Investigating the use of online symptom checkers in general practice from the perspectives of older adults and general practitioners.

by

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Declaration

I, M I Ullah, hereby declare that no part of whole of the work referred to in this thesis has been submitted to any University of institution of learning other than the University of Sheffield, for the purpose of the awarding of an academic degree or any qualification of that sort.

Acknowledgements and Dedication

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This thesis is dedicated to my loving and supportive family, with special recognition to my incredible wife and our truly special darling boy, H.

Abstract

Background: Online symptom checkers are automated tools that ask users about their health symptoms, providing potential explanations or diagnoses, and, when suitable, directing users to appropriate healthcare providers or offering self-care measures. Despite their convenience, relying on these AI-powered tools in general practice raises concerns about access inequalities and their impact on the doctor-patient relationship. This is particularly pertinent for older adults, who encounter additional obstacles in accessing GP services, are often digitally excluded, and value their doctor-patient relationship.

Methods: The research comprises four studies: a systematic review of user perceptions of online symptom checkers (Study 1); interviews and think-aloud protocols with older adults to learn more about their perceptions and experiences with online symptom checkers in general practice, including the impact on the doctor-patient relationship (Study 2); interviews with GPs to explore their views of the impact of online symptom checkers on older patients, including the impact on the doctor-patient relationship (Study 3); and two collaborative user experience (UX) ideation workshops, with the participation of an IT expert, to validate and prioritise user experience and engagement enhancements proposed by older adults and GPs in previous studies (Study 4).

Results: Study 1 showed a gap between perceived and actual effectiveness of online symptom checkers in primary care, highlighting implementation limitations. Study 2 revealed that older adults who had actual user experiences perceived more disadvantages than advantages in the use of online symptom checkers in general practice, leading to an adverse impact on the doctor-patient relationship. Study 3 revealed that GPs recognised potential benefits of online symptom checkers but expressed concerns about negative impacts on older adults and their access to GP services. Study 4 validated the challenges faced by older adults and suggested design improvements and uptake strategies to enhance their usage in general practice.

Conclusion: This PhD study revealed that while GPs generally embraced online symptom checkers in general practice, older adults formed negative perceptions and expressed concerns about the adverse impact on the doctor-patient relationship after some actual user experiences. Further research is needed to assess the effects on vulnerable patient groups, uncover diverse needs, and investigate the impact on health disparities.

CONTENTS

Abbreviations

SC: Online symptom checker

GP: General practitioner

NHS: National health service

UX: User experience

UI: User interface

GUI: Graphic user interface

HCP: Health care professional/provider

RCT: Randomised controlled trial

UCD: User-centered design

RQ: Research question

TAM: Technology acceptance model

HRA: Health research authority

Dr-Pt: Doctor-patient

BAME: Black, asian and minority ethnic

mHealth: Mobile health

App: Application

List of Figures

List of Tables

Chapter 1 Introduction

This chapter presents a general overview of the research project, including background and rationale, followed by a brief description of the four studies conducted and their interrelation, along with an outline of the overall thesis structure.

1.1 Introduction

According to the Office for National Statistics (ONS), almost a quarter of patients were unable to secure an appointment for a medical consultation with a General Practitioner (GP) in a month in 2022 (1). Meanwhile, the UK National Health Service (NHS) is now facing a surge in patient demand and a resource shortage, exacerbated by the Covid-19 pandemic (2,3). As a result, patients are becoming increasingly frustrated with having to wait an average of over two weeks for a routine GP appointment (4,5). Concurrently, patients are showing a growing willingness to engage with healthcare services as consumers (6), and are willing to adopt patient-centric digital health technologies (7,8). A recent report from the King's Fund (9) highlighted that patients with a consumer-oriented mindset now anticipate healthcare services, including general practice, will be supported by new technologies that enhance access and transform the patient experience in line with the expectations of the modern on-demand economy. The UK government also expresses a strong interest in harnessing and leveraging the potential of new digital health interventions as part of a long-term plan to fully digitise the NHS (10–12). Moreover, the NHS has already initiated a major initiative to incorporate cost-effective, innovative technological solutions that can enhance patient outcomes (13–16).

Online symptom checkers are an emerging health technology that is rapidly gaining popularity (17,18). One of the main goals is to help patients feel more empowered by providing them with an easy way to assess their healthcare needs on their own (19–21). Specifically, these technologies purport to utilise clinically robust algorithms within a conversation-centric interface to guide users to relevant health services based on the level of urgency. Additionally, when appropriate, they offer self-treatment advice and recommendations on what to do if the symptoms do not improve. In the context of primary care, some online symptom checkers also allow users to book or request an appointment with their local surgery or an online GP if the

condition is deemed urgent. Various terms are used in the literature to refer to online symptom checkers, including brand and proprietary names such as Doctorlink (22) and e-Consult (23).

Although technology providers accept that online symptom checkers cannot handle all patient interactions typically encountered in general practice, they strongly argue that these tools have the potential to work alongside healthcare professionals in relieving pressure on the health system. They claim that by promoting greater patient self-care (24–26), online symptom checkers could reduce both patient demand and GP workloads (27,28). It is estimated that minor illnesses account for 57 million GP consultations annually in the UK (29), many of which do not require a physical examination (24). Therefore, online symptom checkers, serving as the initial point of contact for health concerns instead of GPs, have the potential to revolutionise the delivery of general practice (24,25).

There are very few studies examining the potential benefits as well as the risks of deploying online symptom checkers in general practice settings (30–32). The few studies that have been conducted in this area have predominantly focused on economic viability, diagnostic accuracy, and clinical effectiveness of online symptom checkers (33). While these factors are indeed important, few studies have been conducted thus far looking at the psychosocial aspects (e.g., thoughts and feelings of users), user experience, and the potential impact on the doctor-patient relationship from the perspectives of GPs and vulnerable groups such as older adults (34–36).

Although older adults are amongst the most frequent users of general practice services, they are one of the least likely user groups to use and adopt new technologies like online symptom checker applications (25,26), which are often designed for younger individuals (37–39). As such, they risk worsening the widening of the digital divide and the exacerbation of existing health disparities faced by older adults. The digital divide refers to the gap between individuals who have access to and use modern information and communication technologies (ICTs) and those who do not. Health disparities are differences in health outcomes and healthcare access among various populations, including older adults.

The research commenced with a thorough review of the pertinent literature concerning the functionalities of online symptom checkers, their potential use in the context of general practice, and the importance of good user experience to enhance uptake and usage (Chapter 2). Subsequently, four distinct studies were undertaken, as delineated in Figure 1.

Study 1 (**Chapter 3**) involved a systematic review that aimed to synthesise existing evidence on user perception, user experience, and the impact on the doctor-patient relationship resulting from the use of online symptom checkers. To the best of the author's knowledge, this study was the first of its kind to focus on older adults in GP settings who had some lived experience with online symptom checkers, which was one of the inclusion criteria.

Study 2 (**Chapter 5**) consisted of interviews conducted with older adults who had some prior users' experiences of using online symptom checkers in the context of general practice. The objective was to gather their views and experiences, including the impact on their doctor-patient relationships. Additionally, think-aloud exercises were conducted to gain further insights into their user engagement and experience.

Study 3 (**Chapter 6**) involved interviews with GPs who had experience with online symptom checkers. The focus was on exploring their views and experiences about the effects on older adults, the impact on the doctor-patient relationship, and the broader implications for general practice.

Lastly, Study 4 (**Chapter 7**) comprised two ideation user experience (UX) workshops involving older adults, GPs, and an IT expert. The workshops aimed to validate the findings of Studies 2 and 3 related to the direct experience of using the technology, provide additional insights, and prioritise design suggestions and strategies to increase the uptake of and engagement with online symptom checkers among older adults in general practice.

All three qualitative studies employed thematic analysis as the methodology for data analysis. The outcomes derived from the systematic review informed the GP and older adult interviews, which, in turn, informed the collaborative workshops (see Figure 1).

The findings of this research project will be valuable for key stakeholders such as technology providers, policymakers, and health authorities. From a broader perspective, the research provides insights into some of the grand challenges of the field, including concerns about whether these automated digital healthcare solutions help to reduce or exacerbate existing health disparities and digital exclusion faced by older adults. Additionally, it provides insights

into the potential effects of Artificial Intelligence–Empowered mHealth apps on the doctor-patient relationship.

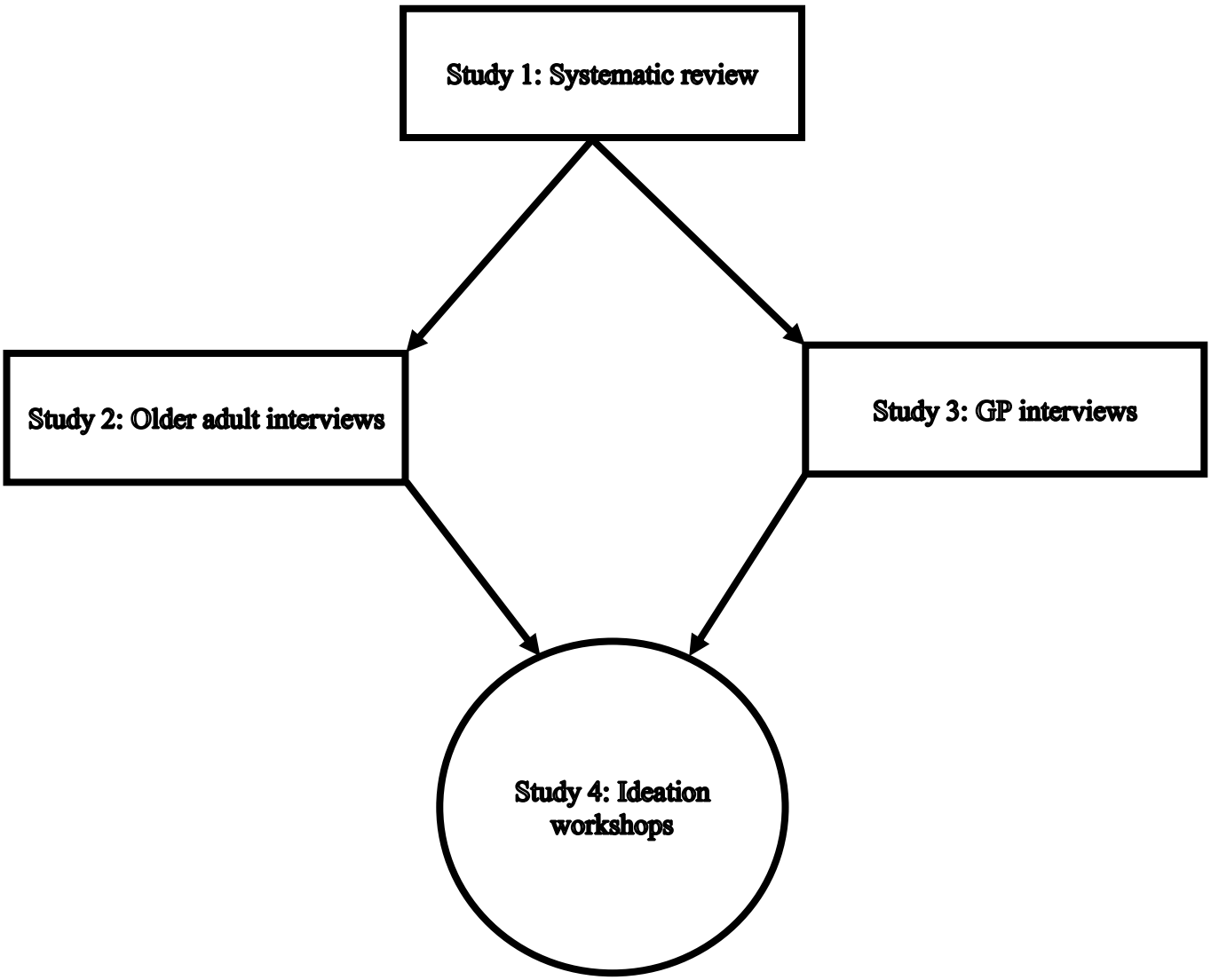

Figure 1: Outline of the project's studies

1.2 Thesis structure

This thesis comprises eight chapters. The first part of the thesis focuses on existing research, including a state-of-the-art literature review, which provides the necessary background material for the studies undertaken, including a systematic review. Each chapter is relatively self-contained and provides a coherent outline of the motivation for the study.

