Perception and Initial Adoption of Mobile Health Services of Older People in London: Qualitative Methods

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Abstract

Background: Advances in mobile technologies and public needs have resulted in the emergence of mobile health (mHealth) services. Despite the potential benefits of mHealth applications, older people face challenges and barriers to adopt them.

Objective: The aim of this study is to understand older people's perception of mHealth services and find out the barriers older people face in the initial adoption of mHealth applications.

Methods: This paper consists of two studies. In Study 1, questionnaires and interviews based on the literature review were carried out to uncover older people's perception of mHealth services. Study 2 was a workshop helping older people to trial mHealth Apps and find out the barriers they faced in the initial adoption period. The interviews and workshop were audiotaped and transcribed. Descriptive statistics and thematic analysis technique were used.

Results: 'Access to technology' and 'perceived relative advantage' were found as important factors for initial adoption, and ageing factors (including 'generation gap') created barriers. Older people's 'perceived usefulness' of mHealth services is associated with lifestyle compatibility and information quality. Based on the synthesis of these results, design suggestions were proposed, including Technical Improvement, Free Trial, Information Clarification and Participatory Design. They will help inform the design of mHealth services to benefit older people.

Conclusions: The perceptions of mHealth services of older people were investigated; the barriers older people may meet in the initial adoption stage were identified. Design suggestions were proposed to help develop more acceptable mHealth services for a wider population.

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Abstract

Background:

Advances in mobile technologies and public needs have resulted in the emergence of mobile health (mHealth) services. Despite the potential benefits of mHealth applications, older people face challenges and barriers to adopt them.

Objective:

The aims of this study are to understand older people's perception of mHealth services and to find out the barriers older people face in the initial adoption of mHealth applications.

Methods:

This paper systematically analysed main determinants related to mHealth service, and investigated them through questionnaires, interviews and a workshop. Two studies were carried out in London. In Study 1, the questionnaires with follow-up interviews were conducted based on the literature review to uncover older people's perception (including perceives usefulness, perceived ease of use and perceived behavioral control) of mHealth services. Study 2 was a workshop helping older people to trial selected mHealth Apps. The workshop was conducted by the first author with the assistance from five research students. The barriers older people faced in the initial adoption period were observed. The interviews and workshop were audiotaped and transcribed. Descriptive statistics and thematic analysis technique were used for data analysis.

Results:

In total 30 older people in London completed the questionnaires and interviews in Study 1. The results of Study 1 show that the lack of obvious advantage, low reliability, scary information and the risk of privacy leakage would decrease older people's 'perceived usefulness' of mHealth services; the design of app interface directly affect the 'perceived ease of use'; ageing factors, especially the 'generation gap' created barriers for older users. Consequently, 12 participants took part in the workshop of Study 2, including 8 who took part in Study 1. The results of Study 2 identified that the 'access to technology', 'the way of interaction', 'the risk of money loss', 'heavy workload' of using an mHealth app and 'different lifestyle' are influential

factors to older people's adoption of mHealth services.

Conclusions:

The perceptions of mHealth services of older people were investigated; the barriers older people may meet in the initial adoption stage were identified. Based on the synthesis of these results, design suggestions were proposed, including Technical Improvement, Free Trial, Information Clarification and Participatory Design. They will help inform the design of mHealth services to benefit older people.

Keywords: Older People; mHealth; Initial Adoption; Technology Acceptance; Design

Introduction

Thanks to the development of Information and Communication Technology (ICT), healthcare services delivery nowadays goes beyond traditional face-to-face interaction. ICT supports healthcare with electronic communication and system networking capabilities to provide, exchange and/or facilitate exchange of health-related information [1]. Mobile health (mHealth) emerged in 2003; the term was coined by Robert Istepanian to describe the use of 'emerging mobile communications and network technologies for healthcare'[2]. Compared with online health services delivered from desktops and laptops, mHealth services have the advantage to interact with individuals with a much greater frequency and flexibility, without being limited by time and place [3]. Mobile technologies, especially smart phone-based applications, can improve the efficiency of healthcare delivery, ultimately make healthcare more effective [4-6] and help people to better control their chronic conditions[7, 8]. However, despite the numerous benefits of mobile health (mHealth) apps, relatively little is known about whether older adults perceive that these apps confer such benefits. Their perspectives towards the use of mobile applications for health-related purposes have not yet been fully investigated [9].

'Living a healthier independent life' is vital for older people's quality of life [10]. Given that the ageing population has become a global issue, making mHealth service more acceptable by older people is of paramount importance. For instance, the World Health Organisation has identified a good practice case study in Singapore's Action Plan for Successful Ageing where a mobile app 'Healthy 365' was successfully utilised [11].

Prior Work

Although there has been a steady increase in the number of studies exploring technology adoption/acceptance among older adults, few have focused on mobile technologies, and even fewer have explored the acceptability of mobile technology use for health-related purposes [12]. Studies on mHealth adoption among older people are far more less than those on general technology adoption among older people [13-15]. Because of the importance of, and the increased interest in the field, a scoping review protocol has been proposed in 2020 to investigate the willingness, perceived barriers and motivators in adopting mobile applications for health-related interventions among older adults [9].

Published studies on mHealth adoption [16-20]are mostly based on the Technology Acceptance Model [21] and its extended variations (i.e., TAM2, TAM3, UTAUT and UTAUT2). Health Belief Model (HBM) and Protection Motivation Theory (PMT) also prove helpful to understand mHealth

adoption. In the research of health behavior, e-health literacy [22], self-efficacy [23], perceived vulnerability, perceived severity, and health consciousness [24] are listed as influential factors to people's adoption of health information technologies. Sun et al.[25] integrated several models to find that users' intention to use mHealth services was determined by five key factors: performance expectancy, effort expectancy, social influence, facilitating conditions, and threat appraisals.

Deng et al. [18] extend Technology Acceptance Model (TAM) with 'trust' and 'perceived risks' in studying mHealth adoption in China. Alam et al.[19] extend UTAUT to include 'perceived reliability' and 'price value' to investigate mHealth adoption in Bangladesh. These studies used quantitative methods (e.g., survey questionnaires) and recruited patients from local hospitals. Cajita et al. investigate the intention to the use of mHealth in older adults with heart failure [26], and associated facilitators and barriers [12], using a mixed-method (i.e., large survey + small scale interview). Minimal qualitative research was conducted with 'well-old users' [27] who are the largest potential beneficiaries of mHealth services.

Previous research has mainly investigated how older adults use technologies before the objectification phase and usability problems after the conversion phase [28], and little investigated the initial adoption stage, i.e., using only elementary features and limited functions of mobile technologies. Grindrod et al. [29] evaluated user perceptions of four mobile medication management applications with older adults (those aged 50+) through usability testing, and found that most participants "were frustrated by their initial experiences with the applications."

