



Older Informal Carers' Experiences Using a Digital Mindfulness-Based Intervention

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Abstract. Across the world a change in demographics is occurring, with the average age of populations increasing alongside longer life expectancy. Increases in demand for health care alongside fewer staff and resources are resulting in policy shifts towards ageing in place. The number of older informal carers, often caring for a spouse, older family member or friend, will therefore continue to grow. A significant issue facing this cohort is stress, which can negatively affect other areas of health and wellbeing such as sleep quality, physical health, and psychological wellbeing. Mobile technologies delivering interventions to reduce stress offer an important alternative to traditional face-to-face supports which may not be accessible for those unable to leave a care recipient unattended for significant periods of time, or for those living in rural areas. Moreover, mindfulness-based interventions (MBIs) have been used to increase awareness and support coping strategies by providing carers with tools to manage their emotional and physical health and wellbeing. This paper addresses a gap in the literature by focussing specifically on older informal carers' experiences and engagement during an eight-week home-based trial with a digital health application, Mind Yourself, which delivered an MBI to manage stress alongside monitoring and management of blood pressure, activity and sleep.

Keywords: Older Adults · Informal Carers · Mobile Technology Design · Stress Management · Mindfulness-based Interventions

1 Introduction

Across the world a change in demographics is occurring. The average age of populations is increasing, which is happening in tandem with an increase in life expectancy. While such changes are clearly positive and to be celebrated, they bring with them some unique and pressing challenges. As people get older and continue to live longer, the number of diagnoses of dementia and other age-related illnesses continues to grow. With these changes further burden is likely to be placed on health systems, with increases in demand for care coming alongside decreases in available staff and resources [1]. It will become more common, therefore, for policy to shift towards a preference for ageing in place as much as possible, thereby leading to an increase in the number of informal carers, who will quite often also be older adults themselves [2]. The demands associated with

providing full-time and unpaid care are considerable and varied, frequently resulting in feelings of isolation, psychological distress (anxiety, depression, stress), loss of self-esteem, and a tendency to neglect one's own health and wellbeing due to time constraints and feelings of exhaustion [3]. These issues can then negatively affect the carer's capacity to provide adequate care, increasing the likelihood of negative health outcomes for both the carer and the care recipient [4].

There is considerable potential for technology to support both the carer and the care recipient in a wide range of areas, including provision of government services, information and support, news and entertainment, appointments and schedules, social participation, and health and wellbeing self-management [5]. In recent years, there has been an increase in the development and uptake of self-management technologies, primarily focusing on chronic disease management, with less attention being paid to older informal carers and stress management specifically [6]. Nonetheless, the use of mobile and Internet technologies to deliver programmes which aim to increase carer competence and knowledge, delay institutionalization, and enable better care provision has grown somewhat in popularity in recent years [7–9]. Such interventions are particularly important for people who may find it more difficult to access traditional, face-to-face support, such as those who are living in rural areas or in a position where a care recipient cannot be left unattended for significant periods of time. Reaching these groups and equipping them with the tools and strategies to better look after their own health and wellbeing could in turn allow for both the carer and care recipient to remain at home for as long as possible [10, 11].

1.1 Mindfulness-Based Interventions

Mindfulness-based interventions (MBIs) have demonstrated potential to reduce stress and improve wellbeing in general and older adult populations across a range of distress-related conditions [12–17]. A central principle of mindfulness practice is cultivating non-judgemental awareness and acceptance of unpleasant experiences, enabling individuals to respond more effectively to situations perceived as overwhelming and to reduce avoidant coping behaviours. For informal carers, mindfulness may enhance emotional, cognitive, and physical self-regulation while supporting existing coping strategies [18, 19].

Delivering MBIs through digital health and wellbeing applications offers older informal carers an accessible alternative to traditional face-to-face programmes, enabling self-management without the need to attend classes. While research indicates that digital health technologies can support emotional wellbeing among older adults [20–24], evidence specific to older informal carers remains limited. Existing work has largely prioritised chronic disease management, physical activity, and diet, with comparatively little focus on supporting carers' own health and wellbeing [25]. Although research in human–computer interaction and digital health has increasingly addressed in-home care, assistive technologies, and information support for carers [26–29], these efforts remain predominantly patient-centred or task-focused, offering limited support for carers' self-care and wellbeing management [30, 31].

1.2 Digital Mindfulness

Digital mindfulness refers to technologies designed to support awareness of the present moment [32]. Although commercially available mindfulness and relaxation applications have increased substantially over the past decade, they vary widely in both design approach and intended outcomes. Existing applications can broadly be divided into brain-training tools aimed at cognitive enhancement and mindfulness-based meditation apps focused on mental state and experiential awareness. Mindfulness apps offer a conceptual alternative to brain-training approaches, as mindfulness practice emphasises being rather than doing, requiring less active cognitive processing [32].