Chapter 2: Background

This chapter provides an overview of the current crisis in general practice, followed by an introduction to online symptom checkers. It includes a review of existing literature on their potential benefits, challenges, usability, acceptance, and impact on the doctor-patient relationship.

Furthermore, the chapter examines computer interface design standards and recommendations specifically for older adults, with a focus on health chatbots, including online symptom checkers. Since research on online symptom checkers' usability is limited, the review also considers generic health chatbots and UX principles. Additionally, it maps literature recommendations to the online symptom checkers identified in the systematic review in chapter 3.

Chapter 3: Systematic review

This chapter presents a systematic review of the existing evidence on user perception, user experience, and the impact on the doctor-patient relationship in relation to the use of online symptom checkers.

Chapter 4: Methodology

This chapter presents the overall approach to the series of studies conducted, as well as the philosophical foundations and the conceptual frameworks.

Chapter 5: A study of older adults' experiences and perspectives

This chapter describes the two-phase qualitative approach that explores the experiences (usability and utility/usefulness) and perspectives of older adults regarding the use of online symptom checkers in general practice, including how it may impact the doctor-patient relationship.

Chapter 6: A study of GPs' perspectives

This chapter describes the qualitative study that investigates GPs' perspectives on the potential impacts of online symptom checkers on older adults, how it may affect the doctor-patient relationship, and general practice operations.

Chapter 7: UX ideation workshops

This chapter describes two UX workshop sessions that explore how to improve the use of online symptom checkers within general practice from the perspectives of GPs, older adults, and domain experts.

Chapter 8: General discussion

This chapter presents the main findings of four studies conducted in this PhD project, along with reflections from both the researcher and existing literature. It discusses strengths, challenges, and limitations, and concludes with overall findings and recommendations for practice, policy, and future research in this area.

Chapter 2 Background

2.1 Introduction

This chapter presents a brief introduction to the crisis faced by general practice, highlighting the importance of exploring and implementing digital health interventions. Specifically, the focus of this chapter is to examine the potential of online symptom checkers as a means to alleviate some of the burden on GP services and enhance the overall patient experience. The chapter will provide an overview of the potential advantages and obstacles associated with online symptom checkers. Additionally, it will conclude with an appraisal of three key topics of interest related to the use of online symptom checkers: user perception, user experience, and the impact on the doctor-patient relationship.

2.2 Search strategy

The search strategy used to identify resources for this chapter was twofold. Initially, an organic search strategy was employed to explore broad terms related to online symptom checkers and general practice, primarily using Google and Google Scholar. Following this, a more structured search strategy was implemented. This involved compiling a list of keywords and synonyms for each concept identified in the initial search and reviewing relevant citations. Boolean operators were then used to perform searches across relevant databases and search engines, ensuring comprehensive coverage of the research area and concepts of interest.

2.3 General Practice Crisis

General practice in the UK is widely acknowledged as both the cornerstone and gatekeeper of the NHS (35). Nonetheless, the current primary care model's GP services have encountered unparalleled strain and are nearing their limits (40,41). The underlying causes of the unfolding GP crisis are multifaceted and encompass factors such as prolonged underfunding (42), a scarcity of GPs resulting from unsustainable workloads (43), and an inadequate healthcare infrastructure to tackle the challenges posed by an aging population (44,45). According to the Institute for Government (46), the demand for GP appointments has been consistently

escalating (47), surpassing the point where it outstrips capacity (48) , while the number of full-time equivalent (FTE) fully qualified GPs has dropped (49). This situation has the potential to compromise the quality of care and patient experience. In emphasising the significance of GP services within the NHS, Roland and Everington (50) assert that ‘if general practice were to fail, the whole NHS fails’ (50).

2.4 Digital Health Service

In recent years, significant changes have occurred in patients' behaviour, expectations, and lifestyle choices, largely influenced by the rapid growth of the on-demand economy, which provides immediate access to goods and services (22). Notably, a considerable increase in the number of adults seeking online health-related information has been observed, with 53% of adults over the age of 16 reported engaging in this behaviour. This represents a significant rise of 30% since 2008, as reported in the latest 2018 census report (51). The widespread availability of Internet access in over 90% of UK households has facilitated this trend (51). These aforementioned factors, combined with financial constraints, have prompted health authorities and policymakers to substantially change their attitudes towards digital health innovations. As a result, substantial investment (52) has been allocated to support the digital transformation of the NHS, with the aim of enhancing productivity and patient care.

GP services, along with the broader NHS, are expected to fully embrace and integrate the latest cutting-edge eHealth technologies (53–56) to alleviate some of the challenges faced in general practice (57). There is a growing emphasis on implementing self-management strategies (58) that empower individuals to take charge of their health. Examples of such interventions include self-monitoring of blood pressure (59,60) and tools for managing type 2 diabetes (61,62). While these single-condition digital health interventions are gaining traction due to their perceived effectiveness among consumers, they are still limited in scope, and in contrast to multiple condition online symptom checkers, usually target a narrow segment of the population with specific medical conditions.

2.5 Introduction to online symptom checkers

A promising emerging technology in the field of healthcare is the utilisation of online symptom checkers to aid patients in self-triage and self-treatment. An online symptom checker is a digital tool, often accessible via a website or smartphone app, designed to help individuals assess their health symptoms and determine the next steps based on the urgency of their medical needs. These online symptom checkers are considered to be a more advanced form of interactive health communication applications (IHCA), representing a natural progression from the practice of seeking healthcare information online (63). The latest generation of online symptom checkers, equipped with intelligent algorithms, offers round-the-clock access to an automated 'GP' for addressing common health concerns (24,64), all without requiring human interaction.

The operational flow of online symptom checkers is relatively straightforward. Once the user enters their medical symptoms and concerns by responding to a series of pertinent questions, either through text or speech, the underlying algorithm of the technology provides recommendations regarding the appropriate next steps based on the severity of the health issue (19). These recommendations can span from self-treatment advice to immediate action such as dialling emergency services (999) in the case of a medical emergency, as depicted in Figure 2.

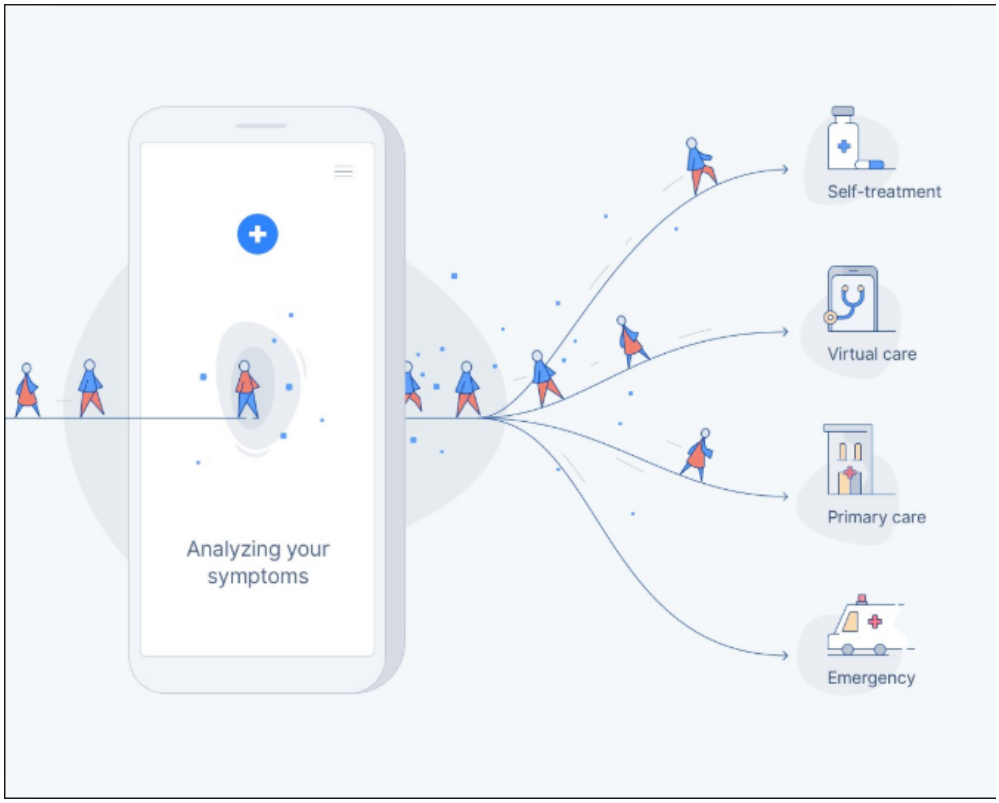

Figure 2: Symptom checker as the first point of contact for patients (62)

The advancement of computational algorithms and hardware technology, such as dynamic memory and faster processors, has notably augmented the capacity of online symptom checkers to assess user symptoms, employing substantially greater memory and computational power. Consequently, this has resulted in expedited and more precise diagnoses.

Online symptom checkers have demonstrated their applicability in various healthcare settings, ranging from student health care settings (27) to primary care (31). These tools can function independently as standalone applications or be integrated with other digital health applications (see section 3.3.4). These additional applications encompass features such as medication reminders (44), online appointment booking, online doctor consultations (65), and non-medical primary care administration support, such as assistance with sick notes through eConsult (26). Furthermore, online symptom checkers offer a wide array of medical and health education resources, covering diverse topics from first aid (65)) to infectious diseases (66). Some of these platforms also include health lifestyle interventions, such as calorie counters (67) and health monitoring applications (35). Accessibility to online symptom checkers is facilitated through

mobile applications (e.g., Self-Care (65)), web browsers (e.g., FamilyDoctor.org (67)) or a combination of both (e.g., GP at Hand (24)) on devices with internet connectivity.

While googling health symptoms on Google, colloquially known as 'Dr. Google' (68), is often regarded as a faster and more customisable tool due to its capability to freely input symptoms into the search engine, online symptom checkers offer the distinct advantage of personalisation, enhancing user-friendliness, and seamless integration within the broader healthcare system. This includes their valuable role within the diagnostic process in primary care (69,70). These platforms have undergone a transformation in user interface design, incorporating interactive chatbot interfaces that enable a conversational experience resembling interactions with real doctors. Users can engage with these interfaces through text or voice input (24,25,71), contributing to an enhanced user experience. Additionally, some online symptom checkers allow users to select a specific area of the body of concern (as illustrated in Figure 3) before proceeding with a series of multiple-choice questions, which helps narrow down the focus and swiftly generate a list of potential differential diagnoses.