In review of the above, this paper fills these gaps by exploring older people's initial adoption of using mHealth applications, using qualitative questionnaires combined with interviews and user trial workshops to reveal their perceptions and contextualised experiences. The insights help generate design suggestions to make mHealth service more acceptable by older people.

Theoretical Framework

MHealth services utilize information communication technology (ICT). They are relevant to technology adoption theories which can be traced back to the Theory of Reasoned Action (TRA) [30]. Based on the TRA, Davis develops the Technology Acceptance Model (TAM) in which he suggests that 'perceived usefulness' and 'perceived ease of use' are the two most important individual beliefs about using an information technology [31]. Other researchers have extended TAM and proposed TAM2[21] and TAM3 [32], decomposing the 'perceived usefulness' and 'perceived ease of use'. Ajzen [33] develops the Theory of Planned Behavior (TPB) to extend TRA and adds the new construct of 'perceived behavioral control'. Venkatesh et al. proposed United Theory of Acceptance and Usage of Technology (UTAUT), combining eight existing theories[34]; and UTAUT2 emphasized the consumer use context [35].

As a kind of health behavior, mHealth adoption is also relevant to theories of health behavior, e.g., Health Belief Model (HBM) [36]and Protection Motivation Theory (PMT) [37]. HBM hypothesizes that health-related behavior depends on the combination of perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy. PMT stems from both the threat appraisal (perceived vulnerability and perceived severity) and coping appraisal (response efficacy, self-efficacy and response cost) processes.

The theoretical framework of this study is based on TRA, TAM, TPB, UTAUT2, HBM and PMT (Column 2 in Table 1). Eight main constructs (shown in Column 1 in Table 1) were extracted through grouping similar factors in these models. These constructs will be further investigated through primary studies in order to gain insights into older people's perception and initial adoption of

mHealth services.

Table 1. Eight main constructs extracted from existing models.

Construct	Origin		Definition
PU (perceived usefulness)	TAM	Perceived usefulness	An individual's perception that using a particular system would enhance his or her job performance [38].
	UTAUT2	Performance expectation	
	HBM	Perceived benefits	
	PMT	Response efficacy	
PEOU (perceived ease of use)	TAM	Perceived ease of use	An individual's perception that using a particular system would be free of effort [38].
	UTAUT2	Effort expectancy	
	HBM	Perceived barriers	
PBC (perceived behavioral control)	TAM	Perceived behavioral control	An individual's perception of how easy or difficult it will be to perform the target behavior [33]. The perceptions of internal and external constraints on behavior and encompasses self-efficacy, resource facilitating conditions, and technology facilitating conditions [34].
	UTAUT2	Facilitating conditions	
	HBM	Perceived barriers Self-efficacy	
	PMT	Self-efficacy Perceived cost	
SI (social influence)	TRA	Subjective norm	An individual's perception of the degree to which most people who are important to him or her approve or disapprove of the target behavior [30].
	TPB	Subjective norm	
	UTAUT2	Social influence	
HM (hedonic motivation)	UTAUT2	Hedonic motivation	An individual's perception of the fun or pleasure derived from using a technology [35].
PV (price value)	UTAUT2	Price value	An individual's cognitive tradeoff between the perceived benefits of the applications and the monetary cost for using them[39].
HB (habit and experience)	UTAUT2	Habit	The extent to which an individual tends to perform behaviors automatically because of learning [40]. Habit is a perceptual construct that reflects the results of prior experiences [35].
	UTAUT2	Experience	
PHC (perceived health condition)	HBM	Perceived susceptibility Perceived severity	An individual's perception of the risk of acquiring an illness or disease [37] and the seriousness of contracting an illness or disease [36]
	PMT	Perceived vulnerability Perceived severity	

Methods

The overview of this research is shown in Figure 1. Study 1 investigated the older people's perception of mHealth devices by questionnaires and interviews based on the literature review. Study 2 observed how older people initially use mHealth apps in order to find out the barriers and experiences they have in mHealth adoption.

The research has received the ethical approval from Queen Mary University of London (QMERC2016/31). The insights from these two studies help generate design suggestions to make mHealth service more acceptable by older people.

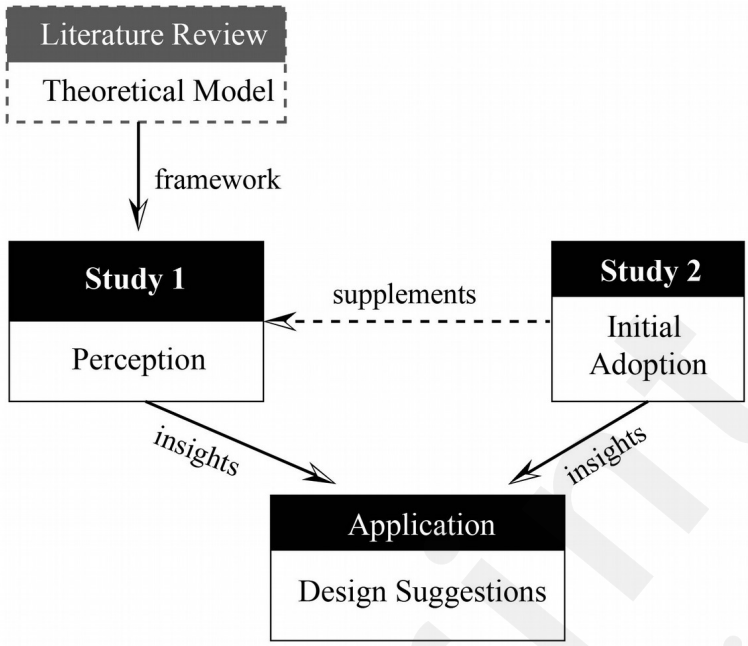

Figure 1. The overview of this research.

Study 1: Investigation of Perceptions

Study1 was conducted from January to February in 2017 in London. The study comprised a 15-minute questionnaire and a follow-up interview (about 30-45 minutes). Conducting face to face interviews following questionnaires can not only help get more detailed information from the participants but also help rectify any misunderstanding of the answers. The mHealth service discussed here mainly focused on health-related services that can be accessed by smartphones and tablets, for example websites and mobile apps.

Existing studies have proved that age plays a moderating role in mHealth adoption [41-43] and factors have different impact on mHealth adoption intention among different age groups [23]. In Britain, old age can be “any age after 50” and this definition has been adopted in many HCI studies and initiatives such as age-friendly cities. In this study, we recruited “well-old users[27] ” aged between 50 and 70 years in East London. People with serious disease/impairments and aged over 70 years were excluded; this was to ensure independent taking part in the study (requiring travelling and basic understanding of digital technology).