Digital mindfulness applications can be categorised into three overlapping levels [32]. The first, digitalised mindfulness, involves the translation of traditional, teacher-led mindfulness practices into digital formats, most commonly through audio-guided meditation. The second level, personalised mindfulness, tailors content based on user preferences or contextual data. The third level, quantified mindfulness, integrates sensing technologies and wearables to provide real-time feedback on physiological or behavioural indicators, as seen in systems such as Muse, PAUSE, and Spire.

Mindfulness components have also been incorporated into applications targeting related health behaviours, such as mindful eating, with evidence suggesting that engagement is influenced by difficulty levels and social features [33, 34]. In parallel, commercial devices increasingly offer automated stress tracking alongside relaxation support; however, accurately measuring stress remains challenging due to its subjective psychological components, which are less readily quantified than physiological indicators [35]. Overall, existing research highlights the promise of digital MBIs as flexible, low-cost interventions capable of improving wellbeing across diverse populations, including informal carers. However, sustained engagement and adherence remain critical challenges that must be addressed to ensure long-term benefits.

This study investigates the problem of chronic stress among older informal carers of persons with dementia and its negative impact on health and wellbeing, as well as the potential for mindfulness training, education, feedback and health self-management to address this phenomenon. The study focussed on the design and delivery of a digital application, Mind Yourself, delivering an MBI to manage stress alongside blood pressure, activity and sleep management through tracking, data visualizations and educational advice. An eight-week home-based trial was conducted to evaluate experiences and usage of the application with eight older informal carers of persons with dementia. A number of perceived improvements and positive outcomes for informal carers using the application were revealed, such as reduced stress, increased confidence, a willingness to engage in more social activities and interactions, heightened sense of present moment awareness and an improvement in sleep quality. At the same time, barriers to sustained engagement with the mindfulness content over the course of the trial were noted, including discipline, perception that engagement was time-consuming, and a lack of understanding of the importance of adherence with mindfulness meditation in general. This paper discusses older informal carers' engagement levels and experiences using Mind Yourself during this eight-week home-based trial.

2 Materials and Methods

2.1 Study Design

The study was an eight-week mixed-methods feasibility trial exploring engagement and experiences of using the Mind Yourself digital health application. Both qualitative and quantitative data were collected.

2.2 The Mind Yourself Application and Design Process

An iterative user-centred and participatory design process was followed in the design, development and deployment of the Mind Yourself application. Three iterative design cycles involving 29 older adults over a four-year period were implemented in order to allow for a design that was seen as useful, effective and usable (see [36]). Applying principles of user-centred design such as continuous user involvement and iterative testing when developing health technologies can address the problem of alienating diverse populations, and evidence of usability and usefulness can be provided by considering users' needs and abilities during the design, testing, and evaluation stages [37]. As well as this, attention needs to be paid to the evaluation of health technologies for older adults, given that the unique characteristics of this population may not be appropriately or sufficiently addressed using general human factor design guidelines [38].

While the application enabled users to track and monitor sleep, steps and blood pressure while also allowing for educational tips and daily self-reporting, this paper focusses on the mindfulness meditation component. This feature of the application delivered guided mindfulness meditation daily. The content for the digital intervention was sourced from the book 'Mindfulness – a practical guide to finding peace in a frantic world' by Mark Williams and Danny Penman (2011) [39]. Topics and practices covered are common to typical mindfulness meditation courses and include meditations including Habit Releaser, Mindful Awareness of a Routine Daily Activity, Mindfulness of the Body and Breath, Body Scan, Mindful Movement meditation, Three-minute Breathing Space meditation, Sounds and Thoughts meditation, Exploring Difficulty meditation and Befriending meditation (see Fig. 1). Each day the application presents the user with that day's practices, both in audio and text format. Modal windows displayed a particular meditation's text as well as the audio controls to play the accompanying guided meditation, with the prescribed or recommended content varying from week to week (see Fig. 2). As the user moves through the eight-week course, they are encouraged to incorporate these new skills and practices into their everyday lives.

2.3 Participants, Recruitment and Inclusion Criteria

This trial involved the deployment and evaluation of the Mind Yourself application with eight community-dwelling older informal carers. Participants were recruited through a local service which offers support and provides information to carers of persons with dementia. Staff within the service identified possible participants and made initial contact. Once initial interest had been expressed, telephone contact was made to provide more information and answer any queries. A participant information leaflet and consent

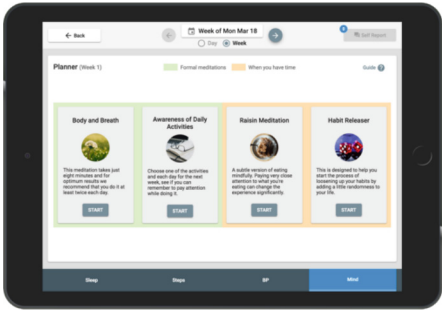


Fig. 1. Mind Yourself application – Mindfulness Week 1 (Planner).

