Fitbits for monitoring depressive tendencies in older aged persons: Qualitative outcomes of a feasibility study

Fiza Mughal, William Raffe, Peter Stubbs, Ian Kneebone, Jaime Garcia

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Fiza Mughal[1] BSc; William Raffe[1] PhD, BSc; Peter Stubbs[2] PhD, MPH, BSc; Ian Kneebone[3] PhD, MSc, BA; Jaime Garcia[1] PhD, BSc

[1]University of Technology Sydney Faculty of Engineering and IT Sydney AU
[2]University of Technology Sydney Discipline of Physiotherapy Sydney AU
[3]University of Technology Sydney Discipline of Clinical Psychology Sydney AU

Corresponding Author:
Fiza Mughal BSc
University of Technology Sydney
Faculty of Engineering and IT
15 Broadway, Ultimo
Sydney
AU

Abstract

Background: Worldwide, in 2021, 929 million people use smart wearables and 31 million use Fitbit devices. While there is growing research on using smart wearables to benefit physical health, more research is required on the application and feasibility of using these devices for mental health and wellbeing. In studies focusing on emotion recognition, inference is often dependent on external cues, which may not always be representative of genuine inner emotion.

Objective: The aim of this study was to identify the facilitators and barriers of utilizing consumer-grade activity trackers for applications in remote mental health monitoring of older aged persons.

Methods: Participants, aged ?65, were recruited using criterion sampling. Participants were provided an activity tracker (Fitbit Alta HR) and completed weekly online questionnaires (Geriatric Depression Scale), and self-report mood questionnaires. We conducted semi-structured pre-post qualitative interviews with participants to gain insight on the facilitators and barriers of the procedure. Interview transcripts were analyzed using a hybrid inductive-deductive thematic analysis.

Results: Twelve participants enrolled in the study, with 9 returning for the post-procedure interviews. Participants were positive about the procedure with 77.78% (7/9) participants finding it feasible, having experienced no inconvenience through the 4-week procedure period. 66.67% (6/9) participants were interested in the full implementation of our prototype, stating that they would feel more at ease knowing that their mental wellbeing was being monitored by their carers remotely.

Conclusions: Fitbit-like devices are an unobtrusive tool to collect user data without being disruptive or inconvenient to the user. Future research should integrate physiological user inputs to differentiate and predict depressive tendencies in users.

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Fiza Mughal[1*], William Raffe[1], Peter Stubbs[2], Ian Kneebone[3], Jaime Garcia[1]
*Corresponding author: fizatariq.mughal@student.uts.edu.au

[1] Faculty of Engineering and IT, University of Technology Sydney, NSW, Australia
[2] Discipline of Physiotherapy, Graduate School of Health, University of Technology Sydney, NSW, Australia
[3] Discipline of Clinical Psychology, Graduate School of Health, University of Technology Sydney, NSW, Australia

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Keywords: digital mental health, Fitbit, smartwatch, smart wearable, geriatric, ageing, health informatics, feasibility, usability

Introduction

Background

Cost effective smart wearables are increasingly used in the daily lives of the general population [1]. As of 2021, there are 929 million smart wearable users around the world [2]. Of these, approximately 31 million are Fitbit users [3]. As a consequence of this proliferation there is a growing number of studies that are incorporating smart wearables, particularly Fitbit devices in health research [4–6]. A recent scoping review investigated the effectiveness and efficiency of mobile health procedures for physical health [7]. Over a 10-year period, including 148 studies, there was no 'one-size-fits-all' procedure for physical health. However, the authors found that mobile health interventions do exhibit promising effects for behavioral change. A similar review [8] found the need for more research on the effectiveness and feasibility of smart wearables for changing/assessing physical health. Incorporating Fitbit as the focal wearable device, Ringeval [6] assessed the effectiveness of using Fitbit devices in interventions to promote and encourage healthier lifestyle outcomes. Evaluating 41 studies [6], the authors concluded that Fitbit devices have the potential to improve lifestyle habits among users. Significant increases in daily step count, physical activity, and weight reduction were identified [6]. A further review [9] investigated various studies to determine the applicability of wearable devices for outpatient vital sign monitoring. While concluding more clinical trials are required to investigate their validity and reliability, they found that early detection of physiological deterioration via wearable devices likely has a positive influence on patient outcomes. The studies assessed included some on-body, potentially obtrusive sensors, such as heart rate monitors, patches, and arm bands. These sensors are effective in monitoring user vital signs, though they may not be feasible for prolonged use in everyday living.