We targeted 30 samples, as suggested by Corder & Foreman[44]. We actually included all the 32 older adults who contacted us, but 2 of them failed to complete the whole process, so the valid responses were 30. Convenience sampling was used; it is cost effective and has been widely accepted in Information System research [45]. Participants were recruited from AgeUK, Hackney Mobile Centre and Queen Mary University in London (QMUL). The questionnaires and interviews were completed in the classrooms of AgeUK East London, Hackney Mobile Centre or the Senior Common Room of QMUL, depending on the time and venue availability. The details of Study1 are shown in Table 2.

Table 2. Details of Study 1.

Construct	Content	
Demographic Information	Age, Gender, Living Arrangement, Education Level, Employment Status	Q1-Q5
PHC	Perceived health condition	Q6
PBC	Facilitating conditions (Access to technology)	Q7-Q8
	Age-related changes in using mobile technology	Q12-Q17
HE	Using different devices for health purposes	Q10
	Using mobile devices for different purposes	Q11
PU	Perceived usefulness of online health information	Q9 Interview
	Perceived usefulness of mobile devices on health and wellbeing	Q18 Interview
	Perceived usefulness of mHealth apps	Q19-31 Interview
PEOU	Perceived ease of use	Interview

To understand older people's perceived usefulness of mHealth apps, the participants were asked to rate the usefulness of different features of mHealth apps and to give the reasons for low scores. An mHealth app typically offers more than one function, in other words, an mHealth app has multiple features. In order to understand main features offered by typical mHealth apps, the authors searched for the term "health" in both App Store (IOS system) and Google Play (Android system) in December 2016, downloaded the top 50 health related apps in each system and analysed the features of each app. For example, Apple Health has features of 'Fitness and exercises' and 'For emergency (providing vital medical information of you in an emergency)'. As the result, 13 features were extracted from the existing health related apps., and they were evaluated by the older adults participating in Study 1.

To understand older people's 'perceived behavioral control' of using mHealth services (e.g., mobile apps), the participants were asked to rate how different age-related changes might stop them from using an app, e.g., "visual impairment", "hearing loss", "decline in memory", "decline in the ability to understand written and spoken languages", "decline in the ability to focus attention" and "decline in movement control" [46]. "Generation gap" was also added because we found from our previous pilot study that older people had difficulties in understanding new terms generated by the younger generation. For example, they were confused by the "menu" or "navigation" of a digital interface.

Study 2: Observation of Initial mHealth Adoption

This study took place as a workshop in March 2017 at Hackney Mobile Centre in East London, where Wi-Fi connection was available. MHealth apps were introduced to older people and they were helped to start using these apps. At the same time, how they initially use mHealth apps was observed in order to find out the barriers and experiences older people have in mHealth adoption. MHealth apps were selected from App Store and Google Play. After reviewing over 100 mHealth apps, we identified four categories beneficial to older people's health, namely: 'Diagnosis Online', 'Step Tracker', 'Calories Calculator/Food Diary' and 'Health Monitor'.

Since Google Fit (Android system only) and Apple Health (IOS only) are embedded in most smartphones, they were also included in the trial. Four more pairs of apps, free and available in both Android and IOS systems, were chosen for each category (see Table 3).

Table 3. Ten apps introduced in the workshop (in 5 pairs)

Pair 1	Pair 2	Pair 3	Pair 4	Pair 5

Embedded Health Platforms	'Diagnosis Online'	'Step Tracker'	'Calories Calculator/Food Diary'	Health Monitor'
				
Google Fit	Health Tap	Movesum	Lifesum	iCare Health Monitor
				
Apple Health	Babylon Health	Pacer Health	My Fitness Pal	mySugr Diabetes Diary

Pair 1: **Embedded health platforms**: Google Fit (Android system) and Apple Health (IOS system)
These two apps are often embedded in users' smartphones. They have the basic function of step counting and integrating health information from third-party health apps in the users' phones or wearable devices to track fitness, nutrition, sleep, and weight.

Pair 2: **Diagnosis Online**: Health Tap and Babylon Health
These two apps enable users to have virtual consultation with doctors and healthcare professionals via text and video messaging. They also help make appointments with GPs or pharmacies in certain locations. Primary consultancy is free while more professional and responsive services need extra cost.

Pair 3: **Step Tracker**: Movesum and Pacer
The main function is to automatically record the user's steps, distance, active time and calories burned all day. Movesum motivates people to do exercise by showing what food they have 'burnt' while Pacer allows people to join different online groups based on common health goals and interests. Both apps use smart notifications to help users reach their daily goals.

Pair 4: **Calories Calculator/Food Diary**: Lifesum and Myfitmess Pal
Unlike the 'Step Trackers', these apps import activity information from other apps and focus more on what people eat. Both of them provide barcode scanners for easy food tracking, recording, and evaluating people's diet. They also give diet or exercise suggestions, but in order to get personalized suggestions, users need to upgrade to a premium version which requires extra payment.

Pair 5: **Health Monitor**: iCare Health Monitor and mySugr Diabetes Diary
iCare Health Monitor measures blood pressure, heart rate, vision, hearing, SpO2, breath rate without extra devices. MySugr Diabetes Diary includes a blood sugar tracker, a carb logger, and a bolus calculator (EU only). After users put in their meal and medical information, together with activity information from other apps, it will show estimated HbA1c (an objective measure of glycaemic control). Users can export their daily, weekly or monthly medical analysis and report with a paid version.

The workshop was carried out as an event of Hackney Mobile Centre. Participants were recruited through Hackney Mobile Centre's group email contact and poster advertisement. The

recruiting criteria were: aged between 50 and 70; using a smartphone and being interested in mHealth apps. 21 older people contacted us for participation, however, taking into account the size of the venue and the number of the researchers, we ended up recruiting only 12 of them. Older adults who took part in Study 1 had the priority. Eight older adults from Study 1 participated in the workshop, and four more participants were selected according to the order they contacted us. All participants were asked to bring their own smartphones. The duration of the workshop was two hours. All the 10 free mHealth apps were introduced to all participants. Then they were invited to decide on which app to be downloaded to their own phones based on their interests.

The first author organized and conducted the workshop with the assistance of 5 research students. The research students were recruited as volunteers through the university's group email contact with the following criteria:(1) have experience in communicating with older people; (2) native English speaker; (3) interested in mHealth apps; (4) have a smartphone which can install at least five of the selected apps. The research students were asked to download and try each selected app the day before the workshop. They were trained by the first author one hour before the start of the workshop, and all followed the same procedure: each was equipped with a record sheet template to tick the apps tried and to record demographic information, negative/positive perception, reasons for giving up, and willingness of using the App in the next 3 months. Each of the research students and the first author took care of two older participants, sitting in between them, helping download apps, taking notes and making audio recordings. After the workshop, the first author collected all the notes and audio recordings, and discussed with each research student about his/her observation of the workshop. The first author transcribed the notes immediately after the workshop, and checked the accuracy of the notes with each research student through email communication.