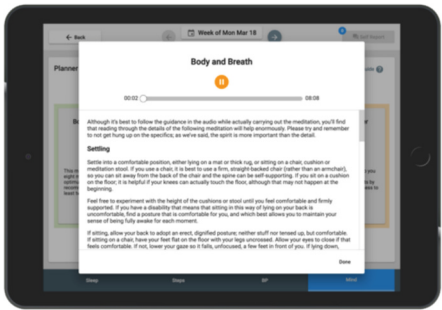


Fig. 2. Mind Yourself application – Meditation Audio Player (Body and Breath).

form were then sent out by post with the researcher’s contact details provided. Further telephone contact was made to provide more information where necessary and confirm expressions of interest. Inclusion criteria were: individuals over the age of 50, capable of giving informed consent, currently caring for another older adult with dementia (unpaid).

2.4 Trial Procedures and Data Collection

The trial lasted eight weeks as per standardized mindfulness-based stress reduction (MBSR) programmes [39]. During the trial, participants self-monitored using a combination of sensing and self-report and received information and education feedback alongside the mindfulness intervention described above. Data collection was varied to provide for rich and mixed data for analysis. Regarding qualitative data, phone call interviews were carried out at the mid-point of the trial and longer in-person semi-structured exit interviews were conducted at the end of the trial. The primary focus was on understanding user experience, including how and why participants used the application, as well as usefulness, acceptance, and motivation. Engagement metrics with the system were collected to allow for insights into levels of adherence. A custom-developed backend platform, CABIE+-SIMS, both acted as the data aggregator for sensing and self-reported data and allowed for the Mind Yourself app to be personalised to individual participants. Engagement data was captured indicating number of days logged in to

the Mind Yourself application, as well as levels of interaction with the mindfulness content across the eight-week trial period. The mindfulness content was presented in modal windows, allowing for insight into how frequently a modal window (e.g., a particular meditation) had been opened, as well as for how long.

2.5 Data Analysis and Methodological Approach

Qualitative data was collected using a Dictaphone and field notes. Prior to analysis, the recordings were transcribed using a word processor by the researcher. Participants were given ID numbers which were then continued throughout the entire study. The transcripts were imported into NVivo for Mac v1010 (qualitative data analysis software) for analysis. Inductive thematic analysis was employed, using the six-step approach outlined in Braun and Clarke (2006) [40]. This allowed for the coding of elements during analysis through the use of nodes and sub-nodes to create a hierarchy of topics [41]. From here it was possible to develop and recognize themes which emerged from the data. Quantitative data during the main trial included questionnaires, sensor data, self-report answers, engagement with the mindfulness and education content, and system engagement data. It was possible, therefore, to use this data to complement the qualitative data to provide a richer and broader picture of what was being explored. This approach corresponds with a convergent parallel design as discussed with Creswell and Plano-Clark (2011)'s method-oriented typology [42]. The quantitative and qualitative data were collected and analysed separately, with results then being compared and integrated, followed by interpretation.

2.6 Ethics

Ethical approval for the study was received from the research ethics committees of both the institute of technology and the regional health service.

3 Results

3.1 Overview

Questionnaire data was collected concerning perceived stress and dispositional mindfulness, while system engagement data around interaction with the mindfulness content was also collected and analysed. The interviews allowed for insights into how the participants put the meditation techniques into practice, along with the degree to which changes were perceived or felt in overall awareness, reflection and behaviour. Participants also discussed challenges they faced throughout the trial.

3.2 Participants

Profiles of the trial participants in terms of age, gender and relationship to the care recipient can be found in Table 1. In each of the cases, the care recipient had some form of dementia and lived with the participant, who was their primary carer.

Table 1. Participant Demographics.

Participant	Age	Gender	Care Recipient Relationship
P21	63	Female	Mother
P22	64	Male	Wife
P23	61	Female	Husband
P24	67	Male	Wife
P25	77	Female	Husband
P26	53	Female	Mother
P27	69	Female	Husband
P28	75	Female	Sister

3.3 Perceived Stress Scores

Participant scores for the Cohen Perceived Stress Score [43] across the trial can be found in Fig. 3. At baseline one participant was reporting low stress (P24), three were reporting moderate stress (P25, P26, P27), and two were reporting high stress (P21, P23). These were the only two instances of high perceived stress (27–40) being reported during the trial (P21 scored 27 while P23 scored 29). Scores falling in the range of moderate stress (14–26) were recorded fourteen times across all participants. Scores falling in the range of low stress (0–13) were recorded five times across all participants.