The aforementioned reviews strengthen the idea that wearable devices elicit positive physical activity changes, however few studies have investigated how a person's mental health can benefit from the use of smart wearables. In addition, most of these studies used younger study participants, with the older adults (65+ years) excluded. As of 2021, there are 264 million people of all ages around the world suffering from depression [26]. While the majority of older adults are not depressed, studies have shown that older adults are at a higher risk [10]. Eighty percent of older adults have at least one chronic illness, which can contribute to mental illness [11,12]. Thirty percent of older adults in residential care are at an increased risk of depression [13]. Mental illness in older people is commonly viewed as an inevitable reaction to changes in socioeconomic standing or age discrimination and as such, seen as untreatable [11]. Older people are also more likely to be concerned about the stigma of seeking treatment [14]. Consequently, older adults do not seek help when they feel depressed[11].

Prior Work

Treatment of mental health conditions can make use of smart wearables, particularly Fitbit-like devices. A recent study investigated the feasibility of mobile health technologies to increase physical activity among users with severe mental illness [15]. Feasibility was evaluated through frequency of use and acceptability through follow-up interviews with study participants. Participants reported high satisfaction levels, and increased motivation through goal setting and self-monitoring. Another qualitative study similarly integrated Fitbit devices with behavioral activation therapy [5]. Findings showed positive self-awareness, peer-based and self goalsetting motivation, while negative feedback consisted of

inconvenience, disinterest, and inaccuracy. Furthermore, a 12-week randomized trial incorporated a non-Fitbit device (tablet) and telephone counselling to increase physical activity [16]. The intervention was feasible and accepted by the participants, and improved weight and physical activity time in older adults.

Factors such as heart rate and gait patterns can be indicative of depression [17,18]. Additionally, research has validated the use of smart wearables for emotion recognition [19–22]. These studies utilized user data extracted through wearable smartwatches or bracelets, paired with external emotion eliciting stimuli to evaluate the reliability and accuracy of their approaches for emotion recognition. In lab-based settings with short timeframes of less than a few hours, three studies provided participants with stimuli to elicit happy/neutral/sad emotions [20–22]. Stimuli included video and music clips of happy/neutral/sad settings and post stimuli activities included walking with a chest-mounted heart rate monitor [20]. Time series analysis and statistical modeling were used for emotion prediction, with results showing a higher accuracy (74%) when detecting happy emotions as opposed to sad emotions. An earlier study required participants to walk for one minute after receiving a visual stimulus, to observe walking behaviors corresponding to the resulting emotion [22]. The algorithm had an overall recognition accuracy of 81.2%. Adopting a different approach for emotion elicitation, one study consisted of participants taking a short break to reduce interference with the previous stimulus set [21]. Using electrodermal activity, skin temperature, heart rate and a Self–Assessment Manikin form, researchers [19] developed an algorithm based on EDA signals. The algorithm achieved an accuracy of 57% for emotion tagging. These studies show that walk patterns can reflect emotions and smart wearables can be used to recognize user emotions.

In a prior study [23], we proposed autonomous mental health monitoring for older aged persons (AutoMAP); an emotion recognition framework using minimal to no explicit user input or interaction (Figure 1). This prototype would operate via smartwatch device data and physiological user inputs. In this paper, we focus on validating the barriers and facilitators encompassed within our framework (Figure 1). Therefore, this paper presents the findings of a feasibility study. The efficacy and accuracy of the emotion recognition techniques in this framework are beyond the scope of this paper. The next section describes the methods we applied for study setup, procedure, and data analysis. We then present our results, followed by a discussion on our findings.

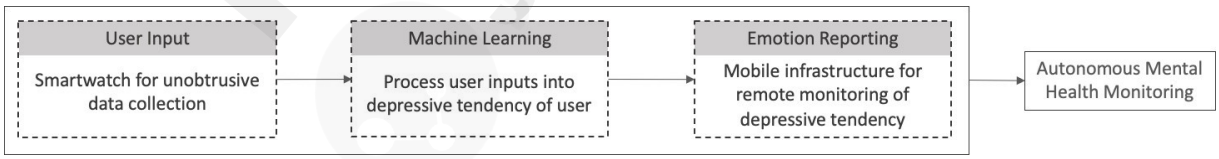


Figure 1: AutoMAP Framework

Methods

Our study aims to acquire insight on the feasibility and applicability of AutoMAP for older adults. Participants wore a Fitbit smartwatch for a 4-week period, completed a validated depressive scoring survey weekly, and self-report their mood daily. This study was approved by the Human Research Ethics Committee (HREC) of University of Technology Sydney (HREC reference ETH20-4912).

Procedures

To identify the feasibility, applicability, and practicality of our framework, we performed a hybrid inductive/deductive thematic analysis on pre-post procedure semi-structured interviews with participants. The study protocol is publicly accessible under Open Science Frameworks [24].