Descriptive statistics were used to summarize the participants' characteristics and outline the general situation of mHealth adoption among older people in London. Qualitative data from interviews and the workshop were analysed with the thematic analysis method. Braun and Clarke's six-step thematic analysis approach [47] was adopted. A hybrid process of inductive and deductive coding [48] was applied to continually reflect on, and refine the themes. Quotes from the participants were referenced to support research statements.

Results

This section reports the outcomes from Study 1 and Study 2.

Outcomes of Study 1

The 30 participants completed both the questionnaire and the follow-up interview. The sample characteristics of Study 1 is shown in Table 4. The participants were asked to rate their own perceived health condition from 1 to 5 (1 for 'poor' and 5 for 'excellent'). The average score of all the participants is 3.7 (Min = 1, Max = 5, SD = 1.15). Twenty of them have a positive perception (scores 4 to 5) of their own health.

Table 4. The sample characteristics of Study 1.

Characteristics		**Number**	**(% or range)**
Age	50-54	12	(40%)
	55-59	6	(20%)
	60-64	5	(17%)
	65-70	7	(23%)

Gender	Male	17	(57%)
	Female	13	(43%)
Living Arrangement	Alone	10	(33%)
	With partner only	6	(20%)
	With child only	3	(10%)
	With partner and child	7	(23%)
	With other relative	1	(3%)
	Other	3	(10%)
Education Level	Postgraduate or higher degree	11	(37%)
	1st Degree	4	(13%)
	HND/HNC/Teaching	2	(7%)
	BTEC/College Diploma	7	(23%)
	A-level	3	(10%)
	Lower degree	3	(10%)
Employment Status	Retired	7	(23%)
	Employed part time	5	(17%)
	Employed full time	9	(30%)
	Unemployed	9	(30%)

Access to technology

Among all the participants, 30 (100%) have access to Internet, 24 (80%) have a personal computer, 14 (47%) have a cell phone (simple mobile phones), 24 (80%) have a smart phone, 20 (67%) have a personal tablet, and 2 (7%) have smart wristbands. In total, 24 participants have a smart mobile device capable for searching online and installing apps.

- **Using different devices for health purposes**

Four participants have used an app relating to health. The apps used were Fitbit, GoogleFit, Runkeeper and Apple Health. Their adoption of mHealth apps was rather passive, as they stated,

> 'I use it because it[is] just there, the information turns out automatically, so I can see it.'
>
> 'My daughter bought the wristband for me, so I wear it. But rarely check the data on the phone.'

We also investigated how frequently the participants use Internet and different devices for health purposes. The result is shown in Figure 2.

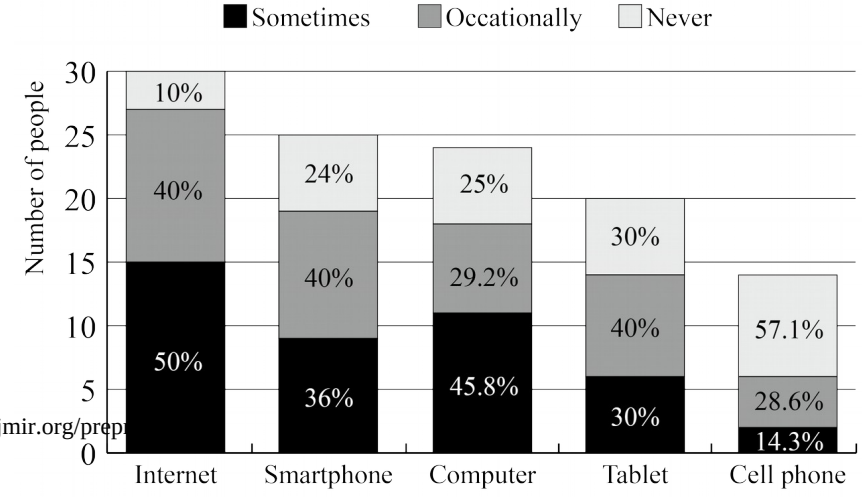

Figure 2. How frequently older people use Internet and different devices for health purposes.

All the participants have access to Internet and 27(90%) of them have the experience of using the Internet for health purposes. Not many people use mHealth apps; smartphones seem to be the first choice for older people to get health information or services online. 18 out of 24 participants (76%) who have smartphones, accessed health information or services by their smartphones.

- **Using mobile devices for different purposes**

In order to adopt mHealth services, mobile devices are required. Therefore, we also investigated how older people use their mobile devices. The result is summarized in Table 5 (excluding people who only have a simple cell phone as their devices may have limited their choices).

Table 5. Frequency of using mobile devices for different purposes

Purpose	Min	Max	Mean	SD
Creation (e.g., taking a photo, filming a video or editing a file)	2	5	3.5	0.9
Traffic and Transportation (e.g., Google map and Citymapper)	1	5	3.3	1.3
Social Engagement (e.g., Facebook, Twitter)	1	5	2.8	1.6
Entertainment (e.g., playing games, listening to music and watching videos)	1	5	2.7	1.5
Health and Fitness (e.g., searching information, sport tracking and health management)	1	4	1.9	1.1
Online Transaction (e.g., online shopping, banking and paying bills)	1	4	1.8	1.2
Valid N	24			

*Note: 1- Never; 2- Less than once a month; 3- Every month; 4- Every week; 5- Every day.

Perceived usefulness of mHealth services

Since not many participants have experiences of using mHealth apps or wearable health devices, we asked how older people perceived the usefulness of mobile devices for their health and wellbeing. The main health-related benefits are to seek information on health issues (70%), to make appointments, and to keep contact with doctors (67%). However, 75% of the participants did not think mobile devices were beneficial to their health or had doubts. As participants said

> 'I don't know who put the health information online, maybe someone is just pretending to be a specialist.'

> 'Same symptoms on different people can be result from different reasons and same recipe may have different effect on different people, even doctors cannot give me suggestions before seeing me face to face.'

If they had to search for health information online, most of the older people would choose the website of the National Health Service (NHS), some also said that they would search academic articles to get more reliable information.

To understand older people's perceived usefulness of mHealth services, the participants were asked to evaluate 13 different functions using a scale from 0 to 4 (0 means 'this function is not useful at all' and 4 means 'this function is very useful'). The most highly valued function is 'For emergency' (M=2.83, SD=1.40) followed by 'Making an appointment with doctors or hospitals/ GPs' (M=2.79, SD=1.50) and 'Knowledge about health and health preservation' (M=2.54, SD=1.39). Some respondents also mentioned that they would try to 'communicate with a doctor online' only in case they were unable to go outside. Most of them thought mHealth

service was not bad but not essential. As one participant noted,

'It is a good service, but not necessary to me. I'm satisfied with life without it.'

The main reasons for lower scores (negative perception) are summarized in Table 6.