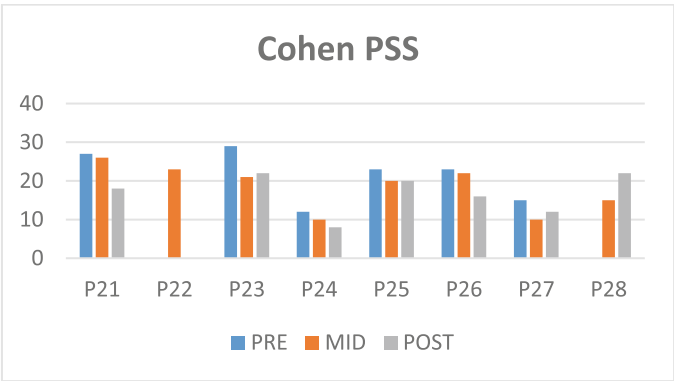


Fig. 3. Cohen Perceived Stress Scales

There was a reduction in perceived stress for six participants from T0 to T2 (P21, P23, P24, P25, P26, P27). The most marked reductions in stress were for P23, who dropped from 29 (high perceived stress) at T0 to a score of 21 at T2 (moderate stress) and P21 who moved from 27 (high perceived stress) at T0 to 17 (moderate stress) at T2.

P27’s score dropped from 15 (moderate stress) at T0 to 12 (low stress) at T2. The change was less marked for P25 and P26, with both participants showing a decrease within the category of moderate stress. P24 scored consistently in the range of low stress from T0 to T2. An increase in stress was observed for one participant (P28) from T1 to T2, with no questionnaire submitted at T0. It should be noted that during the exit interview, P28 commented that during the trial she had undergone eye surgery, and this may have contributed to her increase in perceived stress. Questionnaires were not submitted by P22 at T0 and T2, and a score of 23 was recorded at T1.

3.4 Dispositional Mindfulness

The MAAS [44] uses a 15-item scale to measure trait or dispositional mindfulness. It aims to assess the degree to which the respondent is aware of what is occurring in the present and to what extent the mind is in a receptive state with regard to paying attention to what is taking place. The instrument uses a frequency scale (1–6) ranging from ‘almost always’ to ‘almost never’. Respondents are asked to consider their everyday experiences when answering the questions. To score the scale, a mean of the 15 items is computed, resulting in a total score ranging from one to six. Higher scores reflect higher levels of dispositional mindfulness (Fig. 4).

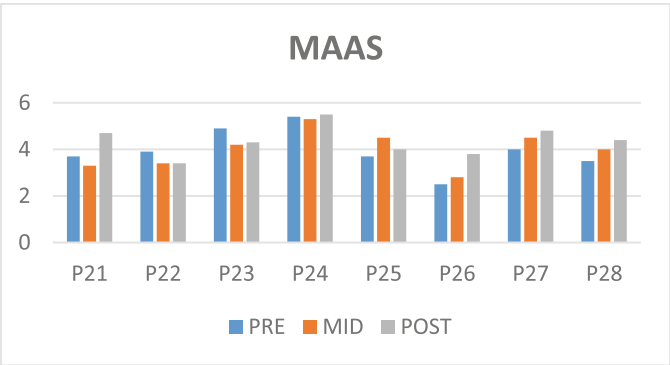


Fig. 4. Mindful Attention Awareness Scale

At baseline the lowest score was 2.5 (P26), five participants scored between 3.5 and 4 (P21, P22, P25, P27, P28), and the remaining two participants (P23, P24) scored 4.9 and 5.4 respectively. An overall increase in dispositional mindfulness from T0 to T2 was observed in six participants. The most marked change was observed in P26, who scored 2.5 at T0 and 3.9 at T2. This score of 2.5 at T0 was the lowest observed among all participants at any time point. P24 showed the most consistent level of dispositional mindfulness and scored high throughout, with scores of 5.4, 5.3, and 5.5. The score of 5.5 at T2 was also the highest observed among all participants at any time point. Small decreases in dispositional mindfulness were observed in two participants. P22’s score decreased from 3.9 at T0 to 3.2 at T1, and remained the same at T2. P23 recorded a score of 4.9 at T0 and finished the trial with a score of 4.3.

3.5 Engagement with Mindfulness Content

Figure 5 shows the number of times the mindfulness content was accessed each week for each participant. Specifically, this refers to the number of times a modal window in the Mind section of the application was opened. As can be seen in Fig. 1, levels of engagement varied considerably across the eight participants. Among most of the participants there was a decrease in engagement in Week 2, but this was followed by an increase in Week 3 for four of the participants (P27, P26, P22, P23). The highest level of engagement with the mindfulness content was observed in P27, followed by P26. P21 and P22. P27 also adhered closely to the recommended approach to the content by using an optional guide which outlined in what order and how frequently content should be engaged with. The lowest level of engagement with the mindfulness content was observed in P24, who did not engage at all with this feature of the application following the second week of the eight-week trial.

While engagement levels with the mindfulness content varied, these interaction logs could not capture how often participants used the techniques learned within their daily lives, and this data was therefore captured through interviews. Broadly speaking there was a positive response to the mindfulness content across participants, and this is outlined further in the sections below which present findings from the qualitative analysis of interviews.