Participant Recruitment and Onboarding

Inclusion criteria for the study were (1) able to speak and understand English (2) aged over 65 years, (3) willing to wear a Fitbit for 4-weeks, (4) living alone with no external assistance, (4) being able to provide informed consent, and (5) having access to the internet through a computer or mobile phone. The participant recruitment flowchart can be seen in Figure 2. Independent living individuals were chosen for this study as this is our target cohort for our proposed AutoMAP framework.

Exclusion criteria included (1) having pre-existing conditions affecting sleep, gait, or heart readings, (2) having travel plans within the duration of the 4-week period, (3) foreseen out of the ordinary plans within the 4-week period, (4) inability to walk, (5) inability to access online surveys within the time requirement, (6) having a history of skin rashes around the wrist area, (7) having a nickel allergy that may cause a reaction to the smartwatch charging probe and (8) having any pre-existing diagnosed mental health conditions. At this preliminary stage we explicitly excluded participants with pre-existing mental health issues, as we are in the exploratory stage of this research.

After screening the initial expressions of interest (Figure 2), participants were provided with an information sheet detailing the inclusion criterion and requirements during the 4-week period. Twelve participants were sent a participant pack that included (1) a Fitbit Alta HR device, (2) participation confirmation and information sheet, (3) distress management resource list, (4) simplified Fitbit user guide and (5) summarized task checklist. Sample size was calculated prior to the study with an expected p-value of 0.05. The critical F-value showed that a minimum sample size of 8 people would be sufficient. While no statistical analyses are performed in this paper, this sample size is required for future analysis on the collected smartwatch data and its use in training an initial test classifier for emotion recognition.

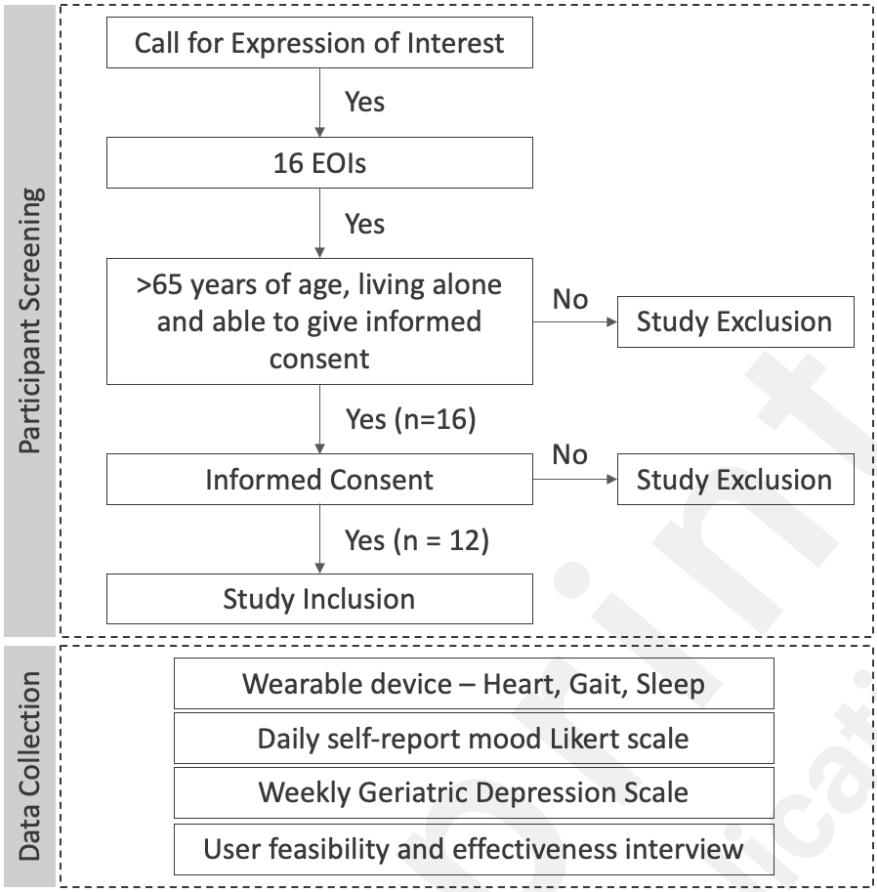


Figure 2: Participant recruitment flow

Wearable Device

For this study, all participants were provided a smartwatch. Based on literature [4, 22], we chose the Fitbit Alta HR smartwatch for our study due to its cost effectiveness for the eventual end user, as well as ease of setup and usage. Studies have shown fair performance accuracy for similar Fitbit devices (Fitbit Charge 2), with a heart rate estimation error of 14% [2]. A review of Fitbit centered sleep studies additionally showed sensitivity values of 0.95-0.96 and specificity values of 0.58-0.69 for detecting sleep stages [25].