Table 6. Negative perception of mHealth services

Function	Reasons for giving a low score
Knowledge about health and health preservation information	*'I don't trust it.'*
Self-assessment or self-diagnose (e.g., check health statues with apps or websites by yourself)	*'I'm not a health professional, I prefer to see a doctor.'* *'Pharmacy is just around the corner, why should I do it myself?'* *'I rarely do self-diagnose or assessment, the thinking if there's something wrong with me will make people really sick.'*
Health measurement (e.g., body temperature, blood pressure, blood glucose and heart beat)	*'I'm afraid that I can't use it in a right way and that will make the measurement not accurate.'* *'I don't want to buy all the devices for measurement.'*
Access to health record/history	*'I don't really understand all the terms, there's no need for me to see it.'* *'Looking into the bad record makes me feel even worse.'*
Making an appointment with doctors or hospitals/GPs	*'Calling the GP is easy, using an app for it may make it more complicated.'*
Helping with healthy diet (e.g., healthy recipes, calories calculator, food diary)	*'It's hard to calculate the calories or sugar in an accurate way.'* *'I don't think I can keep on with the diary.'* *'I'm already eating in a quite healthy way.'*
Information of medicine	*'I can check it on the package.'*
Fitness and exercises (step counter and exercise guide)	*'I don't need it.'* *'I'm not an exercise person.'* *'The number is not accurate.'*
Communicating with a doctor online	*'I like seeing people's eyes.'* *'I feel more comfortable to talk with a doctor face to face.'* *'Doctors cannot see and feel how I am online.'* *'Although you have communication with a doctor online, he/she will always suggest you to come to the GP.'* *'You will still have to go to the GP or hospital for some tests.'*
Communicating with people who have the same health issue	*'I don't want to talk about my disease with strangers.'* *'Same symptoms on different people can be result from different reasons and same prescription may have different effect on different people. They are not specialist, there's no meaning to discuss with other patients.'*
Long-term situation management	*'I don't have serious long-term situation.'* *'My diabetes is under control and I don't think I need an app to deal with it.'* *'I think going to see the doctors regularly is the best way to*

	control my long-term situation.'
Reminder for taking medicine or meeting a doctor	*'I don't take medicine.'* *'My GP will send me a message to remind me of the appointment'*
For emergency (e.g., calling for help automatically, providing vital medical information of you in an emergency, like allergies and medical conditions...)	*'I don't want my information to be seen by others, what if I lost my phone?'*

Four main factors that decrease the perceived usefulness of mHealth services were identified:

1. No obvious advantage: compared with older people's own way of taking care of themselves, the mHealth service did not seem to show sufficient advantages for them.
2. Low reliability: the information or result provided by the mHealth service did not have or show high reliability.
3. Scary information: health information can be difficult to understand or scary to know to some people.
4. Risk of privacy leakage: the concern on privacy has hindered older people from putting their personal information in their mobile phone or on the Internet.

Perceived ease of use of mHealth apps

To understand what really affects older people's perceived ease of use of apps, the participants were asked the following questions:

'What is "ease of use" of an app to you?', 'Which of these two apps you use is "easier to use"? and why?'

The factors identified are: 'clarity of the language', 'text size', 'knowing where (which icon/button) to press', 'knowing what the icon/button means', 'finding what I need easily', 'knowing how to use without learning', and 'having no problem to do what I want'.

Perceived behavioral control of using a mobile app

In the questionnaire, participants ranked how ageing factors might stop them from using an app. The higher the score, the greater the influence. The result is shown in Table 7.

Table 7. How ageing factors influence older people's adoption of mobile apps.

Factors	Min	Max	Mean	SD
Generation gap (having difficulty to understand the new terms generated by the younger generation)	0	4	1.7	1.3
Visual impairment	0	4	1.5	1.4
Decline in memory	0	4	1.5	1.3
Decline in the ability to understand written and spoken languages	0	4	1.2	1.5
Decline in the ability to focus attention	0	4	1.1	1.3
Hearing loss	0	4	0.9	1.0
Decline in movement control (e.g., typing, clicking)	0	4	0.9	1.1
Valid N	30			

*Note: 0 - no influence; 1 - small influence; 2 - some influence; 3 - big influence; 4 - great influence.

'Generation gap' has the most influence on older people's adoption of mobile apps. 'Visual impairments' have the second biggest influence, followed by 'Decline in memory'.

Outcomes of Study 2

The workshop (Study 2) was conducted in March 2017, a month after the completion of Study 1. In total 12 participants (5 male, 7 female), aged between 50-70 (Min = 52, Max = 66, Mean = 56.8, SD = 4.5) took part in the workshop. Table 8 shows the sample characteristics of Study 2.

Table 8. The sample characteristics of Study 2.

Characteristic		**Number**
Age	50-54	2
	55-59	5
	60-64	4
	65-70	1
Gender	Male	5
	Female	7
Living Arrangement	Alone	2
	With partner only	6
	With child only	3
	With partner and child	1
	With other relative	0
	Other	0
Education Level	Postgraduate or higher degree	0
	1st Degree	1
	HND/HNC/Teaching	2
	BTEC/College Diploma	5
	A-level	4
	Lower degree	0
Employment Status	Retired	7
	Employed part time	3
	Employed full time	0
	Unemployed	2

Barriers to the initial adoption of mHealth apps

Embedded health platforms proved the easiest ones for participants to try because of no need for downloading. One participant abandoned the tests when downloading a new app; there was not enough storage space in her phone. She said,

> 'It says there's not enough space. I have to delete old apps for installing the new one. But I'm not sure if I really want this one [the app introduced in the workshop].'

Two participants withdrew from the tests while doing the installation. When the app asked for access to their location or photos, they gave up, worrying about the security of their personal data.

> 'Why they want to access my camera? I don't want to share my location. It's unsafe. I'd rather not use it.'

Two participants decided to quit the tests during the registration process. Almost all the health-related apps needed registration which often required personal information such as age, gender and weight. Participants felt that their privacy was invaded, especially when they had no idea what these apps could do for them. One participant complained,

‘It asked for too much. You need to be cautious when putting personal information online. You’ll never know who is on the other side of the app. Of course, if it can really benefit my health, I’ll take that. But for now, I just want to have a try, I don’t know if it is what I want.’

The physical barriers to mHealth adoption are illustrated in Figure 3 based on these observations. First, older people must have access to a mobile device with enough space for app installation. Second, the Internet must be available (meaning that people are willing to pay for using mHealth apps and are comfortable with connecting their devices to the Internet). Third, people will choose an mHealth app to download and then install the app. Registrations are often required after the installation of an mHealth app.