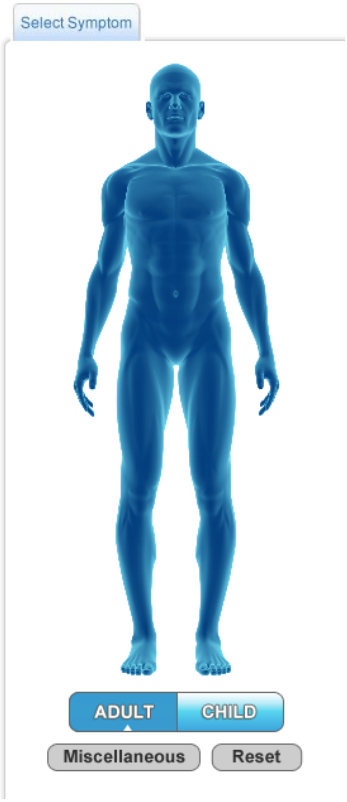

Figure 3: Hancock health symptom checker (72)

2.5.1 Intervention Characteristics

The primary functionalities of the online symptom checker can be categorised as follows:

- Symptom checking: This feature allows users to input their symptoms, and using algorithms and databases of medical information, provides an indication of potential explanations or suggestions for their health condition.
- Triage: The triage functionality assesses the severity of user symptoms, determine the level of urgency, and directs users towards the most suitable health service for their needs. These services may encompass online health platforms like telemedicine providers, as well as an array of offline options from making a trip to the local pharmacies to advising users to visit an emergency department.

- Self-care advice: When appropriate, the online symptom checker offers guidance for self-treatment to the user. This advice is gathered from reputable clinical guidelines, such as those provided by NICE (National Institute for Health and Care Excellence), ensuring the reliability and trustworthiness of the information provided (73).

Some online symptom checkers also incorporate the following additional functionalities:

- Signposting: These platforms provide recommendations for other services within the health network, such as directing users to medical emergency departments or other relevant healthcare resources.

- Communication with Healthcare Providers: These online symptom checkers allow users to consult with medical practitioners either from their own medical practice or by selecting from a private directory of doctors.

It is important to note that the presence and extent of these functionalities may vary among different online symptom checker platforms. However, a cross-sectional investigation carried out by Meyer et al. in 2020 found that patients predominantly employed the online symptom checker for the purpose of comprehending the origins of their symptoms (76.3%, 232 out of 304). Additionally, it was commonly used to aid in the decision of seeking medical care (33.2%, 101 out of 304) and determining the appropriate healthcare setting (e.g., primary, or

urgent care: 20.7%, 63 out of 304). Furthermore, it was employed to obtain medical advice without visiting a doctor (15.8%, 48 out of 304) and gain a better understanding of their diagnoses (12.8%, 39 out of 304).

Communication with HCPs

There are various methods of communicating with healthcare professionals (HCPs) through online symptom checker platforms. Certain online symptom checkers offer the option to communicate with an HCP following the use of the symptom checking feature. For instance, WebMD (67) provides users with an extensive list of outsourced private specialist doctors to choose from, whereas 'GP at Hand' and webGP (26) grant access to in-house HCPs but with a more limited selection. Advanced online symptom checkers like 'GP at Hand' (24) facilitate HCP communication through their dedicated portal. However, most other online symptom checkers are still in the early stages of development and rely on conventional consumer communication methods (e.g., Skype), which pose a higher risk to data security.

2.5.2 Concerns about online symptom checkers

Just as there are risks associated with seeking online health information from unverified websites (74), the use of online symptom checkers also carries certain risks (75). Alongside the privacy risks (20,52), users face the possibility of receiving a false positive diagnosis, leading to unnecessary anxiety, or worse, a false negative diagnosis that can have profound consequences (76).

Introducing online symptom checkers into healthcare settings presents several key challenges, including technology acceptance, safety concerns, diagnostic accuracy, and the impact on other healthcare services, as well as considerations of cost-effectiveness and reliability (77–79). Aboueid et al. (80) conducted a qualitative study where the majority of participants expressed the view that, given the limitations, online symptom checkers were more beneficial for self-triage rather than self-diagnosis. A comparative case simulation study conducted during the Covid-19 pandemic offered criticism of the effectiveness of the NHS Covid online symptom checker, suggesting that it may have failed to identify seriously ill patients, such as those with sepsis, potentially leading to delays in professional assistance (81).

Despite claims by technology providers that online symptom checkers provide reliable health information sourced from trusted databases (53–55), critics argue that these platforms lack transparency and accountability. This deficiency is attributed to hidden assumptions embedded within the algorithms, which are metaphorically confined within a black box (57,59,82,83). Furthermore, the lack of available evidence supporting the algorithms of online symptom checkers can be attributed to restricted access, such as proprietary restrictions, as well as the absence of objective scrutiny (60–62,84,85).

The existing literature on online symptom checkers primarily consists of weak observational studies. Notably, there is a lack of high-quality studies, particularly randomised controlled trials (RCTs) (20). Moreover, the prevailing inconclusive results in studies with weak design and limited scope are particularly evident in the areas of digital inclusion of older adults and the impact on the doctor-patient relationship. This highlights the need for further research to address these gaps (20).

The UK Digital Strategy recognises that not everyone has the skills, confidence, or motivation to use online services (86). The Government Digital Service has identified older people as a section of the population who are more likely to be digitally excluded (86). Despite being key targets for digital health solutions, older adults who have a higher proportion of individuals living with chronic illness, disability, and isolation (87) were largely excluded during the pandemic. Covid lockdowns prevented many from meeting their physical, emotional, and social needs (88). This may increase their segregation from an increasingly digitally driven society and exacerbate the digital divide (89) by creating an additional barrier to access health services. This raises questions about both the advantages and opportunities on the use of online symptom checkers, as well as the effects of potential digital exclusion on access disparity and health inequality among older adults (90,91).

2.5.3 Online symptom checkers to reduce older adults' barriers to GP services

Although medical research often defines a person as an older adult when they are 65 years of age or older (92,93), broader literature defines older adults as being between 50 and 80 years of age or older (94). Taking this into consideration, and to enhance the chances of recruiting older adults as research participants, particularly after Covid-19, this research defines older

adults as being aged 60 or older, in line with both the United Nations (95) and the World Health Organisation (96).

Older adults are experiencing extended lifespans, often accompanied by multiple long-term chronic ailments and intricate care requirements (97). The United Nations (98) and World Health Organisation (99), report that older adults encounter specific disadvantages when it comes to accessing suitable, affordable, and high-quality healthcare. Despite being among the most frequent users of general practice services, older adults encounter notable obstacles when attempting to access GP services.

Dixon-Woods et al. (100) conducted an extensive review commissioned by NHS Service Delivery (101) to examine the barriers faced by older individuals when accessing health services, specifically GP surgeries. The authors identified a multitude of factors that contribute to these barriers, including a lack of social support, challenges in obtaining necessary information, and limited access to transportation (102). As a result, older adults may resort to seeking hospital care for conditions that could have been prevented, thereby exacerbating the issue of chronic bed shortages. The difficulties encountered in accessing timely and appropriate healthcare can have a significant impact on the overall health and well-being of older adults.

Table 1 provides a brief summary of the access barriers faced by older adults when seeking GP services (as identified in study (100)). It also outlines how the use of online symptom checkers can potentially help overcome some barriers for older adults in general practice, taking into account the functionalities and features of these tools.

Common access barriers to health care faced by older people (OP) as identified in (100)	How may online symptom checkers (SC) help?
Mobility problems *(transports are typically costly and unreliable)*	Transport not required; therefore, mobility is not as much of an issue.
Safety concerns at night	Use from the comfort of home, therefore reducing the need to go out at night.

(less likely to use out of hours general practice services)	
Face ageist discriminations (affects confidence and decision to seek help)	SC in theory should be free from ageist stereotypes and discriminatory assumptions.
Poor knowledge of services (find it hard to navigate complex organisational structures)	SC claims to direct users to the appropriate care setting which should in theory make it easier to navigate the system.
Many illnesses of older people are under-detected and under-treated	OP able to check symptoms to improve early detection of health conditions.
Older people sought help for less than a quarter of identified needs	Empower OP to seek help with more identified needs.
Withdrawal from social contact (low expectations of contacting their doctor)	Potential to empower OP and encourage them to contact their doctor or seek opinion with the SC.

Feel they are considered a 'burden' or a 'timewaster'	SC is automated therefore feelings of 'timewasting' will be eliminated.
Age-attribution (sometimes mistakenly attribute symptoms to 'old age')	Helps to identify health issues rather than tolerate or ignore them as problems of old age, which can be addressed in early stages.
Potential cultural and racial discriminations (faced by ethnic minority groups)	SC should in theory not have any cultural or racial discriminations.
Institutional settings vulnerability (e.g. physical dependency)	SC can provide a form of second opinion to compare with staff judgement.

Table 1: Older people's barriers to GP service

Online symptom checkers offer potential solutions to the barriers outlined in Table 1. Due to the ease of access and availability on any internet-connected device, online symptom checkers theoretically do not require extensive social support for usage. Additionally, they could potentially reduce travel expenses and the need for transportation. The overall clinical significance of online symptom checkers in primary care is further explored in the systematic review (see Chapter 3).

The favorable reception of online symptom checkers among older adults holds the potential to significantly enhance accessibility for this demographic. Consequently, it could lead to a

reduction in consultations with general practitioners, resulting in substantial cost savings for NHS.

Integrating health technology into the lives of older individuals remains a significant challenge; however, an expanding body of evidence suggests that digital health interventions can yield benefits for older adults (37). Notably, older adults are more inclined to embrace technology when they perceive its usefulness and potential advantages in meeting their specific needs or aligning with their current lifestyle (103), rather than merely for the sake of novelty. Nevertheless, older adults exhibit reluctance towards adopting technologies when the potential benefits and utility of the technology are unclear or lack significance to them (104–106).

2.5.4 Covid-19

Digitisation of health services was increasing before Covid-19, but the pandemic greatly accelerated this trend due to the need for social distancing (107). For instance, innovative digital health technologies, such as online symptom checkers, were swiftly deployed into the NHS as part of the response to the pandemic. The objective was to minimise in-person healthcare services and safeguard the NHS from being overwhelmed (108). This development has been recognised as a significant advancement in the field, prompting a review of the literature to incorporate the most recent evidence.

An examination of the available literature indicated that the majority of peer-reviewed publications during the global pandemic primarily focused on Covid-specific symptom checkers, rather than the broader category of online symptom checkers that is the subject of this research project. For instance, an online survey conducted by Kujala et al. (109) revealed that while most healthcare professionals supported the use of online symptom checkers and found the services beneficial to patients, they were less confident in the ability and willingness of most patients to utilise these tools. Conversely, some even perceived online symptom checkers as disruptive to clinical work and time-consuming. However, it is important to note that this quantitative study had a small sample size of 61 participants and did not explore the views of healthcare professionals regarding the impact of online symptom checkers on older patients or the doctor-patient relationship.

Furthermore, a recent qualitative study (110) investigated the use of online symptom checkers from the perspectives of young individuals. While online symptom checkers were deemed useful, particularly during pandemics, several areas for improvement were identified, ranging from better explanations of symptoms to the provision of a more personalised user experience.

2.5.5 Older adults' attitudes toward digital technology

Although attitudes of older adults toward technology have been relatively underexplored compared to those of younger adults, researchers have recently become more interested due to the trend of digitalisation and the growing elderly population (111). This interest has further intensified following the Covid-19 pandemic, highlighting the potential role of digital self-care interventions as a facet of public health (112).

The attitudes of older adults toward digital technology can vary widely based on factors such as their past experiences, how useful they find it, how easy it is for them to use, and their personal preferences (113,114). Older adults often have negative views because they find digital technology inconvenient, encounter unhelpful features, and worry about security and reliability (115). These sentiments may be exacerbated if the technology fails to meet age-related needs and personal characteristics, such as limited mobility, dexterity, and declining visual abilities (39), or if individuals lack prior knowledge about digital technology and are afraid of the consequences (116).