Participants were required to wear the device at all times during the 4-week period with the exception of showering. As the study required sleep data, the participants were asked to wear the device when sleeping. To ensure minimal loss of data, we asked the participants to leave the Fitbit to charge before they showered.

Participant Protocols

Participants were provided with a list of resources available to them in case of any emotional distress during the study period. While the introductory interviews were basic questions about the everyday lives of the participants, we set protocols to terminate the interview session and stop participation if a participant got distressed at any point, especially during baseline Geriatric Depression Scale (GDS) entries. Refer to the Interviews section for more details on the GDS.

Researcher Interventions

Researchers in the study could advise the participants to seek assistance from a provided resource list or medical professionals. Participants were provided with point of contact information for the research team.

COVID-19 Protocols

The study took place in zero-contact settings to accommodate for COVID-19 protocols. Participant document packs and devices were sent via post and all interviews were held via phone.

Data Acquisition and Analysis

Questionnaires

Participants completed a daily questionnaire consisting of (1) a self-report mood rating Likert scale, (2) open questions on activity and food preferences (diversion questions away from depressive symptoms), and (3) an optional section to add details of any out of the ordinary events in the preceding 24-hour period. For the mood scale, participants were asked 'How would you rate your mood in the past 24 hours', rated on a scale from 1-10 once per day. Meanwhile, diversion questions, such as 'What do you feel like eating?' and 'What do you feel like doing?' were added to the daily mood reported questionnaire to reduce response bias.

Participants also completed an online 15-item Geriatric Depression Scale (GDS-15) once per week [26]. This short form of the GDS consists of 15 yes/no questions with a single point score for each response indicative of depression [27]. The participants also completed the GDS-15 questionnaire online during the introductory briefing. These responses were used as the baseline GDS to observe outliers (if any). Any participants scoring 6+ would be advised to have a GP consultation prior to participating in the study. Higher scoring participants were not excluded immediately, as the GDS is a screening rather than a diagnostic tool for depression [27].

Interviews

Pre-intervention (Introductory) Interview	Post-intervention (Closing) Interview
1. How have you generally felt over the past four weeks?	1. How was your experience over the past four weeks?
2. How often do your caregivers visit you/you visit them (family, friends, or medical professionals)?	2. Did anything cause you discomfort over this time?
3. Was this the same/less/more prior to the COVID-19 pandemic?	3. How was wearing the Fitbit for 4 weeks
4. Do you feel that your lifestyle or your daily life has been impacted by COVID-19 in anyway?	4. Was the daily survey inconvenient?
5. Do you feel more dependent on others now as opposed to a few years ago?	5. Was there any part in the survey that made you feel uncomfortable or distressed?
6. GDS Questionnaire	6. Do you have any feedback or suggestions for how we can improve the study in the future?
7. Do you have any questions for us?	7. Let's say we build a mobile app to send notifications to you or your families based on our findings, in real-time. Would that make you feel more relaxed while living independently?
Follow-up questions will be asked based on their responses to the above questions.	8. What would you want in such an app?
	9. Do you feel more at comfort when you know someone is looking after you or concerned about your inner wellbeing, regardless of whether they are with you all the time?
	10. Do you have any further questions from us about our study?
	11. Would your experience or answers with this study have been different prior to the COVID-19 pandemic?
	Follow-up questions will be asked based on their responses to the above questions.

Figure 3: Pre-post interviews

Two sets of interviews (Figure 3) were held with the participants; at baseline and at the end of the study period (week 4). Both sets of interviews were transcribed verbatim. Pre-procedure interviews were performed to provide insight into the everyday lives of participants in the 4-weeks preceding the procedure, as well as the impact of COVID on regular interactions (if any). Post-procedure interviews were performed to gain feedback on the procedure period itself.
The first set of semi-structured interviews (pre-procedure) were held in the introductory session, where participants also filled out the baseline GDS. The introductory interviews consisted of a series of questions relating to the participants' everyday lives and whether they were impacted by the COVID-19 pandemic. We added the COVID-19 component to account for anomalies in participant data, if they in fact did feel impacted by the pandemic.

The second set of semi-structured interviews (post-procedure) were held after the 4-week study period. Participants were provided more detail on the study and its objectives. To determine feasibility and usability, we asked the participants (1) about their experience during the 4-week period, (2) whether they would be interested in the autonomous mental health monitoring system we have proposed, (3) and what they would or wouldn't want to see in the mobile application. Such an application would report their emotional state. For example, clean, straight forward notifications versus a detailed dashboard view of vital signs.