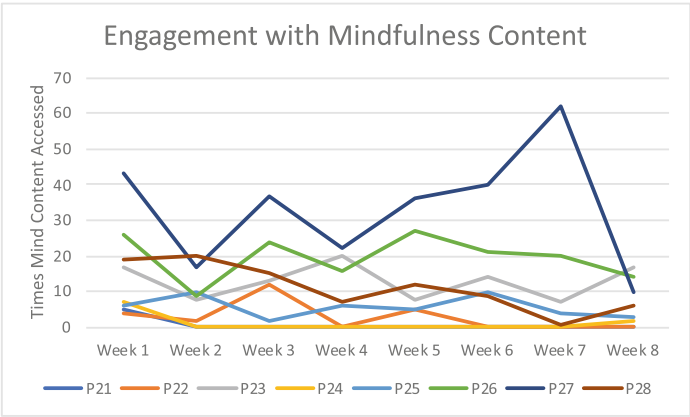


Fig. 5. Engagement with mindfulness content. The vertical axis represents the number of times the mindfulness meditation content was accessed in a given week with the horizontal axis indicating weeks 1 to 8 of the trial.

3.6 Putting the Techniques into Practice

Some meditations and techniques were generally more popular than others, while participants reported that some were easier to recall than others when needed. Most participants enjoyed the meditations that focussed on breathing (Breath and Body, Three-minute Breathing Space), as they act as a relatively simple means for the user to stop the mind

from wandering and focus on one thing: the constant inhalation and exhalation of the breath. P22 reported using the breathing meditations in times of need such as trying to get to sleep, saying 'Take it back to the centre. I found that very, very relaxing and go back, instead of letting your mind wander, go back'. Here, P22 was describing what is recommended in the mindfulness content and suggested with these particular practices-a 'go-to' practice for when you need to bring stress levels down, or when your mind is racing. P22 found that practising breathing-focussed meditation can alleviate stress and he noticed himself becoming calmer, allowing him to sleep: 'You'd feel yourself calming down'. P25 enjoyed and found benefit in the short Three-minute Breathing Space meditation and explained how she also had success getting her husband, who has dementia, to practice it too: 'And actually a couple of the short ones, I succeeded in getting (husband) to sit with me and actually engage in them in his head, you know'. P27 was similarly very positive towards this practice and appeared to find it very useful and effective. She reported turning to this as a stress coping-mechanism in times of need and finding it very relaxing. Indeed, P27 referred to this practice as '(her) little space'.

The Body Scan was also popular with many participants. This guided practice involves scanning or moving down through the body slowly, paying close attention to each part. The user is asked to hold their focus on each region in a sense of non-judgemental awareness, which is achieved through analysing what is happening in a specific part of the body. This appeared to be P25's 'go-to' meditation and the one she felt most comfortable with: *'that's the one I'm finding quite good myself It's the best one really'*. P23 said: *'I loved the one where you lay on the bed. And you start at the feet. And work through the body'*. P26 found this meditation useful and used it to relax and get to sleep.

The interviews revealed that participants developed personal preferences and habits with regard to the mindfulness content during the trial, with many trying out the various techniques to understand which were most effective for them. P26 felt she tried out the majority of the meditations at least once. She then stuck with what she felt was proving most effective and useful and forged her own course: *'And then as things progressed, it was like right, we'll stick with those two'*. P27 reported that she would generally meditate once a day, and would follow what was suggested on the Planner screen in the Mind Yourself app. P24 was much less positive about the mindfulness element of the system than the other sections. He put this down to individual preference: *'I found it a bit... Like some people are into that, yoga and mind things... Some people aren't, you know... It didn't appeal to me now'*.

3.7 Increased Awareness, Reflection, and Behaviour Change

Throughout both the mid-trial and final interviews, participants spoke about increased focus on and awareness of their health and wellbeing as a result of using the application. Raised awareness and reflecting on behaviour were outcomes for P25, for example, who found benefit in each of the four health and wellbeing sections of the application. She spoke about how she had learned to turn to the Three-minute Breathing Space as a coping mechanism when she was feeling annoyed by something, saying *'if I was very annoyed or upset, I'd go and just do the three minute and that, you know... Whereas normally, I wouldn't take the time to do a three-minute break'*. This participant suggests

that increased self-reflection, heightened awareness around the importance of self-care and acknowledgement of the need to take time for oneself may result from participating in a trial such as this.

P23 reported being much less stressed, losing her temper less and in a better state overall as a result of participating in the trial: *'the meditation, the mindfulness and the exercise ... just calmed me down'*. She said *'I was motivated to, you know, do the steps... And the meditation, you know, it wasn't a chore'*. She described an increased sense of mindful awareness and appreciation of everyday things, such as noticing small things like new flowers or the smells while chopping vegetables. P23 felt more present and attentive to what is happening around her: *'you could see all that as you walked round the park and taking it in, whereas before, I probably wouldn't have thought about doing that'*. She also felt her confidence had improved since taking part in the trial, to the extent that she wanted to engage in social activities that she had not done in some time. She said *'And I also had my sister and her husband over for dinner on Sunday, which I haven't done since my son left home because it's just me doing everything... I just felt more confident or something, you know...'* Later in the interview P23 noted how she had been 'in a bad way' and in a low mood generally prior to the trial and that the trial had a particularly positive effect on her wellbeing in general: *'Delighted to have done it... It kind of got me out of a rut'*.