Contrary to common perceptions, older adults are not a uniform demographic; they encompass various age categories. Studies indicate that older seniors show less willingness to adopt technology compared to younger older adults (117–119). These differences are often attributed to declining health status and a tendency toward conservatism with age (120–122). Researchers suggest that older adults' attitude towards the use of technology use may be influenced by social and cultural gender norms (123–125).

In addition, older adults with a higher level of education, greater income, and self-confidence typically harbour more positive attitudes toward digital technology (126). However, attitudes can evolve over time through exposure, support, and positive user experiences (127). User

experience is crucial for older adults to uptake and use mHealth applications in their daily routines (128). In the realm of mHealth, chatbot user interfaces are being increasingly used to support self-management (129,130), and the following section reviews health chatbot user experience (UX) guidelines for older adults.

2.6 A review of health chatbots user experience guidelines for older adults

Introduction

This research focuses on chatbot-based symptom checkers, which are the prevailing type of user interface that mimic human-like conversations through text or voice interactions. A review of the existing literature reveals a limited number of studies and guidelines pertaining to the user experience of chatbot-based symptom checkers among older adults. Consequently, it is not surprising that there is currently no internationally recognised set of user experience guidelines and design standards aimed at enhancing and optimising the user experience of chatbot-based symptom checkers for older adults. Nonetheless, a small number of UX recommendations for seniors in the context of health chatbots (e.g., references (131–133)) do exist. Since chatbot-based symptom checkers fall under the health chatbot category, the primary UX considerations regarding health chatbots are relevant to chatbot-based symptom checkers as well. In addition to exploring UX recommendations for older adults in health chatbots, this review investigates if commonly available online symptom checkers have incorporated these key UX considerations.

Older adults' specific needs

When designing innovative healthcare applications, it is widely recommended to incorporate the requirements of the end user, including their needs, capabilities, and expectations, into the product design. This approach ensures the delivery of a better user experience (134–136). Older adults, in particular, present a diverse range of age-related needs such as complex co-morbidities, disability, and frailty. These factors undoubtedly influence their utilisation of interactive technologies, such as health chatbots (131,137). For instance, older adults are more susceptible to presbyopia, a gradual age-related vision loss (138), which may impede their ability to read small and closely spaced text. Furthermore, there exist several other age-related

human factors, such as cognitive impairment and impaired mobility, as well as geriatric syndromes, which significantly impact the end user experience (139,140). Consequently, the limited number of studies conducted in this area (e.g. (131,141,142)) advocate for a human-centred design approach to harness the considerable potential of health chatbots for older adults and their specific needs.

Principles of Universal Design

There is a consensus among experts that incorporating usability, best practice, and accessibility guidelines in an application significantly enhances its senior-friendliness (143–146). An example of such guidelines is the set of 7 principles of universal design (see Table 2), which were developed in 1997 by a working group of design experts from both industry and academia in the United States. Theoretically, these principles should address the majority of design requirements for all user groups, including older adults (147,148). Inclusivity, the concept that a product or service should be accessible and usable by as many individuals as possible without the need for adaptations or specialised design, is deeply ingrained within the framework of universal design (147). The design principles of equitable use (e.g., catering to people with diverse abilities), flexibility in use (e.g., accommodating a wide range of abilities), and low physical effort (e.g., minimising fatigue during usage) serve to reinforce this notion. Nevertheless, some argue that the general UX guidelines should be considered the bare minimum for health applications aiming to be senior-friendly (145). For example, while Apple's Human Interface Guidelines (149) recommend a minimum button size of 9.6mm, it is suggested that the size should be even larger (e.g., exceeding 16mm) when designing for older adults (150).

Universal design principle	**Description**	**Example of symptom checkers from the systematic review**
(1) Equitable Use	The design is useful and appealing to individuals with varying abilities.	NHS111 symptom checker, GP at Hand.

(2) Flexibility in Use	The design caters to a broad spectrum of individual preferences and capabilities.	None
(3) Simple and Intuitive Use	The design's usability is easily comprehensible, regardless of the user's level of experience, knowledge, language proficiency, or current level of concentration.	webGP, SymptomMD, GP at Hand, Everydayhealth.com, FamilyDoctor.
(4) Perceptible Information	The design effectively conveys essential information to the user, irrespective of surrounding conditions or the user's sensory capabilities.	None
(5) Tolerance for Error	The design reduces risks and mitigates the negative outcomes of accidental or unintended actions.	None
(6) Low Physical Effort	The design allows for efficient and comfortable use with minimal fatigue.	None
(7) Size and Space for Approach and Use	Appropriate size and space are available for approach, reach, manipulation, and use, regardless of the user's body size, posture, or mobility.	None

Table 2: Universal design principles (148)

2.6.1 Pragmatic vs Hedonic attributes

Although there is a prevailing preference for pragmatic attributes, researchers such as Folstad et al. (142) argue that blending both pragmatic and hedonic chatbot attributes can enhance the user experience of older adults engaging with health chatbots. Specifically, incorporating empathy (considered as both pragmatic and hedonic) and emotional support (hedonic) as strong attributes can foster a sense of trust among users. This is particularly relevant for older adults who experience reduced social contact and more severe illness (131,151,152). To offer emotional support, a chatbot can be programmed to detect the user's emotional state and understand their intentions, thereby triggering appropriate responses during conversations (131,153).

Although hedonic attributes, such as empathy and emotional engagement, can enhance the user experience of task-oriented chatbots for older adults and foster positive attitudes, it has been argued that pragmatic characteristics, such as usefulness and usability, have a greater impact on their overall positive experience with chatbots (131,154,155). For instance, a study conducted by Folstad et al. (142) revealed a positive association between reporting pragmatic chatbot attributes and older age, while reporting hedonic chatbot attributes showed a negative association with older age.

A key pragmatic UX attribute frequently mentioned in literature is the inclusion of technological help and assistance (131,156,157). This feature can be highly useful for older adults as they are more likely to turn to an application’s help tutorials when they run into problems (156). It is recommended that the tutorial gives step-by-step instructions, and uses clear and educational language without appearing condescending or patronising to older adults (156). Poorly designed features may increase older adults' insecurity and decrease user engagement with the application, particularly if they are not familiar with technology (156,158).

2.6.2 User Engagement

Due to the significant impact that older adults' interactions with health chatbots have on their overall user experience, Neda et al. (131) suggested in their study that all aspects of the interaction should be simplified, ensuring ease of understanding and completion. Furthermore, the visual design employed in these interactions plays a pivotal role and should be tailored to

meet the specific needs of older adults. This entails considering their sensory and cognitive capabilities, such as diminished motor skills and weakened eyesight. Thus, it is imperative to develop a visual design that is uncomplicated and suitable for the target user group, addressing their unique requirements.

There is a strong emphasis on incorporating prominent visual cues in the design of chatbots to enhance user engagement among older adults (151,157). Visual cues play a crucial role in stimulating memory, particularly for older individuals who experience age-related memory decline. However, it is advisable that these visual cues be unambiguous, easily comprehensible, and effortless to interact with (157).

Interactive technologies often employ gestures to facilitate rapid and intuitive task execution on touchscreens. Nevertheless, older individuals, who are relatively new to touchscreen technologies, may encounter challenges in performing certain gestures, especially those affected by age-related health conditions that result in decreased motor function (157). Consequently, it is advisable to incorporate gestures that are relatively straightforward to execute while avoiding complex ones that necessitate swift movements or intricate positioning (156).

Navigation

Navigation, a fundamental process involved in traversing from one point to another, holds significant importance within the realm of user experience (159). The efficacy of navigation exerts a profound influence on other vital aspects, including learnability and accessibility (151,156). Scholars have emphasised that well-designed navigation should not only facilitate seamless and intuitive movement but also ensure that users remain focused on their primary objectives while minimising exposure to secondary functionalities (156). In the context of designing user interfaces tailored for older adults, it is advisable to incorporate navigation techniques that facilitate progressive learning of new functions, commonly referred to as onboarding (160). This approach serves to alleviate older adults' apprehension and enhances the overall usability of the interface. Furthermore, it is recommended to maintain a simplified navigational structure with fewer hierarchical levels, ensuring that essential navigation buttons, such as 'home' and 'return,' are readily accessible. These design considerations are particularly relevant when catering to the needs of an aging population (79,151,156).

Conversation Length

When designing conversational chatbots for older adults, it is advisable to prioritise short and concise user-chatbot interactions. Prolonged and intricate exchanges tend to frustrate users and diminish their interest (151). The responses provided by chatbots should be well-organised, easily comprehensible, and avoid overwhelming users with excessive information (151,161).

While the length of conversations on symptom checker chatbots are not often explicitly stated, existing literature indicates that such conversations are often prolonged and burdensome. This is primarily attributed to the utilisation of chatbot decision trees aimed at eliminating numerous potential diagnoses (151).

Personalisation

Chatbots are well-suited for personalisation and can be effectively adjusted to cater to the unique requirements of older adults, such as providing emotional support. Specifically in the domain of health, chatbots can be personalised to enhance older adults' familiarity with the conversational user interface, thereby improving their overall user experience (162). However, despite the significant potential benefits, the practical implementation of personalised chatbots has been lacking across all age groups.

Effort expectancy

Effort expectancy, as defined by Venkatesh et al. (2003), pertains to the level of ease associated with the utilisation of a technological system. Put simply, it refers to the extent to which a user perceives the technology as requiring minimal effort. In a study conducted by Neda et al. (131) that examined factors influencing the acceptance of health chatbots among older adults, it was revealed that seniors value the ability to utilise chatbots with minimal effort. To optimise user experience and alleviate the required effort, it is advisable to design health chatbots with simplicity in mind, ensuring that the dialogue and answer formats are easily comprehensible.

Efficiency and effectiveness

In the context of task-oriented chatbot applications like symptom checkers, it is crucial to prioritise the resolution of users' issues and facilitate the accomplishment of their objectives in

a manner that is both effective and efficient (131,163). This consideration holds particular significance for older adults, as they tend to place a higher emphasis on the efficiency and effectiveness of chatbots compared to younger users, who may exhibit a greater receptiveness towards more light-hearted and playful chatbot interactions (131,151). Furthermore, in addition to fulfilling their intended purposes, health chatbots must accurately comprehend users' intentions and deliver appropriate responses that are deemed valuable by their users (131,137,151).

2.7 Significance of research

Despite the increasing prevalence of online symptom checkers and the growing usage of these tools in general practice, there are very few studies exploring the potential benefits as well as the risks of deploying online symptom checkers in general practice settings from the perspectives of older adults and GPs (30–32). Previously, there was little to no evidence regarding the examination of user perception, user experience, and the potential impact on the doctor-patient relationship (34–36). As outlined above, older adults are among the most frequent users of general practice services, yet they are among the least likely user groups to adopt new technologies such as online symptom checker applications (25,26). Consequently, they are at risk of exacerbating the digital divide and widening existing health disparities among older adults. This research aims to address this lack of evidence.

2.7.1 User Perceptions

In the context of this study, user perception pertains to the participants' subjective understanding, assessment, and interpretation of the utilisation of online symptom checkers for self-triage purposes within primary care. It should be noted that user perception and user perspectives are frequently employed interchangeably in the existing scholarly literature.

A recent extensive systematic review focused on the application of online symptom checkers. This review highlighted the need and value of qualitative research to investigate perceptions of symptom checkers and the barriers to their use by people who are less familiar with digital technology, addressing a significant knowledge gap (20).

Therefore, it is crucial to gain a deeper understanding of user perceptions regarding the complexities, challenges, and advantages associated with the use of online symptom checkers within healthcare systems, from the user's perspective. The absence of qualitative investigations exploring user perspectives has been extensively discussed in the literature concerning similar health technologies (164–166).