We performed a hybrid inductive/deductive thematic analysis [28] with four coders. Our deductive thematic analysis consisted of going into the analysis with an existing direction, concept, or theme. Analysis was initially directed toward usability, however we developed

sub-themes based on common texts to provide more insight and direction, as is typically performed in an inductive thematic analysis. In a workshop discussion setting among the authors, de-identified interview responses were assessed to (1) generate initial codes, (2) search for themes, (3) review the themes, and finally (4) define and name the themes.

Results

Twelve participants were interviewed prior to the 4 weeks with 9/12 participants returning for a post-procedure interview (75% retention). The 3 participants that did not attend the closing interviews were uncontactable. Closing interviews were held with the remaining participants, to identify potential improvements to the proposed framework (Figure 1) and the effectiveness and feasibility of an autonomous mental health monitoring approach in reducing caregiver burden and dependence. Figure 4 provides an example of how interviews were analyzed. Themes were formed based on key words and overall response context.

R: How was your experience over the past four weeks?
P: Great it was good to sit down and put the thoughts down

R: Did anything cause you discomfort over this time?
P: No no, not at all. It was interesting to see how much walking I've been doing

R: Would you prefer to not wear the Fitbit for so long (4 weeks)?
P: Hasn't bothered me because it's so light when it's not on my arm I'm like 'oh gosh where is it?'. Became automatic putting it back on. Hasn't been an issue. It was light and tiny, so it was very suitable for people our age

R: Was there any part in either survey that made you feel uncomfortable or distressed?
P: No, I enjoyed it really

R: Let's say we build a mobile app to send notifications to you or your families based on our findings, in real-time. Would that make you feel more relaxed while living independently?
P: Yes

R: What would you want in such an app?
P: Vital signs, blood pressure (researcher note: semi-detailed)

R: Do you feel more at comfort when you know someone is looking after you or concerned about your inner wellbeing, regardless of whether they are with you all the time?
P: Definitely don't have an issue on that part

R: How was your experience over the past four weeks?
P: Was good. Didn't notice anything except one day got late with answers. Never an imposition and went very quickly. Didn't feel stressed, normal life.

R: Did anything cause you discomfort over this time?
P: None at all whatsoever. Actually surprised how quick it ended.

R: Would you prefer to not wear the Fitbit for so long (4 weeks)?
P: It doesn't worry me except call vibration (researcher note: minor technical difficulty)

R: Was there any part in either survey that made you feel uncomfortable or distressed?
P: None

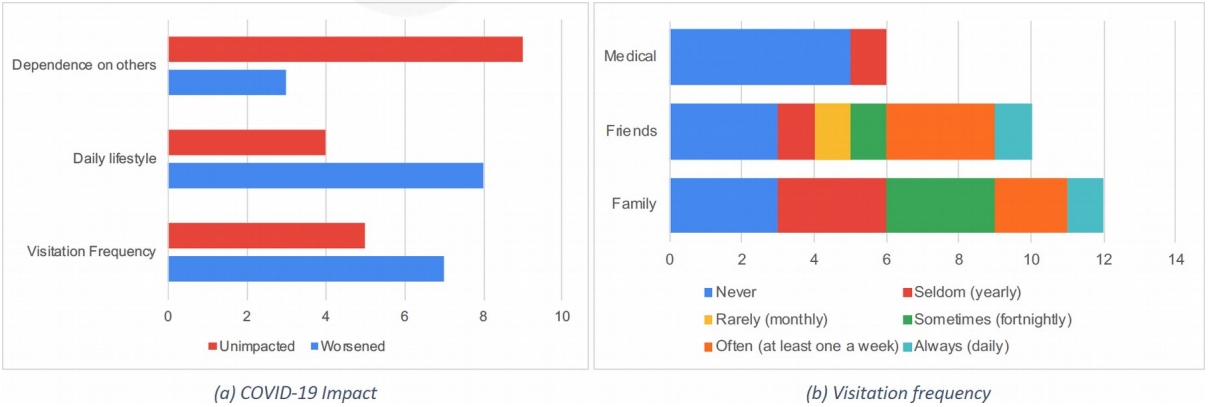
R: Let's say we build a mobile app to send notifications to you or your families based on our findings, in real-time. Would that make you feel more relaxed while living independently?
P: I think that would be nice but I don't have drops that major

R: What would you want in such an app?
P: A very clean app. Knowing physical details wouldn't particularly benefit anyone unless they have heart issues. I have a mentally disabled sister I think this would be good for. Should just say XYZ needs contact today.

