected data indicated that seniors felt both formal and informal caregivers close to them (M=5/5 and M=5/5) with the help of Guardian. Moreover, they felt mostly safe (M=4.75/5) as well as supported and understood by the network including caregivers and the Guardian system (M=5/5).

Item	Score, mean	n
Using Guardian helps me to take my medication on time.	3.375	8
Using Guardian helps me to become more active.	2.875	8
Using Guardian helps me to eat and drink enough.	2.25	8
Guardian system helps me to make me feel less lonely.	3.625	8
Using Guardian helps me to feel more independent.	1.875	8
Guardian helps me to have a daily routine.	2.75	8
Guardian helps me to inform my caregivers about my wellbeing.	4.375	8

Table 1: General questionnaire (seniors), items rated 1 to 7, 7 being “strongly agree”, average is 4.

Item	Score, mean	n
Overall, I am satisfied with how easy it is to use the Guardian system.	4.7	6
It was simple to use the Guardian system.	4.5	6
I could (effectively) successfully complete the tasks and scenarios using the Guardian system.	5.3	6
I was able to complete the tasks and scenarios quickly using the Guardian system.	5	6
I was able to efficiently (quickly) complete the tasks and scenarios using the Guardian system.	4.2	6
I feel comfortable using the Guardian system.	4.2	6
It was easy to learn to use the Guardian system.	5	6
I believe I could become productive quickly using the Guardian system.	3.8	6
The Guardian system gave error messages that clearly told me how to fix problems.	2.8	6
Whenever I made a mistake using the Guardian system, I could recover easily and quickly.	3.8	6
The information (such as online help, on-screen messages, and other documentation) provided with the Guardian system was clear.	5.2	6
It was easy to find the information I needed.	5	6
The information was effective in helping me complete the tasks and scenarios.	4.5	6
The organization of information on the Guardian system screens was clear.	5.3	6
The interface of the Guardian system was pleasant.	5	6
I liked using the interface of the Guardian system.	4.7	6
This Guardian system has all the functions and capabilities I expect it to have.	3.8	6
Overall, I am satisfied with the Guardian system.	5.3	6

Table 2: Computer System Usability Questionnaire, items rated 1 to 7, average is 4.

Item	Score, mean	n
I think that the final product is in line with my expectations.	2	7
I received enough and satisfactory information to provide my consent and authorization.	5	9
I feel safe when using Guardian.	5	9
I think that the data collected by Guardian are well protected.	5	9
The robot is not time consuming, but saves time.	4	7

Table 3: Ethical questionnaire, rated 1 to 5, average is 3.

Item	Score, mean	n
I feel formal caregivers close to me.	5	5
I feel informal caregivers close to me.	5	5
I feel supported and understood by the homecare network.	5	5
I feel safe with the Guardian's care network.	4.75	4

Table 4: Social Connectedness Index, rated 1 to 5, average is 3.

Caregivers' Point of View

Helpfulness.

Caregivers were handed a first general questionnaire (Table 5) that revealed Guardian was mostly helpful in strengthening the cooperation between the caregivers (M=4/5) as well as feeling more involved in the care of the older adult (M=4.2/5). For some caregivers, Guardian was also somewhat helpful in early detection of problems (M=3.6/5) and offered some "peace of mind" (M=3.6/5).

Technology Acceptance.

The data from the Technology Acceptance Model questionnaire (Table 6) indicates that caregivers found Guardian fairly easy to use (M=5.4/7). Some agreed it was easy to become skilful at using Guardian (M=5/7) and felt confident finding information in the system (M=5/7). It appears Guardian did not significantly increase productivity (M= 4.2/7) nor made work much easier (M=4.2/7). Even so, some caregivers agree that working through Guardian is a good idea and a wise idea (M=5/7); caregivers were globally positive towards Guardian (M=5/7).

Item	Score, mean	n
Using Guardian helps me notice something is wrong in an early stage	3.6	5
The Guardian system offers me peace of mind	3.6	5
The Guardian system helps me to feel more involved in the care of the older adult	4.2	5
Guardian helps me feel more equal in a conversation with a (in)formal caregiver	3	5
Guardian strengthens the cooperation between caregivers	4	5

Table 5: General questionnaire (caregivers), rated 1 to 5, average is 3.