Adopting a broader outlook, user perceptions can serve as indicators of acceptance and facilitate a better understanding of the practicality of integrating online symptom checkers into conventional healthcare settings (164,167–169). Nevertheless, there is a relative dearth of research on the utilisation and acceptance (or non-acceptance) of technology among older individuals, and insufficient attention is generally given to age-specific or age-related factors (140,170) in the study of consumer health technologies. Consequently, the existing literature provides limited insight into the acceptance of technology among older adults (171).

2.7.2 UX: usability, usefulness, and user satisfaction

It is widely advised that the design of innovative healthcare applications incorporates knowledge of the end user, their needs, capabilities, and expectations to enhance the overall user experience (4–6). However, the existing literature indicates a scarcity of high-quality research on the actual usage, experience, and evaluation of online symptom checkers by consumers. A recent scoping review in this domain identified the user experience of online symptom checkers as an area that remains largely unexplored. In light of this finding, the review emphasised the need for more research to understand the user experience (83).

Although a universal definition of user experience does not exist, the International Organisation for Standardisation (ISO) provides a definition: "User experience refers to a person's perception and responses resulting from the use or anticipated use of a product, system, or service" (93,126). The concept of UX is characterised as dynamic, context-dependent, and subjective, encompassing a wide range of potential benefits that users can derive from a product (ISO, 127). Essentially, UX serves as an overarching term encompassing all factors that influence an end-user's interaction with a particular product, including their emotions, perceptions, and preferences. In the context of this study, user experience specifically pertains to participants' experiences with the components of online symptom checkers. More specifically, this study

will explore participants' perceptions of usability and usefulness, which are considered core components of user experience, in addition to user satisfaction.

The effective design of user experience and products plays a critical role in the success or failure of any product, particularly in the case of emerging technologies like online symptom checkers. However, numerous studies (e.g. (79,115,140)), have indicated that older adults are often overlooked by developers and frequently encounter design discrimination, which hampers their overall user experience. Consequently, this oversight diminishes the likelihood of older adults adopting and accepting these technologies. Instead of empowering patients, this situation has the potential to exacerbate existing health inequalities (170).

2.7.3 Impact on doctor-patient relationship from older adults' perspective

The doctor-patient relationship has long been an essential component of the treatment process and holds particular significance for older adults (32,174–176). The conceptual framework of the doctor-patient relationship encompasses four key elements: mutual knowledge, trust, loyalty, and regard. These elements are highly valued by older adults and have a significant impact on their satisfaction with general practice (177).

There are concerns that the adoption of an algorithmic approach to medical diagnosis may have a negative effect on the traditional doctor-patient relationship by restricting doctor-patient communication and in-person visits. Literature has cautioned against the danger of replacing human doctors, as empathy and compassion are unique human attributes that are crucial to patient care and treatment (32,174,175). However, counterarguments suggest that online symptom checkers serve as tools for users and do not replace healthcare professionals. Furthermore, there is a possibility that the use of online symptom checkers may even enhance the doctor-patient relationship. For instance, Ly et al. (178) demonstrated the effectiveness of a fully automated conversational agent in promoting mental well-being and reported that some participants developed a distinct 'digital relationship' with the chatbot.

2.7.4 Healthcare professionals' perceptions

While early indications suggest that Health Care Professionals (HCPs), including doctors, are generally enthusiastic about adopting new digital technologies to support their role (78), there

remains a significant level of scepticism among some HCPs regarding the actual advantages of online symptom checkers (179) and their role in the established diagnostic process. Furthermore, a recent cross-sectional study conducted by Palanica et al. (180) through a web-based survey revealed that more than three-quarters of participating physicians believed that online symptom checkers cannot comprehensively address their patients' needs. It is widely acknowledged that these applications cannot fully interpret human emotions or take into account specific personal factors associated with patients, thus limiting their ability to provide accurate diagnoses. Moreover, the majority of physicians (74%, 74/100) expressed concern that patients may be at risk if they excessively rely on self-diagnosis through healthcare chatbots. Nonetheless, most physicians recognised the potential of chatbots to offer non-medical administrative benefits, such as facilitating doctor appointments (78%, 78/100) and providing medication information (71%, 71/100).

According to a study conducted by Kujala et al. (155), health care professionals reported a beneficial influence of symptom checkers on their work. The perceived usability of these tools was positively correlated with professionals' support for their usage. However, the study also found that the perceived threat to professionals' autonomy was negatively associated with their support for symptom checkers.

2.8 Research Aims and Objectives

The central aim of this research is to explore and understand the experiences and perspectives of older adults and GPs regarding the use of online symptom checkers in general practice, including its potential impact on the doctor-patient relationship.

Within this broad aim, the research has several specific objectives:

- To investigate the experiences and perceptions of older adults regarding the use of online symptom checkers in the general practice setting, including perceived advantages and disadvantages.
- To gain insights into the impact of online symptom checkers on the doctor-patient relationship in general practice, as perceived by both older adults and GPs.
- To investigate the perspectives of GPs on the use of online symptom checkers by older adults.

- To examine how older adults and GPs perceive the broader impacts of using online symptom checkers in general practice.
- To explore ways in which the use of online symptom checkers can be improved in general practice, taking into account the perspectives of older adults, GPs, and IT experts.

Research Questions

The research questions **(RQ)** to be answered are:

(RQ1) - What is the evidence in the academic literature regarding user perception and experience of online symptom checkers, and their impact on the doctor-patient relationship?

(RQ2) - What are the experiences and perspectives of older adults regarding the use of online symptom checkers in general practice, including how it may impact the doctor-patient relationship?

(RQ3) - What are the perspectives of GPs regarding the use of online symptom checkers with older patients and how does their use affect the doctor-patient relationship?

(RQ4) - How can the use of online symptom checkers in general practice be improved for older adults, considering the perspectives of both older adults and GPs?

Chapter 3 Online Symptom Checkers: A Systematic Review of User Perception, Experience, and Impact on the Doctor-Patient Relationship

3.1 Introduction

This chapter presents a systematic review that synthesises the existing scientific evidence regarding user perception, experience, and the impact on the doctor-patient relationship concerning the use of online symptom checkers. The review also investigates the implementation of online symptom checkers within primary care settings. The results of this review influence the subsequent studies presented in the thesis.

The majority of studies in this field have thus far primarily concentrated on the economic viability, diagnostic accuracy, and clinical effectiveness of online symptom checkers (33). Although these outcome measures hold significant importance, the findings of the previous chapters have highlighted a scarcity of research on psychosocial factors such as user perceptions and experience that could affect the uptake of, and engagement with, online symptom checkers

The user experience and perception of online symptom checkers play crucial roles in the exploration and comprehension of whether end-users would be willing to embrace the use of such applications in conventional healthcare settings (115,181). Specifically, the perceived usefulness and perceived ease-of-use are significant determinants when it comes to predicting technology acceptance behaviour and the actual utilisation of technology, as emphasised in the original Technology Acceptance Model (TAM) (182) and its numerous extensions (37). Alongside numerous other intricate factors, non-user-centered designs contribute to the lack of use, which, in turn, can lead to escalating disparities in healthcare, particularly among vulnerable groups (100,183).

The user perception and user experience of symptom checkers can potentially influence the doctor-patient relationship (184), which has historically played a crucial role in the treatment process and has had an impact on patient outcomes (22,92,93). Online symptom checkers

possess the capacity to enhance the doctor-patient relationship by enhancing the patient experience: by providing a seamless service experience that enables immediate health management, as well as an alternative means of communication with a doctor (184). Nevertheless, they also possess the potential to negatively affect the doctor-patient relationship by reducing the frequency of doctor-patient interactions and visits to healthcare facilities, thereby potentially disrupting the traditional continuity of care and patient experience (22).

This systematic review aims to consolidate the available evidence pertaining to user perception, user experience, and the impact on the doctor-patient relationship. To the best of our knowledge, despite the potential of online symptom checkers in primary care settings, no previous synthesis encompassing these specific outcomes of interest has been conducted.

The identification of knowledge gaps within this review will not only facilitate the formulation of well-grounded research questions but also provide a point of reference for selecting appropriate research methodologies in subsequent studies within this thesis.

While there may be nuanced theoretical differences between user perception and user attitude, this review uses these terms interchangeably. Due to word count limitations, supplementary components of the systematic review are provided in Appendix 1-3.

3.2 Methods

This review adhered to the guidelines outlined in the PRISMA statement, which serves as a standardised framework for reporting systematic reviews (185). The study selection procedure has been represented in Figure 4. Due to the scarcity of research available at the time of conducting this systematic review, particularly with older adults, the decision was made to intentionally lower the age of the research participants to 16 years old. This was done to increase the likelihood of including some eligible studies concerning the topics of interest rather than risking potentially getting none.

3.2.1 Eligibility Criteria

The inclusion criteria of the retrieved studies for this review were dependent on PICOS (186) as described below:

Population

The population consisted of individuals aged 16 years and over who were entitled to consent to their own treatment. There were no restrictions based on participants' gender, computer skills, or socio-demographic characteristics.

Intervention

The intervention involved online symptom checkers (app or API web page) that were compatible with various technological devices (e.g., smartphones, tablets, computers) and operating systems (e.g., Windows, macOS). Online symptom checkers could be deployed in, but not limited to, a primary care setting and accessed either as a standalone online service or as part of a larger digital health platform. consulted a healthcare professional, such as a GP.

Online symptom checkers specialising in secondary care, such as oncology, were excluded because they are not designed to handle multiple health conditions, nor do they serve as initial contact points or guide users to appropriate healthcare providers. Secondary care focuses on specific health conditions and typically involves patients who have already consulted a healthcare professional, such as a GP.

Comparator

The review included non-comparator studies alongside those comparing face-to-face general practice consultations, video telemedicine consultations, or telephone assessments.

Outcomes

The primary outcomes of interest included user perception, user experience, and the impact of symptom checkers on the doctor-patient relationship.

3.2.2 Study Designs

The study designs included in this review were not restricted, encompassing quantitative, qualitative, and mixed-method studies. Additionally, relevant non-peer reviewed publications, commonly referred to as grey literature, such as service evaluations, were considered for inclusion, provided that the reviewer determined the source of opinion held some credibility within the field, adhering to the Joanna Briggs Institute (JBI) checklists (187).

Data Sources and Search Methods

The following electronic databases were searched: Ovid EMBASE, Ovid MEDLINE, Ovid PsycINFO, Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Central Register of Controlled Trials (CENTRAL), Web of Science (Science Citation Index and Social Science Citation Index), Google Scholar, Applied Social Sciences Index Abstracts (ASSIA) and Institute of Electrical and Electronics Engineers (IEEE).

The electronic databases were chosen to ensure comprehensive and relevant coverage of the available literature on the topics of interest. For example, MEDLINE and Embase were chosen because they cover a wide range of health and clinical literature. As the research is interdisciplinary, established and reputable databases such as ASSIA and IEEE were selected to ensure the review spans multiple disciplines. The time limit was set to the last 10 years, which was specified using the search tool; when this feature was not available, papers were manually selected from the last 10 years.

Preliminary scoping searches indicated that there is currently no established consensus on the search terms for symptom checkers within a specific domain or under the medical subject headings (MeSH) system. Certain terms such as "etriage" and "symptom checking" appeared unrelated upon first inspection but they actually referred to similar types of self-diagnosis platforms. To capture diverse search terms related to this rapidly evolving digital technology, Google Analytics (188), which tracks website and app traffic, was employed using click data to determine popularity. To mitigate search engine bias (189), PubReMiner (190), a

conventional tool, was used for word frequency analysis in PubMed publications' titles and abstracts.