Since participating in the trial, P27 reported feeling much more relaxed and appreciating small things in life. She believed she was paying attention more to the present moment, which may suggest a heightened sense of mindful awareness. This allowed her to appreciate things she may have overlooked or neglected previously. She provided examples in relation to eating, tasting, and cooking: *'But it made me appreciate and I spend more time now if I get something handed to me... Or even when I'm cooking, I'm more involved in it... I'm paying attention and I'm really tasting the food'*. She believed this to be a direct result of engaging with the content in the application. The area in her life where P27 felt she benefited most in terms of the trial was this heightened sense of mindful awareness: *'The benefits I got was to be aware of everything around me'*.

P28 reported that engaging with the application raised her awareness about the importance of her wellbeing in general and helped her focus on herself, which resulted in improvements: *'What I've liked most is the fact that it encouraged me to focus on myself enough, which enables me to do everything I do better'*. She felt participation in the trial reminded her to look after herself more, in the same way she had done in the past.

For the other participants, improvements as a result of participating in the trial were more pronounced in other areas of their overall wellbeing. P22, P24 and P25 all reported a heightened sense of awareness around stress levels, with each employing different techniques for addressing this. Improvements in sleep quality in terms of fewer interruptions were reported by P22, P24, P25 and P26, with both P25 and P26 implementing mindfulness techniques to support them in this regard.

3.8 Challenges

There were also some challenges experienced by the participants in relation to the mindfulness techniques and content which potentially impacted on engagement and overall

experience. Participants reported issues such as the time required to complete meditations and a lack of guidance.

One of the main challenges for the participants was the time needed to fully engage with the mindfulness intervention element of the application. P26 had a fixed routine when she was caring for her mother. As a result, she had to fit her time engaging with the system and the mindfulness content into this routine. She said, '*You fit everything in on the time that you can fit them in, so it was very scheduled*'. Indeed, P26 pointed out the amount of time required or suggested can in fact be counterproductive in that it can cause a certain amount of anxiety if the user feels they are not meeting what is required: '*you're thinking about I need to finish this*'.

Some participants also found the time it takes to practice some of the meditation techniques as a barrier with some feeling their time would be better spent doing other things. The main issue with regard to meditating for P24 was the difficulty in staying still and essentially doing nothing: '*you find 10 min is a long time... It's longer than you think*'. During the mid-trial interview, he had described a feeling of restlessness and guilt while sitting and doing nothing. He felt he should be doing something all the time. However, this also made him aware of his 'always on' state of mind. P27 felt some of the meditations were too long, particularly those around 15 min: '*Towards the end, there was one. One of them was 15 min nearly... far too long*'.

There were other practical challenges reported by participants. P27 described a meditation wherein she was to lie on a bed or on the floor (Body Scan). Having done this, she then found it difficult to get up and ultimately felt quite dizzy after it. This is something that needs to be kept in mind for older users. It would need to be made explicit that such a position is not essential and sitting down as an alternative is also possible. P22 noted that location, surroundings and who was present in the room at the time were also significant obstacles to him engaging with the mindfulness content. The use and necessity of audio with the meditations caused significant problems for him. The audio from the meditations resulted in his wife believing he was talking to somebody, raising suspicion and perhaps causing distress. He said, '*it's getting the time to do it... you wouldn't be on your own to really do it*'. He expressed that he regretted not having been able to engage with it more, saying '*I'd have loved to be able to do it*'. P25 spoke of similar issues in terms of the difficulty in finding quiet time and space and how this was frequently an obstacle to meditating. Her husband would become distressed if he did not know where she was: '*Finding a space for myself and sitting quietly is very difficult... It's 'P25, P25, where are you?'*'.

Somewhat related to the issue of the time required to engage fully with a meditation course, is the area of discipline. P25 pointed out on several occasions during the interview that discipline plays a crucial role in getting value from meditating and felt guidance and assistance of some sort is necessary to enable regular and effective meditating. However, she also felt that regular interruptions impacted on her ability to be disciplined in terms of engaging fully with the course content. She said, '*You know, you can maybe we'll say start doing something and then you see something else and you go off and you do something else and then you come back and five hours later, that job is sitting there and you didn't get it finished... Whereas if you're more disciplined, it would train you to be more disciplined*'.

4 Discussion

The findings revealed a number of perceived improvements and positive outcomes for informal carers using the Mind Yourself application. Regarding the mindfulness content, the interview findings revealed that certain positive wellbeing effects were brought about in part as a result of engagement with particular meditations, including reduced stress, increased confidence, a willingness to engage in more social activities and interactions, heightened sense of present moment awareness and an improvement in sleep quality.