R: Do you feel more at comfort when you know someone is looking after you or concerned about your inner wellbeing, regardless of whether they are with you all the time?
P: Yes that's a good idea

Figure 4: Excerpts from two researcher-participant (R-P) interviews with key words highlighted by one coder.

Pre-Procedure Analysis



(a) COVID-19 Impact *(b) Visitation frequency*

Figure 5: Pre-procedure themes: (a) COVID-19 impact on users in preceding 4-week timeframe. (b) Frequency of visitation with friends, family, or medical practitioners. Bars are different lengths as not all patients mentioned each of these items during the interviews

Emergent themes from our analyses have shown that participants had a positive life outlook over the preceding 4-week period. 75% of the participants (9/12) had mostly positive emotions. Forty-one percent (5/12) experienced some negative emotions, of which 60% (3/5) were challenged with negative life events. Fifty percent of interviewees (6/12) expressed a range of health concerns, with 83% (5/6) showing minor concerns, and 17% (1/6) having major health concerns.

All 12 participants had family members visiting them occasionally, while 83.3% (10/12) had more frequent visitation with friends. Only 50% (6/12) had appointments with medical practitioners, usually 1× / yr. Where participants were asked about visitation frequencies, responses (n=28) exceeded the interviewee count (n=12) as categories were non-mutually exclusive. i.e., participants could state visitations with any or all categories (friends/family/medical professionals). Categorically, 57% of the responses (16/28) showed visits ranging between family, friends, or medical practitioners 1 or 2× /yr. However, among participants that had more frequent interactions, 32% (9/28) indicated weekly interaction with friends. Of the 12 participants, 7 people had less interaction since the start of the COVID-19 pandemic (Figure 5b). Additionally, 67% of the participants (8/12) felt that their lifestyle and daily lives were negatively impacted by the COVID-19 pandemic (Figure 5a).

Post-Procedure Analysis

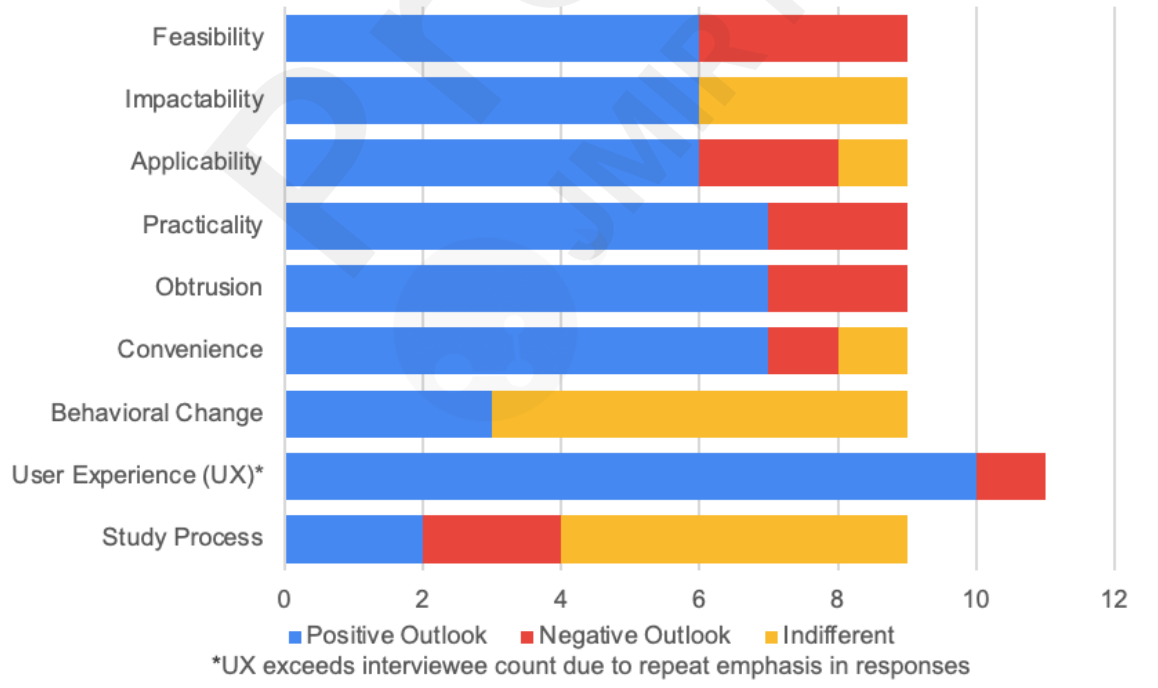


Figure 6: Dominant post-procedure themes for overall AutoMAP implementation and

overall procedure period

The responses after the 4-week procedure were generally positive. 7/9 participants were pleased with the convenience and ease with which the study went as well as the limited hands-on time commitment that was required. Figure 6 illustrates a summary of our thematic analysis for the post-procedure interviews. The user experience theme exceeds 9 participants, with an emphasis on the positive experience being accounted for multiple times when 2 of the 9 participants mentioned it more than once through the interview. 33% of participants (3/9) also experienced positive behavioral changes over the 4-week procedure, particularly increased awareness, and motivation to exercise more.