The different combinations of search terms for online symptom checkers (see Appendix 1 for the MEDLINE search strategy) are as follows:

((symptom checker) OR (online diagnosis) OR (self triage) OR (web based triage) OR (electronic triage) OR (etriage))

AND

((primary care) OR (primary healthcare) OR (gp) OR (general practice) OR (general practitioner) OR (family doctor))

Furthermore, to ensure a comprehensive overview of the topic, the search strategy encompassed terms with a high degree of specificity, as well as incorporating brand and proprietary names. This approach enabled a thorough and in-depth exploration of the subject matter.

The different brand and proprietary names of online symptom checkers that emerged from the preliminary scoping searches are as follows:

(Askmd) OR (DocResponse) OR (EarlyDoc) OR (Econsult) OR (Esagil) OR (FreeMD) OR ("gp at hand") OR (healthdirect) OR (Healthline) OR (iTriage) OR (MEDoctor) OR (NHS Symptom Checkers) OR (Steps2Care) OR (Symcat) OR (Symptify) OR (Symptomate) OR (webgp) OR (WebMD)

The generated search terms were subsequently compared to those employed in a recent publication of a comprehensive systematic review on the subject (20). To enhance the precision and effectiveness of the search terms, the aid of an information specialist was enlisted. Additionally, the search strategy included English-language publications from 2008 to January 4, 2019, ten years prior to the start of this part-time PhD project and before the development of advanced online symptom checkers. This was then reviewed several times in subsequent years for new publications, with the last review date being June 2024. Furthermore, both the reference lists of the review papers and the eligible studies were meticulously examined by hand to identify any further pertinent references.

3.2.3 Exclusion Criteria

The following types of studies were excluded from the review:

- They did not explore at least one of the key outcomes of interest relevant to this review.
- Primary care referral to community pharmacy, dental, and optometry were excluded.
- They described technological development of symptom checkers (such as AI algorithms or chatbot interface design) without reference to this review's outcomes of interest or application in primary care context.
- They examined online symptom checkers without algorithmic decision-making, developed for non-humans or only designed for a specific condition (rather than multiple conditions).
- They were conducted in low- or middle-income countries (LMIC). Primary care settings in lower-income countries will be less comparable to those in higher-income countries, such as the UK.
- They were reviews of the literature including systematic reviews, conference abstracts, personal blogs, newspaper articles, or full text unavailable.
- They were published in languages other than English.

Study Selection

The PRIMSA flow diagram (Figure 4) illustrates the process of study selection employed in this review. Initially, the main reviewer (MU) screened titles and subsequently abstracts against the predefined inclusion criteria. To ensure reliability, a second independent reviewer (AD) performed an independent screening of a randomly selected 10% sample of the search results, using Microsoft Excel's random function RAND() (191). Full-text reviews were carried out by the main reviewer, who documented the reasons for exclusions. Inter-coder agreement was assessed using Cohen's kappa, and any disagreements regarding inclusions and exclusions were resolved through discussion or by involving a third independent reviewer (MH). Eligible studies were stored in a reference management system, specifically Mendeley (192), with shared access granted to the review team.

3.2.4 Data Extraction and Quality Assessment

The primary data from the relevant studies were extracted and organised in Table 4-Table 6 utilising the following categories: outcomes of interest, comparator, population/sample, main

findings, and study limitations. To ensure comprehensive coverage, the studies were divided into subgroups based on primary care and non-primary care, as well as peer-reviewed and non-peer-reviewed sources.

To evaluate the quality of peer-reviewed publications, including observational cohort and cross-sectional studies, a rigorous assessment of bias was conducted using the National Heart Lung and Blood Institute tool (193). Additionally, the trustworthiness and relevance of qualitative studies, as well as textual and opinion-based sources, were evaluated using the critical appraisal tools provided by the Joanna Briggs Institute (187,194).

To enhance the accuracy and consistency of data extraction and quality assessment, a second reviewer independently examined a 10% sample. Any discrepancies or differences in data extraction or quality assessment were resolved through discussions involving a third reviewer, until a consensus was reached.

3.2.5 Data Synthesis and Analysis

The included studies varied widely in their design, sample sizes and outcomes. As a result, data were not combined, and meta-analyses was not considered to be appropriate for this review. Instead, narrative synthesis was performed structured around the key outcomes of interest. The salient characteristics of the included studies such as comparator, main findings and population are summarised and presented in a tabular format classified around context of application.

3.3 Results

3.3.1 Summary of Search Results

Ten electronic databases were systematically searched in February 2019, yielding a total of 3990 records. After removing duplicates, a total of 3023 titles remained for the eligibility screening process, based on the predefined inclusion criteria.

Cohen kappa for agreement between the 2 reviewers was 0.80. The 2 reviewers (MU and AD) then assessed the remaining 208 abstracts; Cohen kappa for agreement between them in that step was 0.90. From this initial pool, 76 studies were identified as potentially relevant and

progressed to full-text article screening. The full publications of these 76 studies were obtained and examined. Cohen kappa for agreement between the 2 reviewers was 1.

Out of the 76 full-text studies, 42 were excluded as it did not evaluate at least one of the outcomes relevant to this review. Additionally, 7 references were excluded because they were in the form of letters or editorials, 6 references were excluded as they were abstracts, protocols and commentaries, 3 references lacked full texts, and 2 references described only technological development. Consequently, a total of 16 studies were deemed eligible for inclusion in this review.

PRISMA 2009 Flow Diagram

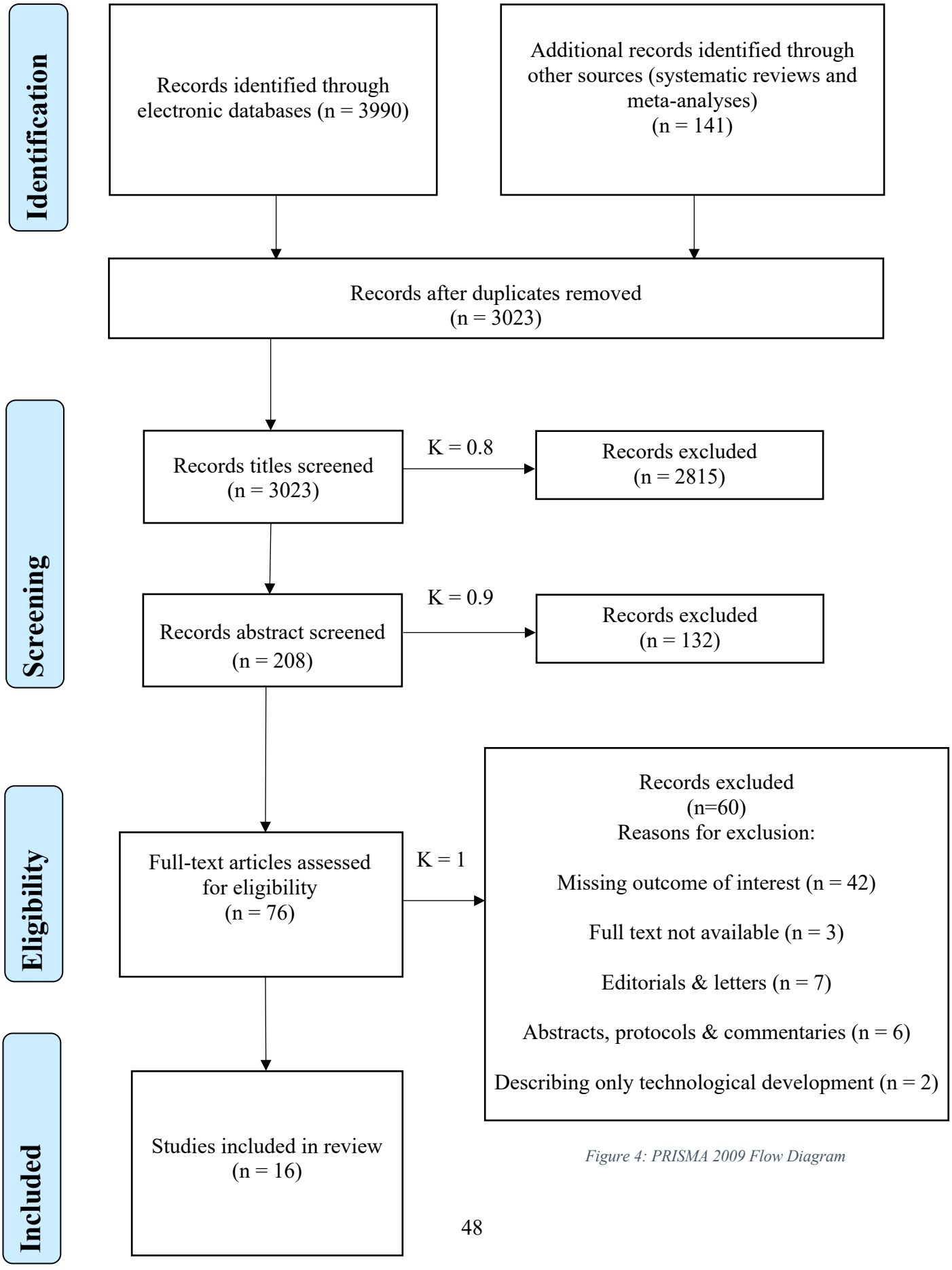

Figure 4: PRISMA 2009 Flow Diagram

3.3.2 Study Characteristics

There were 16 studies included in this review. Most studies (9/16, 56%) were conducted in European countries including the UK (n=5), Netherlands (n=3), and Norway (n=1). The remaining studies were conducted in the USA (n=4), Australia (n=2) and New Zealand (n=1). The majority of the included studies were either observational studies, qualitative studies, or texts and opinions. However, none were randomised controlled trials (RCTs). Two grey literature were included because they were perceived to have some standing in the field of expertise (e.g. NHS England (195)) and included outcome of interests relevant to this review.

In the majority of included studies user experience was explored (12/16, 75%) (26,31,47,65,66,77–79,174,195–197) followed by user attitude (9/16, 56.3%) (26,35,66,77–79,174,195,197) and then doctor-patient relationship (4/16, 25%) (32,174–176). 7 studies (26,77–79,174,195,196) reported on both user experience and user attitude which is not surprising given that these variables are interrelated (198); and 1 study (174) reported on all three outcomes of interest. These review studies were conducted using multiple study methods including quantitative (8/16, 50%), mixed methods (4/16, 25%), qualitative (2/16, 13%) and others which were difficult to categorise (2/16, 13%).

Questionnaires were developed using a wide range of behavioural theories such as: Theory of Planned Behaviour and the Protection Motivation Theory (196); TAM and Cognitive Psychology (66); as well as incorporation of General Practice Patient Survey (78). The other studies did not report the theoretical underpinnings of their questionnaires. The study duration ranged from 4 weeks (78) to 15 months (196). The variety of research methods employed by eligible studies, along with the number of participants, is outlined in Table 3.

Research Design Technique	Participants
Survey	6178 participants but the response rate range from to 6.5% (31) to 53% (66).
Think aloud method	94 participants (79)
Semi structured interviews	54 participants (31,78).
Focus groups	4 participants in study (31).

Table 3: Research design techniques

Studies in Primary Care Context

There were 9 (60%) eligible studies conducted in a primary care context (30–32,35,77,196,197,199), the remaining 7 (40%) studies either did not specify a particular context or were conducted in a urgent care context. In the primary care context, seven studies included user experience as an outcome of interest (26,30,31,77,197,199), 7 included user attitude (26,30,31,35,77,196,199) and 4 studies included both user experience and user attitude as outcomes of interest (26,30,77,199). However, only 1 study explored the potential impact of symptom checkers on the doctor patient relationship (32) in the primary care environment. Studies were mainly narrative inquiry (26,32,35,77,195) and non-randomised observational cross-sectional (30,31,196).