Among the key barriers to sustained engagement with the mindfulness content over the course of the eight weeks were discipline, perception that too much time was required, and a lack of understanding of the importance of adherence with mindfulness meditation in general. Guidance and education could be key factors in addressing this issue. Specifically, this would involve providing content and background as to the theoretical underpinnings of certain practices as well as advice on time management and how to fit meditating into a busy schedule. Concise and focused content that is written specifically for this audience and integrated appropriately into the interface could go some way to addressing the challenges observed during the trial. Another possibility is to integrate persuasive techniques into the design of this part of the application. Solutions could include using rewards once a topic has been covered or completed [45], gamification to provide a challenge, allowing users to set daily or weekly meditation goals [46] or the use of levels that need to be unlocked to reach the next stage of the course [47].

It was apparent from the interviews that the shorter and therefore more accessible meditation practices were particularly popular. To entice users further with a view to maintaining engagement, an option could be to provide both short and long forms of each meditation. While this would likely affect the overall efficacy of the meditation in question, it could still be effective to some degree, and would be more welcome than a practice being overlooked or rejected completely. Both accessibility and convenience need to be taken into account when considering different use case scenarios [48] and this certainly applies to carers given the range of contexts and individual demands or restrictions each carer is likely to face [49, 50] point out that users will perceive a system as a useful tool once tasks can be completed in a reasonable time. As such, the aim should be for the level of investment necessary for engaging in an activity to be minimized, such that the chances for the activity to be completed are higher. Adopting a similar approach with a digital MBI for older users could lead to higher adherence rates overall and could ultimately result in the user eventually choosing to engage with the longer form versions as the course progresses.

4.1 Sustaining Engagement

Levels of engagement, along with the knock-on perceived and observed effects on various aspects of wellbeing, were markedly different across the participants. Usability and design are seen as key factors in sustaining engagement with mobile health applications so that these technologies can be effective in supporting users in meeting health goals [51]. However, it is difficult to define what represents ‘good’ or ‘high’ engagement [52] argue that it may be more valuable to establish and promote ‘effective’ engagement, defined as “sufficient engagement with the intervention to achieve intended outcomes”.

It is particularly important to examine engagement with/adherence to the mindfulness intervention within the application specifically, as adherence is seen as a key indicator of efficacy and success regarding mindfulness-based interventions [53, 54]. Mindfulness allows one to change the behavioural response to current events through acceptance of current thoughts without judgement, but this is a skill that needs to be acquired and honed through long-term practice [47, 55]. Adherence rates varied significantly across the participants, with two participants recording little-to-no engagement with the mindfulness content, and others fully engaging with the content as per the recommended guidance or finding their own preferred level of engagement, which allowed them, for example, to integrate techniques into their daily lives when needed for stress management. Despite this, participants reported experiencing benefits, which potentially suggests that the engagement was 'effective' [56] suggest that even six days of meditation can bring about reductions in stress and improvements in negative effects but contend that continued practice is indeed required for long-term benefit. Nonetheless, the interviews suggest that at least some amount of mindfulness meditation can bring about positive change for some people.

4.2 Relationship Between Mindfulness Adherence and Outcomes

Adherence to regular meditation practice has been shown to be associated with higher levels of dispositional mindfulness, reductions in depression [57], stress reduction and improved psychological wellbeing [58–60]. It is important, therefore, to analyse and discuss engagement levels with the mindfulness content across the participants with a view to exploring possible links between regular engagement and outcomes. It should be noted that given the small sample size, outcome data is more descriptive than definitive. While a weekly guide was provided, participants were free to engage with the content at their discretion. Following what was laid out in the guide for week 3, for example, would result in the user engaging with the content approximately 25 times (Mindful Movement followed by Breath and Body six out of seven days, Breathing Space twice a day, Habit Releaser at least once). However, to fully experience what is involved in an MBSR intervention, it is likely that such levels of engagement would be considered necessary. Nonetheless, work by [53] suggests that it is the quality of practice rather than the duration or frequency that may have more influence on these outcomes.

A number of positive outcomes were observed with P27, who engaged with all the content as recommended, both in terms of time required and sequence as well as repetition of practices. As a result, she reported high levels of dispositional mindfulness, meaning she was more aware of what was happening in the current moment than previously, and had come to appreciate everyday things such as birds singing and the taste of food. P27 was also not particularly interested in meditation prior to the trial, but she had come to accept by the end of the eight weeks that it had in fact contributed to her heightened sense of mindful awareness. The quantitative data supports this, indicating that her stress levels decreased, and dispositional mindfulness increased.