Study Feasibility

Six (67%) of the nine participants retained felt no discomfort during the procedure, while 1 participant felt mild discomfort with having to wear the watch during warmer summer days. Two of the 9 participants stated feeling slight frustration and obtrusion with having to wear the device overnight. Seven (78%) of nine interviewees found no inconvenience during the procedure, with the most common concerns on compliance being with the required daily mood report timing. Two of the nine participants felt worried about responding correctly even though there were no right or wrong answers. One participant found the diversion question ‘What do you feel like eating right now?’ to be irrelevant, which was the purpose of the question. The procedure also resulted in behavioral change in 33% of the participants (3/9), particularly through exercise awareness and journaling during the daily self-reports.

The device setup process and usage were favored by most participants, with only one participant having difficulty with the initial setup. Despite this, during data extraction, we found that two additional participants incorrectly linked their devices to the Fitbit application, which was resolved by requesting the participants to pair their devices again.

Overall, our analysis showed generally positive outcomes during the 4-week procedure. Some participants were seemingly aware of the study objectives, although not explicitly disclosed, while others agreed it to be a good aim once they were provided more detail on our study goals.

Practicality & Applicability

Six of nine participants (67%) were interested in the full implementation of our working prototype and stated that they would also feel more relaxed and at comfort knowing that their mental wellbeing was being monitored, while the remainder felt it would be more useful for those people with major depression or diagnosed ailments. However, there were emergent themes pertaining to (1) privacy, (2) false positives (i.e., the end user is alerted when there is no problem), and (3) false negatives (i.e., the end user is not alerted when there is a problem). These will be addressed under mobile application requirements and constraints. Twenty-two percent of the participants (2/9) suggested that the prototype would be more beneficial for users with specialized needs or diagnosed conditions such as Alzheimer’s, Dementia, Autism, Down Syndrome, Asperger’s or other known mental health issue.

For one of the nine returning participants, pre-post procedure interviews showed a promising and positive outlook, while their GDS scores were relatively high (mean = 7). One participant that did not return for the post-procedure interviews had higher GDS scores

(mean = 8) and an indifferent-to-positive outlook on life in the pre-procedure interview. The same participants also rated their own moods very highly (mean = 8.31 and 7.8) respectively, showing that self-perceptions of emotion are not always entirely accurate.

Seven (67%) of nine participants were pleased with the concept and potential of the prototype but raised concerns on its practicality. They suggested that the prototype may be a better fit for special needs persons of all ages or older aged persons with more serious ailments, aside from general ageing populations. The envisioned end users of AutoMAP are the caregivers of older aged people using the smartwatch. However, one participant presented a circumstance where a user does not have any close friends or family and the end user could be missing or not concerned enough to follow up on alerts.

Mobile Application

The closing interviews were designed to collect suggestions and preferences for our proposed mobile application. Fifty-six percent of the participants (5/9) preferred a clean, minimal application that would only send out plain-text alerts to the application end user (caregiver) when the device user's emotion levels reach a depressive tendency. For 2/9 participants, the application interface was preferred to be semi-detailed and more visually based as opposed to text-only. Another two participants did not specify interface preferences but raised concerns on potential issues such as misinterpretation and alarm in case of false positives, and reduced privacy.

Discussion

Principal Results

Despite some participants facing minor technical difficulties during the initial device setup and syncing process, participants were positive about the framework as a whole. The procedure resulted in positive behavioral change, not only physical wellbeing, but also mental wellbeing. Participants commented that the procedure made them more aware of their physical activity, while some took the daily survey as a means of journaling, which led to mental relaxation. Addressing concerns pertaining to the practicality and applicability of our prototype for those that have no caregivers of their own, we recommend a volunteer function within the AutoMAP mobile app that could allow other nominated persons to check on users. Living through the COVID-19 pandemic, this could also benefit the volunteers through added purpose or interaction.

Participants were concerned about the possibility of false positives sent to caregivers or false negatives. To mitigate this, we will need to train and test our algorithm to achieve high performance levels of emotion recognition from the smart watch data. Where privacy is a concern, device users might choose what extra information is visible to the caregiver. This could include (1) vital signs, (2) emotional range history, and (3) movement patterns. It needs to be considered, whether device users should see their own emotion level information. This could cause subconscious bias or emotion alteration.