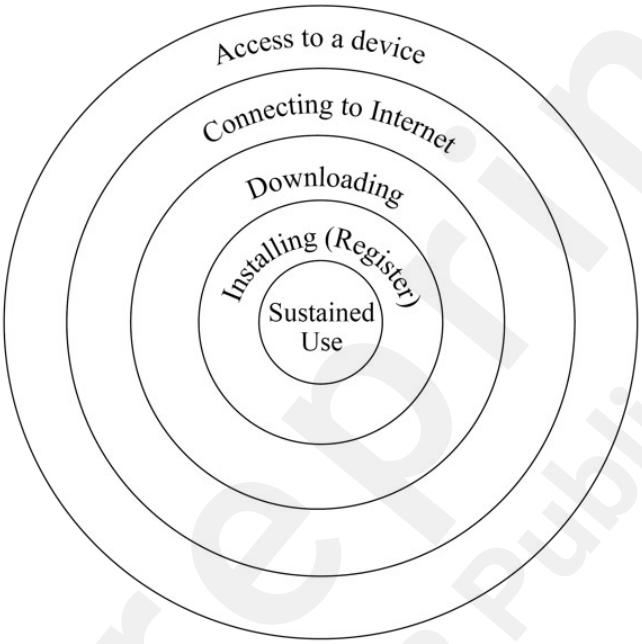

Figure 3. Barriers to adopting mHealth apps.

Feedback from initial experience

Seven participants installed one or more mHealth apps in the workshop. The feedback of their initial experience is summarized in Table 9.

Table 9. Participants’ feedback regarding their initial experience of mHealth apps

Apps Categories	No. of people tried	Feedback
Embedded health platform	9	‘I’m not really using it, I just notice my steps when the notification from the app shows up.’
Diagnose online	4	‘It keeps asking me to put in personal information before I can find out if I really want this.’ ‘If I … will it cost my money?’ ‘It’s useless; it still asked me to see a doctor.’ ‘There’s no response.’ ‘It requires very good Internet connection’ ‘I won’t do a face chat without Wi-Fi.’
Step tracker	3	‘It (Pacer) doesn’t have much difference with Google fit’ ‘I’m not

		eating junk food, showing me how much junk food I have burnt is useless.'
Calories calculator/ food diary	6	'It keeps asking me to put in personal information before I can find out if I really want this.' 'I don't have patience to calculate my calories every day.' 'Scanning barcodes for recording calories is cool, but many self-made food still need to be calculated by myself.' 'If the calculation is not accurate, it isn't helpful to me.'
Health monitor	7	'The way to use it is amazing!' 'I don't want to buy any extra device unless it's really accurate and not very expensive.'

From the participants' feedback, factors influencing older people's initial experience of using mHealth apps were identified, as follows.

· **Access to Technology**

Access to technology can not only stop people from adopting an mHealth app, but also affect their experience in using it. For example, when online consultancy was introduced, one participant mentioned that,

> 'I don't have Wi-Fi connection at home, and I won't do a face chat without Wi-Fi. Otherwise, I'll pay very expensive Internet fees. So actually, this function is not useful to me.'

Some participants had an unnerving experience of the self-diagnosis process. Long waiting for system responses often frustrates people when the responses came slowly due to the unstable connection of the Internet or the low speed.

> 'It doesn't respond.'
>
> 'My phone is stuck. What's wrong with it?'
>
> 'What should I do now?... Should I keep waiting?'

· **The Way of Interaction**

One-way interaction may fail to attract older people's attention and thus has little impact on their health. This was observed most obviously in the 'embedded health platform' and 'Step Tracker'. Before this workshop, the participants who have used the platforms were unaware that they were using an mHealth app. As one participant noted,

> 'I'm not really using it. I just notice my steps when the notification from the app shows up.'

Without connection with other health related apps, the platforms mostly work as a 'Step Tracker'. People who tried this type of apps in the workshop did not show much enthusiasm. One participant said,

> 'I can find that I walk more or less steps than yesterday by using this app. I see it [the numbers], but I don't care about it.'

'iCare Health Monitor', an app to measure blood pressure, heart rate, vision, hearing, SpO2, breathing rate was the most welcomed app in the workshop. Seven participants tried this app and they were surprised to be able to measure their blood pressure with the phone camera. Although they were told the measurements might not be very accurate, all of them intended to use this app in the next three months.

· **Risk of Money Loss**

The participants were not ready to pay for a mobile health service that they did not understand. Many participants kept asking questions like,

> ‘Is it free?’
>
> ‘If I … will it cost my money?’

This was observed in ‘Diagnosis Online’ apps. Using such apps, users can do self-diagnosis step-by-step or consult a doctor or therapist and get medical advice quickly. Four participants tried an app in this category. Although they had been told that ‘Talking to a qualified doctor on demand via a video consultation or phone call’ will cost money while ‘Texting your medical questions to a doctor to receive a quick, personal response’ is totally free, they were reluctant to use this free function, worrying about wasting money by mis-use.

- **Heavy Workload**

Too much workload prevents older people from using mHealth services. This was the case for ‘Calories calculator/ Food diary’. These apps require users to enter lots of information every day in order to get an accurate result. One participant noted,

> ‘This will work only if I put accurate data into it. But it’s difficult to count calories of what I eat. It’s impossible for me to do that every meal.’

Similar feelings were experienced when the participant tried ‘my Sugar Diabetes Diary’.

- **Different Lifestyle**

Different lifestyles lead to different needs. Since many older people eat relatively healthy food, showing ‘how much junk food have been burnt’ (Movesum) was not appealing for them.

While online communities were getting popular among older people, joining an online group (Pacer) was not very attractive when they had no idea who were using the same app. Few participants checked this function.

The barcode scanner in ‘Calories calculator/Food diary’ is designed to reduce the user’s workload of inputting information. However, it can only recognize the information on limited packages, for example fast food. This design is not in accordance with the lifestyle of older people who often cook by themselves. One participant said,

> ‘I seldom eat fast food. I always cook at home. To get an accurate number of calories, I need to weigh how much the raw material I used in the meal by myself. The scanner won’t help much.’

Discussion and Conclusions

This paper has uncovered older people’s perception and initial adoption of mHealth services using qualitative data collected from questionnaires, interviews and workshops in East London.

Study 1 found that the lack of obvious advantage, low reliability, scary information and risk of privacy leakage will decrease the ‘perceived usefulness’ of mHealth services; the design of app interface directly affect the ‘perceived ease of use’; ageing factors, especially the ‘generation gap’ make mHealth difficult to use by older users. Study 2 identified the barriers older people have during their initial adoption of mHealth apps (Figure 3). Access to technology, the way of interaction, the risk of money loss, heavy workload to use an mHealth app and the different lifestyle of older people have great influence on older people’s adoption of mHealth services.

Based on the results from the two studies, implications for design are summarised in Table 10. These suggestions can help design practitioners to develop more acceptable mHealth services for a wider

population.

Implications for Design

The implications fall into four categories: i.e., Technical Improvement, Free Trial, Information Clarification, and Participatory Design. Specific suggestions are shown in Table 10.

Table 10. Implications for designing mHealth apps.