It is interesting to focus on P22 and P25 when discussing adherence and engagement with the mindfulness content in general as levels were low for both participants despite expressing genuine interest and enthusiasm for this aspect of the system. P22 reported high stress both through the interviews and as measured on the Cohen Perceived Stress

Scale. He commented during the interview that he was very interested in the idea of mindfulness meditation but felt he was not able to commit in terms of the time required and in terms of certain practical issues, such as his wife being in the same room while the audio is playing. However, during the interviews P22 did describe a heightened sense of awareness of his own stress levels as a result of meditating during the early stages of the trial, and a realisation that he was often operating on 'autopilot'. He discussed using breathing-focussed meditations to calm himself in times of stress and he felt this had also led to improved sleep quality in terms of fewer interruptions while also finding it easier to get to sleep.

Similar sentiments concerning adherence were expressed by P25. While her level of engagement was higher than P22, it was still low enough (due to time constraints as a result of caring) to reduce the likelihood of deriving long-lasting benefits in terms of acquiring skills for stress reduction. On average she engaged with the mindfulness content seven times per week across the trial. While she did not report any significant changes in dispositional mindfulness, she did experience improvements in sleep quality and a slight decrease in perceived stress. During the interviews she discussed how she had been using mindfulness techniques to help her sleep and found these effective in addressing feelings of anxiety and stress while trying to get to sleep.

The examples of P22 and P25 both highlight that the responsibilities of caring can impact how and when someone can use a digital application such as this. However, the way one approaches such a course is also important. In contrast, P27 was determined to adhere to the content as recommended, and as a result derived genuine benefit. This was despite not being particularly enthusiastic towards this type of practice. P22 and P25, meanwhile, were in fact enthusiastic but could not adhere due to both time constraints and discipline issues. It is possible therefore that they too would have derived further benefit had they adhered further. Time and discipline are genuine concerns when considering how to deliver digital mindfulness interventions into an application such as this for informal carers.

4.3 Positive Effects Regardless of Adherence Levels

While it has been suggested that even six days of meditation can lead to reductions in stress [56], it has also been reported that long-term benefits are more likely to be achieved through regular and sustained practice [61]. This is not to say that one needs to fully adhere to a full programme of MBSR-based content over eight weeks to positively affect stress levels or improve wellbeing in general, however. Indeed, results from the trial show that even some level of engagement with mindfulness content can contribute to noticeable improvements in various areas. Both P23 and P28 serve as good examples. Despite engaging less than would be required in terms of full adherence to a mindfulness meditation programme, both participants described significant improvements in stress, physical health and overall wellbeing arising from both the mindfulness component as well as the self-monitoring elements of the system. For P23 in particular, she had come to value her experiences more and also wanted to start to socialise more. Indeed, even P22, whose engagement levels were among the lowest, reported benefits in terms of stress management from having engaged with some of the mindfulness content [56] found that participants who engaged with over 50% of internet-based mindfulness training

also reported reductions in stress, while [62] report that older adults who engaged with online mindfulness during the COVID-19 pandemic perceived psychological and social benefits. Similarly, [9] observed improvements in cognitive and psychological measures among older adults who engaged with a live web-based MBI, specifically in the domains of verbal memory, attention switching and executive functions, interoceptive awareness, and rumination. Further to this, [53] found that changes in self-report measures including perceived stress among participants in a 14-week mindfulness meditation programme did not correlate with mindfulness practice time, suggesting quality of practice may have had more influence than frequency.

Positive outcomes in terms of reduced stress were also observed with P24, who did not engage with the mindfulness content after the first couple of weeks and who commented that 'yoga and mind things' do not appeal to him. His example suggests that opinions and views towards these types of practice may shape the way one is willing to engage. Similarly, P21 did not engage with any of the mindfulness content, but reductions in perceived stress were also observed and she described a raised sense of awareness around stress in general. The examples of P21 and P24 and indeed the other participants who also found benefit in the health-monitoring aspects of the application suggest that activity and sleep-tracking, blood pressure monitoring alongside integrated self-reporting and education are important elements in a digital health application and demonstrate that offering a suite of features is more likely to cater for a wider range of users, and as such those who do not have a predisposition towards meditating are not excluded. The need for such a broad and holistic approach to wellbeing management was also proposed by Lane et al. [63]. Taking these use cases into account, it is important also to consider how individual preferences affected the way the participants engaged with the content. It became apparent from the interviews that some meditations, particularly those focused on breathing, were more popular than others. These practices are likely the most accessible and at the same time easier to recall unaided than some of the others. The participants forged their own paths, and they engaged primarily with those practices they felt most comfortable with and from which they were able to get the most benefit.

5 Conclusion

The work presented extends current research by focusing on the experiences of older informal carers of persons with dementia with a digital mindfulness-based intervention. The study demonstrates that a viable and potentially effective means to support stress management is through the integration of a digital MBI into a digital health and wellbeing application. Findings from the trial suggest that this approach and design is acceptable, feasible, usable and engaging for older informal carers. Results from both the trial and the study overall would suggest that further research in the area of digital MBIs and connected health for older informal carers is warranted. Reaching this cohort and providing them with the tools and strategies to more effectively look after health and wellbeing could result in both the carer and care recipient remaining at home for as long as possible.

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