3.3.3 Participant Details

The included studies reported a range of 10 to 4456 participants, with a total of 6355 participants. Of these 6355 participants, only 79 GPs and 36 other healthcare professionals (HCPs) and practice admin staff participated, and the number of total participants significantly reduces to 230 if survey and questionnaires are omitted. This is also mirrored by the fact that 8 (50%) eligible studies had sample size less than 100. The mean age of participants ranged from 26.7 ($\sigma = 4.39$) in study (47) to 63.97 years ($\sigma = 7.68$) in study (79). Although the majority of study participants were over 18 years old, 1 study (79) only included participants over the age of 50 to explore older adults' perspective of symptom checkers. There were more female participants in 4 out of 5 (80%) studies which reported participants gender compositions (35,47,66,77,195). In addition, female participation ranged from 48% in study (35) to 77.78% in study (66) whereas male participants ranged from 22.22% in study (66) to 52% in study (35). The majority of participants were highly educated with at least an undergraduate degree in the two studies which reported participants educational background (79,197). Participants' level of IT competency (e.g. previous experience of using internet) was highlighted as an inclusion criteria in 2 studies (47,79). Only 1 study (79) recorded the ethnicity of non-HCP participants which was 98% Caucasians, and 1 study (35) recorded ethnicity of doctors which was predominately (81%) British ethnicity. Online (66,77,197) and GP surgeries (31,78) were the most popular source of participant recruitment. Only 2 studies (78,79) explicitly mentioned that participants with severe cognitive impairment were excluded.

3.3.4 Intervention Characteristics

In the 16 studies deemed eligible for analysis, the focus was on investigating 10 distinct symptom checkers. Among these, webGP (26,31,78) and webMD (47,65,79) were utilised in 6 of the qualifying studies. The primary objective across all interventions was generally consistent: to provide users with a convenient and expeditious self-diagnosis and self-triage service that assists in determining the necessity of seeking medical attention for a health concern. The intervention procedures employed in these studies were also largely similar in nature. Users were required to respond to a series of multiple-choice and yes/no questions, occasionally supplemented by an intensity rating scale (e.g., pain). Subsequently, intelligent computer algorithms were employed by the application to assess the user's responses and generate a list of potential diagnoses, accompanied by an indication of urgency and recommended course of action, including self-treatment guidance. These symptom checkers were accessible via any computer device equipped with an internet connection.

In all of the conducted studies, the symptom checkers were consistently integrated into a comprehensive package of personalised health applications (see Figure 5), and none of them were offered as standalone applications. The bundled interventions predominantly encompassed various features closely aligned with the broader functions of primary care. These features included medication reminders (47,65,79), the ability to schedule teleconsultations or physical appointments with physicians (26,31,35,47,65,78,79), and non-medical assistance related to primary care administration (e.g., requesting sick notes, utilising eConsult services) (26). Furthermore, these bundled applications offered an array of medical and health education resources, covering diverse health topics ranging from basic first aid (65) to specialised knowledge on infectious diseases (66). Additionally, certain health-oriented lifestyle applications were incorporated, such as calorie counters (47) and health monitoring apps (35) which enabled users to monitor their overall well-being. The symptom checkers themselves were employed for both minor ailments, such as headaches, coughs, and fevers (66,196), as well as for complex health conditions such as rare skin disorders (77). Importantly, all of these applications were made available in the open market, targeting the general population.

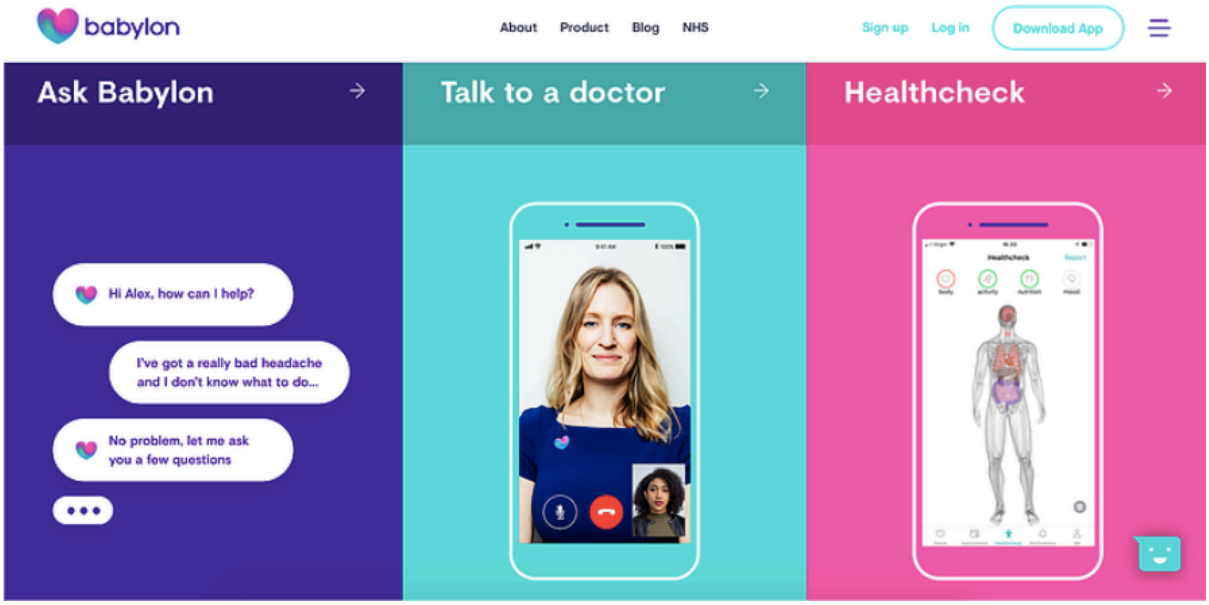

Figure 5: Symptom checker supplemented with other allied digital health interventions

Data Input Method

All the online symptom checkers analysed in this review used multiple-choice questions as the primary method of data entry by design. Notably, four out of ten (40%) symptom checkers, namely SymptomMD, GP at Hand, Everydayhealth.com, and 'Shall I see a doctor,' offered users the option to select a specific body area, facilitating a more targeted assessment of the user's concern.

Intervention functionalities

The 16 studies examined 10 symptom checkers with varying functionalities (see Table 7). All 10 symptom checkers not only provided a list of potential conditions but also offered self-care advice for low-risk symptoms that could be safely managed at home. Six out of the 10 symptom checkers (webGP, Steps2Care, Self-Care, GP at Hand, 'Shall I see a doctor', EverydayHealth) included a triage service to determine the level of urgency and guided users to the most appropriate health service, ranging from online options like video consultations to offline alternatives such as local pharmacies or emergency departments.

Five of the 10 symptom checkers (webGP, webMD, Steps2Care, SymptomMD, GP at Hand) featured some form of communication option with a healthcare professional following the symptom check. For example, WebMD provided an open directory of outsourced private

specialist doctors for users to select from, while GP at Hand and webGP connected users with in-house healthcare professionals, albeit with limited choices. Advanced symptom checkers like GP at Hand facilitated communication through their own secure portal, whereas most others were still in early stages of development and relied on conventional consumer communication methods (e.g., Skype), posing increased risks to data security.

Certain symptom checkers, such as webGP, required user pre-registration before granting access to the symptom checking feature. However, most symptom checkers allowed immediate use of the application (e.g., webMD, GP at Hand, FamilyDoctor, etc.) without registration, only requiring minimal user profile information to expedite the diagnosis process and facilitate quick decision-making. The exception was Everydayhealth.com (47), which requested the user's geographical area before proceeding with the questionnaire. Some symptom checkers inquired whether the help was for the user or someone else, and a few (e.g., Steps2Care and SymptomMD) allowed adults to check symptoms for children. However, the procedure for webGP (77) slightly differed, as it required users to complete a brief online form for review by a general practitioner.

More details about the online symptom checkers that were either the subject of study or discussed in the eligible studies can be found in Table 7. As of June 2024, a significant number of online symptom checkers (e.g., Symptom MD and Babylon's 'GP at Hand') have become defunct for various reasons. Although a web-based version of WebMD has been developed in addition to the app version, DokterDokter and 'Shall I See a Doctor' are still web-based and available only in Dutch. A small number of new online symptom checkers, such as Ada Health and Symptomate, can be found in app stores and online.

Primary Care Context Peer Reviewed

Publication Authors	Outcomes of interest	Comparator	Population / Sample	Main Findings	Study Limitations
Carter et al. 2018	User attitude and experience	Face to face consultation	General Population: Six general practices in Devon. Sample Size: Questionnaires filled by 20 GPs and 81 Patients. Interviews: 5 GP and 5 Admin Staff.	86% of users reported satisfaction with their utilisation of webGP, though there were concerns among staff regarding the potential for misuse, such as manipulating the system to secure appointments.	The study was limited to a small subset of practices within a single Clinical Commissioning Group (CCG). It did not incorporate patient interviews or focus groups to delve deeper into the patient's viewpoint.
Cowie 2018	User attitude	Face to face consultation	General Population: registered with GP practices Focus group / Interviews: * 48 Practice Staff	The study found high patient satisfaction (91.4%) and willingness to recommend eConsult (91.5%), citing its flexibility and compatibility with lifestyles. However, concerns were raised regarding optimal usage timing. GPs were confident in patient safety but had reservations about integrating eConsult into existing practice procedures.	The study's brief duration limited evaluation of eConsult's long-term viability. Time constraints led to the use of third-party survey questions instead of direct patient interviews. Some data details were unavailable for analysis.
Nijland et al. 2010	User attitude	Face to face consultation	General Population Sample size: 3,812 completed triage process out of 13,133 unique visitors who had started it and 6538 completed online consultation. 35 reported on actual compliance out of 192 patients who had completed a follow-up survey on compliance.	The intention to comply was closely correlated with one's attitude toward the advice provided. A disparity exists between patients' expectations and intention to use. Attitude to the advice was influenced by the perceived effectiveness of the advice ($r=0.71$, $p < 0.01$) and trust in web-based triage ($r=0.52$, $p<0.001$).	The description of methods and timeframes was lacking in detail. In online surveys, incomplete responses were a noticeable weakness.

Nijland et al. 2009	User experience	None	General Population: Access to Internet but no experience of e-consultation. Sample Size: 1066 participants eligible out of 1706.	Reasons for utilising the service included its flexibility, which enabled contact with a GP at any time, and its facilitation of follow-up questions post-consultation. Reasons for not using the service included lack of awareness of its existence, preference for in-person consultations with a doctor, or the absence of e-consultation services at their GP surgery.	The study neglects the viewpoints of individuals without internet access, potentially leading to a limited understanding of self-care and online consultations. Furthermore, it only offers general descriptions of the design and implementation of e-consultation services.
Sola 2018	User attitude	None	GPs from authors' network. Sample size: 110 GPs were emailed with the survey, 26 participated (23.6% response rate).	Approximately half to two-thirds of the participants viewed AI as a potential advantage, although there was significant variability in their opinions. Those who felt more confident in their abilities tended to perceive AI more positively or negatively depending on their perspective.	Small-size sample with reduced demography.
Verzantvoort et al. 2018	User attitude and experience	Nurse triage	General Population Sample Size: Questionnaire: n = 4456 Phone Triage: n = 126	The app was well-received by most users, with the majority finding it clear and satisfying. About two-thirds of users planned to follow the app's advice. Additionally, some users provided feedback for enhancements, including suggestions to improve symptom entry functionality.	The study examined users' intentions rather than behaviour, noted potential biases in participant selection, and lacked reported phone triages for detailed analysis.
Karchers et al. 2018	Doctor-patient relationship	Primary care physicians	General Population	AI symptom checkers in primary care can disrupt doctor-patient relationships by standardising interactions, lacking empathy, and hindering personalised care and effective communication.	Using a non-specific app or website for qualitative study, referencing outdated conceptual frameworks and theoretical critiques lacks solid evidence or justification.