Category	Suggestions
Technical Improvement	Reducing the size of the app.
	Improving data security.
	Improving the accuracy of information.
	Providing quick and easy ways of inputting data, especially when similar data are required frequently.
Free Trial	Providing a free and quick trial of the main service instead of asking for personal information before people know the function of the app.
Information Clarification	Clarifying what is 'free' and what is 'paid' service.
	Making 'security' visible. For example, showing who have access to the data, and explaining why the app needs access to users' photos or locations.
	Providing instruction of the next step, especially when processing takes long.
	Avoiding information that scares people.
Participatory Design	Involving older people in the design process when designing apps that are expected to be adopted by them. Treating them as active consumers of technology [11, 49].
	Involving healthcare professionals in the health information design. The information should be easy for older people to understand.
	Taking the traditional or other existing healthcare services into consideration and offering (added) advantages.

Contributions

Compared with prior studies, the value of this paper lies in its three contributions:

Theoretical contribution: This paper systematically analysed several main determinants from theoretical models such as TRA, TAM, TPB, UTAU2, HBM and PMT, and investigated them through primary research. Some factors have been redefined or decomposed according to our research results.

'Perceived usefulness' has been used to predict mHealth adoption [16-18, 20]. In this paper, 'perceived relative advantage' is found to be a better substitute in explaining older people's initial adoption of mHealth services. This is in line with the 'related advantage' in the Diffusion of Innovation Theory [50]. MHealth services should not only be good but also have more 'relative advantage' over the traditional healthcare. Older people's 'perceived usefulness' of mHealth services is associated with lifestyle compatibility and information quality. An mHealth service is perceived to be 'useful' only when it is compatible with older people's lifestyle. This is in accordance with the 'compatibility' factor in the Diffusion of Innovation Theory, which

indicates how consistent the innovation is with the values, experiences, and needs of the potential adopters [50]. Information should not only be 'easy to understand' but also avoid frightening older people.

'Perceived behavioral control' in this paper is investigated through the access to technology and age-related ability decline. 'Access to technology' affects older people's initial adoption of mHealth apps. Many older people do not often upgrade their mobile devices or internet services, their 'out-of-date' facilities constrain them from downloading new applications (see Figure 3). Age-related ability decline influences older people's adoption of mobile apps. This is consistent with findings from previous studies [42, 43]. Our study also suggests that 'Generation Gap' creates understanding barriers (Table 8), which has not been addressed by published studies.

'Ease of use' is thought to be perceived firstly from the interface of an App, such as the text and icons (Study 1). However, heavy workloads for registration and inputting information often put older people off before they get started (Study 2).

'Perceived reliability' is positively correlated with the intention to use mHealth services [19]. However, it seems that 'the accuracy of the information' is less important in the workshop than what people said in the questionnaire and interview sessions. A novel and easy interaction (e.g., using the phone camera to measure blood pressure) can motivate people to get started.

MHealth apps generate new security and privacy concerns [51]. Evidence has shown that 'perceived risk' including performance risk, legal concern, and privacy risk, may significantly decrease older people's intention to use mHealth apps[52]. In our study, the risk of using mHealth apps perceived by the participants came mostly from the privacy leakage (Study 1) and unexpected money loss (Study 2).

Methodological contribution: The hands-on trial (Study 2) illustrates concerns and frustrations when older people 'bodily experienced' mHealth apps, and provides deeper insights into key issues of initial adoption. The entire study is digitized (access to Internet, smart phones, iPads, downloading apps, and initial trial), and goes beyond common technology use among older people in general.

Practical contribution: We not only investigated perceptions and barriers, but also proposed suggestions to design out potential barriers. The design implications and specific suggestions are built upon the findings of our studies (shown in Table 10) to support better design of mHealth services. Our suggestions share some commonality with [53] which proposed to face cultural resistance and concerns, improve engagement of users in design (see 'participatory design' suggestion in Table 10), and build/increase users' trust (see 'free trial' and 'information clarification' in Table 10). Our more detailed suggestions will help designers tackle the barriers more effectively.

Limitations and Future Work

Several limitations should be noted. This research was conducted in East London, and the sampling was not representative to the UK older population or older adults in general.

Participants from different countries, regions could have various perceptions and face different barriers to mHealth services. Besides, gender balance could also have certain impact on the results. We have tried to make the participants gender balanced, but in reality, Study 1 had more male participants (57%) and Study 2 had more female participants (58%). Our participants were relatively well educated, and around 60% were younger 'well-old users' (aged 50-60). This is because of our recruiting methods and criteria. However, they may be 'early-adopters' of mHealth services in the future. The workshop participants have limited experience of using mHealth services, which is common among older population (and given the sampling, the situation of a general older population may be worse). We focused on the initial adoption of mHealth regardless users' prior experience. It is useful to observe five users' withdrawing from the trial because of various barriers encountered during the process. Seven users still give good insights into major usability problems [54, 55], and we have been able to learn from both successful and 'failed' user testing.

In our study, e-health literacy, hedonic motivation (HM), price value (PV) and social influence (SI) were not fully investigated. Future research can address these in greater detail. For future work, more participants with experience of using mHealth apps will be recruited in order to find the motivations in additional to the barriers. Our research was conducted before the COVID-19 pandemic, and health service systems have been largely challenged by the pandemic; significantly more people have experienced remote/online health consultation since 2020, and this might motivate more older people to accept mHealth, if barriers are addressed and trustworthiness is ensured.