Although most participants favored a minimalist visual based notification application, we will provide options for semi-detailed views instead of very minimal or pure text-only for those that may prefer more information in the app. We propose a mobile application that (1) notifies caregivers when a user's scores are indicative of depressive tendencies, (2) facilitates autonomy and privacy, and (3) allows for interface selection. User scores will be

determined through their physiological data and machine learning techniques.

Strengths and Limitations

This study has several strengths. The procedure was convenient and easy to implement from a user experience perspective. While some participants felt mildly concerned about the device setup and compliance with a consistent time for the weekly and daily surveys, all those who attended the follow up interviews were positive about the general study design and ease of participation. We blinded participants to our study aims during our pre-procedure interviews and informed participants of the study aims after the 4-week procedure. This type of blinding prevented subconscious response bias. The overall impression of the study was positive, with participants reporting that the 4-week study was well conducted, easy to follow and had no significant inconvenience to their everyday lives. Generally, the daily survey was perceived to be clear and concise, although in future iterations, efforts should be made to add more range to the mood rating components of the survey. This could potentially allow for finer, more detailed self-reported emotion mapping.

However, our study exclusively recruited participants over the age of 65, with no diagnosed mental health issues. A more diverse sample could improve the applicability and practicality of AutoMAP, as well as its performance and accuracy. While participants found the study favorable, some preferred not wearing the device overnight. There may also be issues pertaining to sharing private medical user data. The latter will be assessed and detailed in future research. Despite our efforts to maintain engagement with all participants, we were unable to interview 3 of the 12 participants for post-procedure feedback. Including these dropouts in our analysis may have provided a different perspective on the barriers and facilitators of the procedure.

Comparison with Prior Work

Our findings align with previous research on smart wearables for emotion recognition [20,21] or mental wellbeing [5,16]. These findings have shown that wearable sensors can be utilized for emotion recognition. Some of these studies [20,21] were in controlled settings, with deliberate emotion stimulation, where participants were not emotionally invested in the stimulus. These studies also observed participants for short time periods, meaning it is questionable whether the stimuli provided for emotion elicitation had the intended effect. By contrast, our procedure was performed in real-world settings, with participants keeping the Fitbit on throughout their daily lives. Therefore, collected sensor data reflects emotions in real day-to-day life.

Promoting behavioral change through telephone counseling and smart wearables has identified promising outcomes [16]. Investigators additionally highlighted that competing wearable products may have different applications and accuracies, which should be accounted for in future replications of procedures utilizing smart wearables. Another concern is the sustainability of the procedure. The aforementioned study used a device from the Jawbone company, which is no longer manufacturing devices. This could render the implementation of procedures using Jawbone devices potentially invalid for long-term implementation. Concordant with previous literature [5], we found Fitbit devices to be an acceptable tool to monitor user mental health. Additionally, our work differs in that we sought to determine the feasibility of Fitbit devices for preemptive depressive tendency detection, in contrast to implementing the devices for behavioral therapy for people with diagnosed depression.

Conclusions

On the basis of our pre-post interview findings, we will make modifications for future replication of our study, including (1) predefined weekly and daily survey times for all participants, (2) fewer diversion questions, (3) assisted device setup and walk-throughs and (4) more check-ins with participants during the study period.

Additionally, we gained valuable insight on end user preferences for the mobile application component of our framework. The combination of pre-post interviews enabled us to validate that everyday conversations and external cues on their own are insufficient to detect depression or depressive tendencies in people alone. Future procedures should also aim to recruit specialized cohorts on a more diverse diagnoses, such as those with other diagnosed mental health issues such as dementia, autism, and communication impairment. Special cohorts were explicitly excluded from this preliminary study.

This study is a vital step to validate our framework and identify requirements for the development of our proposed mobile application. Moving forward, we will develop the mobile application, as well as train and test our machine learning algorithm to detect depressive tendencies using physiological inputs. The machine learning component will be integrated with the mobile application, to notify caregivers if the user's score is indicative of potential depression.

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FM, WR, and JG conceptualized the study. IK consulted on the study design. FM, WR, PS and JG contributed to the interview guideline, interpretation of results, drafting and revision of the manuscript. FM conducted the interviews, performed data analysis, and wrote the first draft of the manuscript. WR, PS and JG provided guidance on data analysis and critical feedback on the manuscript. All the authors read and approved the final version of the manuscript.

Conflicts of Interest

None

Abbreviations

AutoMAP: Autonomous mental health monitoring for older aged persons
GDS: Geriatric depression scale

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