Item	Score, mean	n
I find Guardian system easy to use.	5.4	5
Learning how to use technological tool is easy for me.	5	5
It's easy to become skilful at using the Guardian system.	5	5
Guardian system would improve my working performance.	4.8	5
Guardian system would increase my productivity.	4.2	5
Guardian system could make care work easier.	4.2	5
Working through Guardian system is a good idea.	5	5
Working through Guardian system is a wise idea.	5	5
I am positive towards Guardian system.	5	5
I intend to check announcements from Guardian system frequently.	5	5
I intend to be a heavy user of the Guardian system.	4.3	5
I feel confident finding information in the Guardian system.	5	5

Table 6: Technology Acceptance Model (TAM) questionnaire, rated 1 to 7, average is 4.

User Direct Feedback: Themes

Positive Comments.
In regard to the qualitative approach of the analysis, participants were invited to share their thoughts and comments about Guardian: various positive and negative points were thus brought up, and many improvement ideas were offered by the users.

Shared Information.
It seems that participants liked the ability to share data efficiently between the older adult and the caregivers, as well as between the caregivers themselves. One user added that it provided the older adult with a sense of security. One older adult also liked being able to easily consult appointments:

> *The information shared with the network is relevant and provides the older adult with a sense of security.*
>
> *It is nice to be able to consult appointments.*

Company.
One participant acknowledged the benefits of having "a presence". The company the robot provided was appreciated and one of the users saw some psychological benefits to using a social robot such as the Guardian's Misty. A caregiver felt it was nice the older adult had to care for the robot, as it also provided the senior with a feeling of company:

> *The robot almost has a human contact, it is a presence.*
>
> *The robot feels like a buddy, because seniors have to care for it.*
>
> *The robot has some psychological benefits, even if the system is not smart enough to have better interactions with the senior.*

Negative Comments and/or Improvement Propositions.
Many concerns were formulated, notably regarding the technical bugs and limitations of the Guardian system. User experience, interaction, limited actions and safety were the main topics of concern for seniors and caregivers.

User Experience.
Participants felt user experience could be improved on different points such as the ability to "postpone reminders when the senior is not at home". A commentary was made on the effective weight of the robot, deemed "too heavy" for frail seniors to manipulate. It was thought that user accessibility could be improved for both caregivers and seniors: "caregivers don't like having to use a computer, an app should be available" and "it is hard for seniors to use the tablet properly". One user also felt the user manual should be clearer. A caregiver found the identification information too complex for the older adults, as it impaired the accessibility of the system:

> *Older adults' IDs are too complicated and source of bad user experience.*
>
> *Older adults should be able to change the language of the application.*
>
> *The robot is too heavy for seniors to carry.*
>
> *The reminders should be postponed when the older adult is not at home.*
>
> *The Guardian system should be able to figure out whether the senior is at home or not.*
>
> *The tablet can be difficult to use for some older adults, and this can prevent the entire system from functioning correctly.*
>
> *The user manual is not clear enough, it should contain only relevant information.*

Interaction.
Interaction with the robot was judged insufficient by some participants who felt Guardian should be able to audibly formulate questions and answers and found the emotion recognition ability of the system and reactions below expectation: "the robot should ask a question when recognizing the senior's emotion." Some participants also pointed out that interaction with Guardian would be easier through exclusively vocal commands and that it would help the interaction remain natural:

> *The older adult can speak to the robot, but the robot cannot answer apart from looking at them. The robot is only able to inquire "are you there?"*
>
> *The robot should be able to ask unprompted questions to the older adult, for example: "Hello [name]! Do you want to know what's on TV tonight?"*
>
> *When recognizing the seniors' emotion, the robot should be able to formulate a question or sentence according to its detection: "You look angry, what's going on [name]" or "Wow! Seeing you happy makes me happy!"*

The robot should be able to show a happy or in love eye expression when it recognizes the senior.

End-users do not want to use a tablet anymore.

The interaction should remain natural: speaking not clicking.

Accessibility.

Other participants found some actions limited: "the older adult should be able to input their own appointments" instead of requiring a caregiver to do so for them. Self-reports were thought to be too succinct and not enough freedom was permitted in those reports: "seniors should be able to do more self-reports than only meal and medications reports":

The older adult should be able to easily decide who can reach the information gathered by the system, depending on simple robots' questions.

The older adult should be able to enter their own appointments on the tablet, it's complicated and frustrating to have to go through somebody else.

The older adult should be able to know who put the reminders/requests and be allowed to contact them through the Guardian system.

Activity suggestions are not available in the tablet but should appear like the appointment functionality.

Older adults should be able to do more self-reports, apart from saying how they are doing and how they have slept, for example medication or meal self-reports.

Safety.

Lastly, some concern arose regarding safety. Caregivers thought "Guardian should be able to recognize if the senior has fallen" and found the system's field of view of the too limited. It was also noted that the battery life and management of both the tablet and the robot could be complicated to some:

There should be a feature allowing to see if the older adult has suffered a fall or it should be connected to other tools which detect falls?