Acknowledgements

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References

Abbreviations

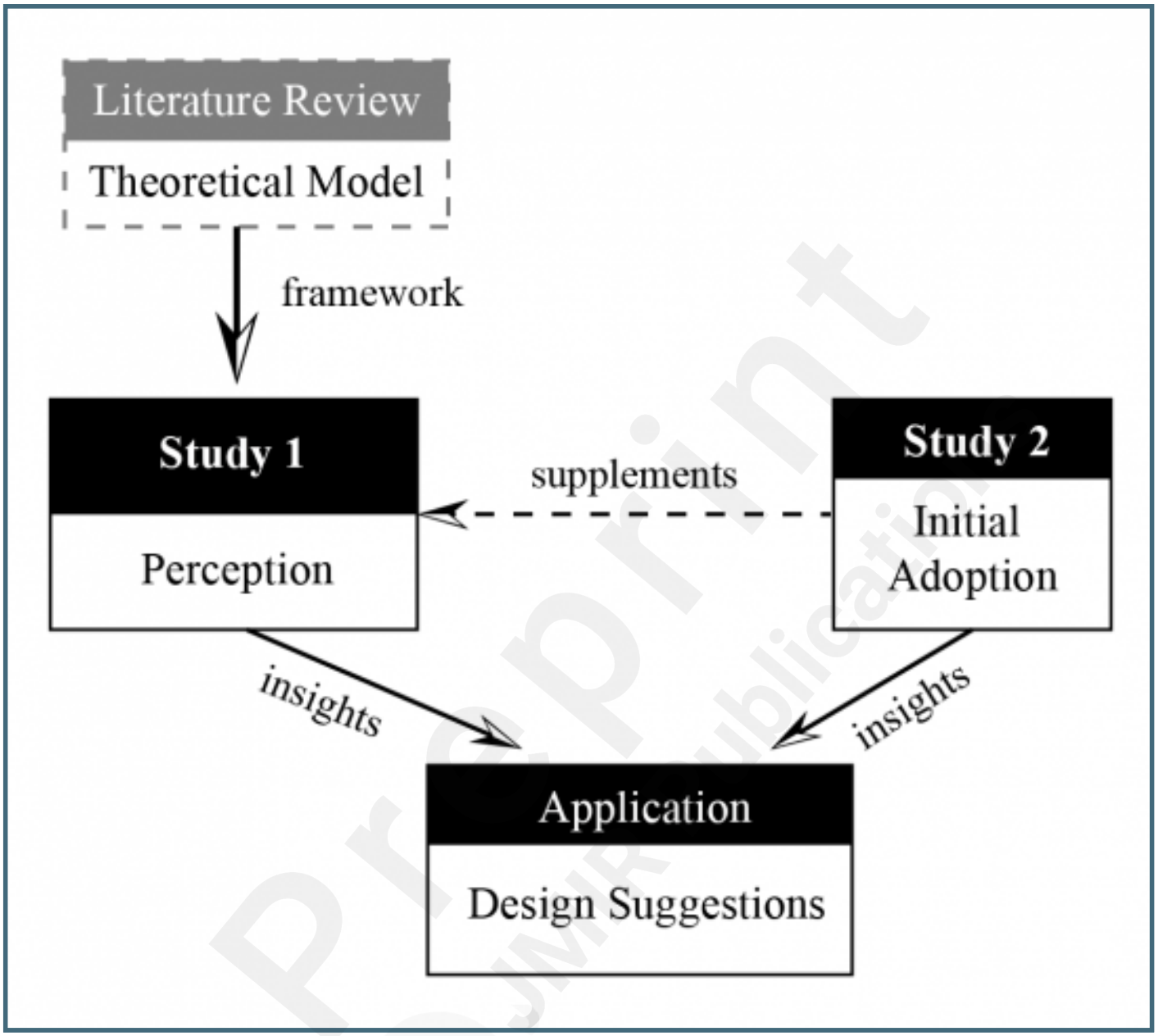
mHealth: Mobile Health
ICT: Information and Communication Technology
TAM: Technology Acceptance Model
UTAUT: United Theory of Acceptance and Usage of Technology
HBM: Health Belief Model
PMT: Protection Motivation Theory
PU: Perceived Usefulness
PEOU: Perceived Ease of Use
PBC: Perceived behavioral Control
SI: Social Influence
HM: Hedonic Motivation

PV: Price Value
HB: Habit and Experience

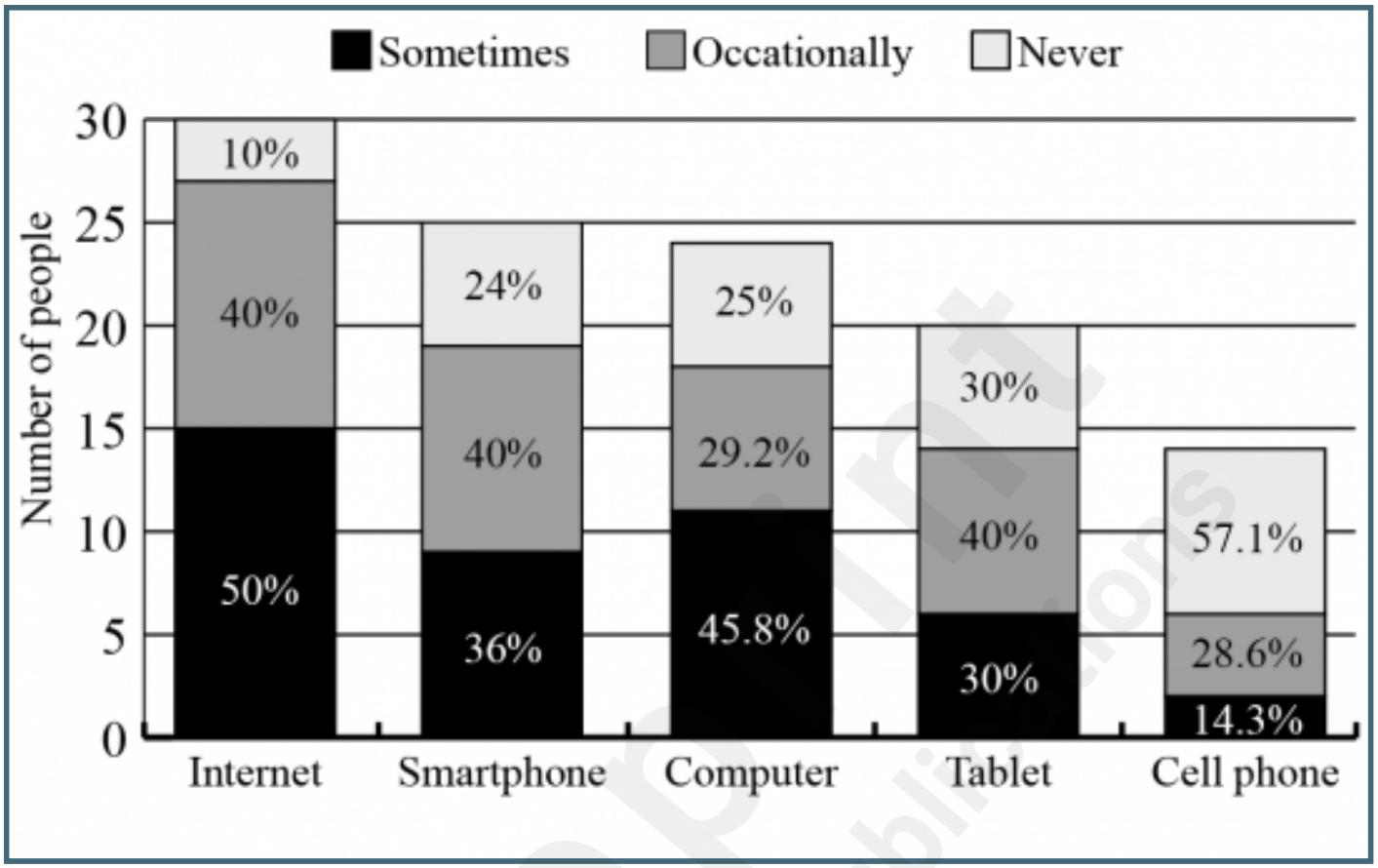
Supplementary Files

Figures

The overview of this research.



How frequently older people use Internet and different devices for health purposes.



Barriers to adopting mHealth apps.