Frail seniors can be in danger if they have to rely too much on reminders and requests in their everyday life.

The robot should be able to recognize the older adult from further away; the robot would not recognize the older adult from more than 2 meters away.

The system should help older adults better understand their treatment. The senior application should have some practical information.

It can be complex to maintain both tablet and robot fully charged; if tablet runs out of battery the older adult cannot access the system and thus will not receive any reminders, etc.

Discussion

Principal Results

Globally, the Guardian system in its actual state seems to be more helpful to the caregivers than to the seniors. The results of the Social Connectedness Index questionnaire and the general questionnaire seem to indicate that even though some seniors found the system helpful to stay in touch with their caregivers, the other functionalities did not appear to meet their expectations in terms of helpfulness in everyday activities. Since reminders and activity suggestions are set up by the caregivers, it is possible that this was partly due the number of set reminders being too low. It is clear that Guardian did not help the older adults feel more independent nor have a daily routine, but the ability to inform caregivers of their actual state was appreciated by some of the older adults. In terms of usability, the Computer Usability questionnaire highlighted the main problem to be about error messages: they did not help fix problems that older adults encountered while using Guardian. Overall, it appears that older adults were not truly convinced of how easy it was to use Guardian, with a mean of 4.7 out of 7 (n=6). It seems the main positive points for the seniors are that they feel safe using Guardian, and that they feel well included in the homecare network: they feel close to both formal and informal caregivers.

As for the caregivers, results of the general questionnaire show that they appreciate the improved collaboration between formal and informal caregivers Guardian allows for. The impact of the Guardian system on the workload also seems to be an important point for the health professionals even if it did not help as much as it was thought it could. Again, this might be due in part to the robot being only accessory in the care process for professional caregivers that may not have relied on Guardian as much as it could have been expected. In any case, the Technology Acceptance Model questionnaire revealed that caregivers found the system rather easy to use. They also found Guardian to be a somewhat *good* and *wise* idea. Caregivers were mostly positive towards using Guardian. Even so, it appears formal and informal caregivers did not really intend to use the Guardian system if it was commercialized (mean of 4.3 out of 7 [n=5]).

In any case, the early test revealed that both seniors and caregivers expect more from a social robot than what was offered by Guardian. Some of the direct feedback shows that accessibility is key and that users would rather use the robot mainly with voice commands; that would probably allow for improved usability and a smoother interaction between the older adult and the robot. This is at least what was expected by the users.

Future Directions

In order to improve the Guardian system user experience, different functionality and accessibility issues, described in the Results section, will have to be addressed. For example, the human-robot interaction can be improved so that the robot is accepted better by older adults and caregivers alike. As for the testing process itself, many issues specific to the real-life conditions arose during this stage and impacted the involvement of some of the participants. One of the main problems of this kind was that some users encountered bugs which were not fixed right away; this discouraged some from testing further. To prevent this during the next testing phase, a closer follow up of the system shall be implemented so that seniors are not so easily stuck with functionality issues and bugs that would discourage them from using Guardian.

Strength and Limitations

A key aspect of this early test design was the inclusion of caregivers, formal and informal, to the evaluation process. This helped broaden the spectrum of the collected data and include very different points of view on the Guardian system functionalities. The user-centered approach including different health providers helped us develop the next prototype to better fit the expectations of both older adults and caregivers.

Another strength of this testing phase is the conditions in which it was conducted. Indeed, the real-life setting of this test allowed us to uncover features that needed to be implemented on the next prototype. The uncontrolled testing environment proved very beneficial to the development process of the Guardian system.

As for the limitations of this evaluation, the main limitation may be the number of participants that actually fully completed the testing phase and the questionnaires. Even if the qualitative approach of the data yielded useful and relevant results, the evaluation could have used more answers the questionnaires in order to get a better representation of the general opinion on this digital tool. The low number of participants was probably due to difficulties encountered during the recruitment process combined with some of the problems that users encountered while using Guardian. The real-life conditions of the test brought usability problems that were not expect and which appeared to have discouraged some of the participants.

Conclusion

In conclusion, it appears that older adults and caregivers alike are ready to start using digital tools within the homecare process. It is clear that the expectations toward robotic technology are very high and that Guardian failed to meet some of these expectations, for example the fully automated voice command, or the expected level of interaction provided by the robot. On account of those high expectations, the Guardian system is still perceived as a work in progress by some of the users, but could certainly be made an interesting tool for caregivers and seniors alike with some of the discussed improvements and corrections.

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Conflicts of Interest

None declared.

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