Table 4: Primary care context peer-reviewed

Primary Care Non-Peer Reviewed

Publication Authors	Outcomes of interest	Comparator	Population / Sample	Main Findings	Study Limitations
Madan et al. 2014	User attitude and user experience	None	General Population Sample Size: * Participants/data size: 133,000 patients of 20 London GP practices via practice websites.	Patients mostly rated their website experience positively, with 3% indicating they wouldn't have sought medical services otherwise. GPs felt confident in e-Consult.	The unclear advantages of e-Consult for GP surgeries impede their efforts to encourage patient participation.
NHS England 2017	User attitude and user experience	None	General Population	User feedback for the system is positive, and triage drop-off rates seem lower compared to the previous symptom checker, possibly due to increased internet use and demographic variations.	Pilot durations were brief, and user groups were small. Comparing pilot sites was challenging due to differing demographics in each area.

Table 5: Primary care non-peer reviewed

Non-PC Context Studies Peer Reviewed

Publication Authors (make it alphabetical)	Outcomes of interest	Comparator	Population / Sample	Main Findings	Study Limitations
Morreale et al. 2018	User experience	None	General Population	The majority of users find it convenient to utilise a symptom checker on their mobile devices. They react positively to the ease of identifying tasks within the application.	Only 13 respondents completed the questionnaire, which lacked clarity and specific goals, such as creating a simple interface.
Jutel et al. 2015	Doctor-patient relationship	None	NA	The diagnosis may cause disagreements between patients and doctors, altering the balance of power in their relationship.	Content analysis lacked a standardised framework, covering a broad range of diagnostic apps. Focusing on a specialised group could have provided more detailed insights.
Luger et al. 2014	User experience	Other: think-aloud contents of participants who were accurate in their diagnosis with those who were not.	Older adults aged over 50 years or older.	Participants faced navigation challenges, requiring enhanced navigation aids in web design, potentially leading to inaccurate diagnoses when encountering difficulties with internet tools.	The study involved mostly wealthy, educated white seniors. To ensure broader relevance, diverse socioeconomic and geographic factors should be included. Participants lacking home computer and internet access were excluded.
Lupton et al. 2015	Doctor-patient relationship	None	General Population	The use and impact of apps on diagnoses during doctor-patient encounters, alongside the balance between patient empowerment and medical authority, raise questions about how clinicians respond to self-diagnoses.	There's a lack of genuine understanding from actual users regarding their motivations and preferences for using these applications.

Marco-Ruiz et al. 2017	User attitude and experience	None.	Population/condition • General population (Internet tool users) Sample size • 53 completed the evaluation: 15 completed the Think-aloud phase.	Users found the system useful and understood information correctly. However, guided navigation needs improvement, with unnecessary medical jargon in interfaces. Users prefer shorter questions, but interpreting time patterns causes confusion.	Study population not clearly defined; no sample justification provided; unclear if subjects were selected/recruited from same/similar populations.
Robertson et al. 2014	User attitude, experience and doctor-patient relationship.	None	N/A	Few studies explore how consumers use online self-diagnosis and its impact on their broader healthcare engagement with professionals.	Literature review method lacked clarity and system. IT resource affordability not addressed. Other key stakeholders like health professionals, regulators omitted.
Li 2017	User experience	None		70% preferred the FamilyDoctor.org symptom checker, but all favoured Google for self-diagnosis due to its familiarity and speed.	The web-based symptom checkers were chosen without clear criteria, and the sample consisted mainly of young, educated females from Binghamton University, lacking diversity.

Table 6: Non-PC context studies peer-reviewed

Intervention Functionalities

Study	Symptom Checker (Multiple Conditions)	Country	App	Web-based	Functionalities			
					Automated Symptom Checking	Triage with sign posting	Self-treatment advice	Communication with HCP
(26,31,78)	webGP, later known as eConsult.	UK	✓	×	✓	✓	✓	✓
(47,65,79)	webMD	USA	✓	×	✓	×	✓	×
(65)	Steps2Care	USA	✓	×	✓	✓	✓	✓
(65)	Self-Care 2018 (Symptom MD)	USA	✓	×	✓	✓	✓	✓
(196)	DokterDokter.nl (gezondheidsplein.nl)	Netherlands	×	✓	✓	×	✓	×
(35)	GP at Hand (Babylon)	UK	✓	✓	✓	✓	✓	✓
(77)	'Shall I see a doctor'? Moet ik naar de dokter	Netherlands	×	✓	✓	✓	✓	×
(66)	Erdusyk	Norway	×	✓	✓	×	✓	×
(47)	Everydayhealth.com	USA	×	✓	✓	✓	✓	×
(47)	FamilyDoctor.org	USA	×	✓	✓	×	✓	×

Table 7: Intervention functionalities

3.3.5 Quality Appraisal

Quality assessment was undertaken for peer-reviewed publications as well as text and opinion papers. Assessment of the overall strength of evidence for each outcome of interest, including those in the context of primary care, is part of the narrative synthesis.

Of 16 studies, 10 were identified as observational cohort, and cross-sectional studies (31,35,47,65,66,77–79,196,197). The application of the NIH Quality Assessment Tool to these studies (193) (see Appendix 3) showed varied results, with the majority being rated as fair (7/10, 70%) followed by poor (2/10, 20%). It is worth noting that only 1 observational study was rated as good quality (79). All 6 observational studies conducted in a primary care setting were rated as fair, but in non-primary care settings, the quality of studies varied in ratings from poor (2/4, 50%) to good (1/4, 25%). In all 10 studies, clear research question and objectives were stated.

There were wide range of deficiencies in the study designs. For example, in study (66), the population was not clearly specified, and it was unclear if subjects were selected or recruited from the same or similar populations. Additionally, the participation rate of eligible persons was less than 50%. Studies (35,65) had small-sample sizes and selection bias with asymmetric distribution of sex and education. Other studies had limitations of short study duration (e.g. 4 weeks in study (78)) and recruitment limited to predominately highly educated Caucasians (e.g. study (79)) as opposed to different socioeconomic and geographic locations which would enhance generalisation scope. Only 2 studies (66,196) were deemed to give sufficient time to reasonably expect adequate observation and conjecture an association between exposure and related outcome. None of the studies assessed exposure more than once over time, nor were the outcome assessors blinded to the exposure status of participants. Furthermore, only 2 out of 10 studies (31,197) measured confounding variables and made statistical adjustments to take consideration of their impact.

There was clear agreement (congruity) between research methodology and research objectives in the 2 qualitative studies (175,176) which were assessed using the JBI Critical Appraisal Checklist for Qualitative Research (187) (see Appendix 3). However, in both of the qualitative studies, where the researcher plays a substantial role, there was no statement clarifying the

researcher's cultural and theoretical orientation, and in one study, it was unclear if the researcher's influence on the research, and vice-versa, was addressed (175). In addition to making reference to the extant literature, any incongruences with the literature were logically defended in the 2 studies (32,174) that were assessed using the JBI Checklist for Text and Opinion Papers (187).

3.3.6 User attitude and compliance

Although there were 9 studies (9/16, 56%) which reported outcomes related to user attitude, the term user attitude was not clearly defined in the eligible studies. This makes comparisons difficult as the term can have multiple meanings as well as carry different meanings in different contexts. It is also important to note that these 9 studies, varying significantly in design and quality, reported limited results on user attitude per se. Instead the limited reporting was more about the influence of user attitude on other variables such as intention to comply (66,77,196), uptake (30,31,196,199) and self-efficacy (35). Nevertheless, user attitude was reported to be generally positive with a high level of user satisfaction within the limited number of studies (77,196). Study (65) reported that the majority of users felt comfortable with a symptom checker on their phone.

Three studies reported a positive relationship between user attitudes to advice, intention to comply and actual compliance (66,77,196). Two studies (77,196) reported the majority of respondents intended to follow the symptom checkers' advice (e.g. 65% in study (77) in non-emergency outcomes. The perceived usefulness, which affects user attitudes towards symptom checkers and treatment compliance, was reported to be high among all users in the study (66).

User attitude captured in the studies were mainly of young adults and not representative of the general population. Only 1 study (79) out of 9 focused on older adults (aged 50+) and found that while they tried using symptom checkers, they still relied on their past medical knowledge and illness history for diagnosis. Six out of 9 studies (77%) reporting user attitude were conducted in primary care settings and explored user attitude of patients and clinicians, and 3 out of 9 studies (22%) were conducted in non-primary care settings but focused on consumer perspectives and perceptions of general users.

Clinicians' attitude

Five studies (5/9, 55%) included clinicians' attitudes as part of their brief appraisal of user attitude (26,30,31,35,77). The majority of clinicians respondents considered symptom checkers as an opportunity rather than a threat (26,31,35,78). For example, one study (31) reported that 78% of GPs wanted their GP practice to adopt the system, and 100% of the clinicians in the study were confident in using eConsult. However, these findings are contradicted by the findings of another study (78) which reported that UK GPs seemed reluctant to implement alternative approaches compared to their counterparts in the Netherlands, who generally had a positive attitude towards eHealth and alternative approaches. According to study (35), GPs must trust symptom checkers and feel capable of using it positively for patient care. To achieve this, proactive engagement with clinicians as well as a major change of professional behaviour were required to develop a positive attitude.

While the overall attitude of clinicians was generally positive, the findings should be interpreted with some caution due to the fact that 5 out of 9 studies (55%) were rated poor (30,66) or fair quality (35,77,197). Only 1 study (44) was assessed as being of good quality (see Appendix 3), and only 1 study (199) met all of JBI's critical appraisal criteria for text and opinion papers (187).

3.3.7 User Experience

The majority of eligible studies (12/16, 75%) in this review reported user experience as an outcome of interest. Six out of 12 studies (50%) (26,31,65,77,78,195) reported that the majority of participants were satisfied with symptom checkers and reported a positive user experience. For example, 86% respondents were satisfied with their overall experience of using webGP (78) and 83% of patients were extremely likely to recommend the service to others (26). However, participants in study (47) still preferred Google search for self-diagnosis over symptom checkers, citing Google's familiarity as the main factor towards users' preference. User experience data related to the NHS111 symptom checker was not included because it was not used in a general practice context.

Notably, the user experience studies in this review were predominantly quantitative. However, studies (78,174) highlighted the need and scope for in-depth exploration using qualitative research methods to achieve an in-depth understanding of user experiences and preferences.
Four studies (26,31,65,66) reported the importance of user-friendly design to successfully help users navigate through symptom checkers and increase uptake. Five out of 10 symptom checkers (50%) were identified as having good user interface design (webGP, SymptomMD, GP at Hand, Everydayhealth.com, FamilyDoctor) characterised by minimalist, intuitive and mobile friendly interfaces with basic colour schemes, appropriate font sizes, and short questions in plain language. However, the user interface design of other symptom checkers were compromised by a combination of factors, such as unfriendly colour schemes and low-quality visuals (e.g. Steps2Care), text-based interfaces (e.g. Eduysyk), an overload of information (e.g. webMD), limited and unclear instructions (e.g. Dokter Dokter), lengthy questions (e.g. Shall I see a doctor?), too much marketing clutter and third party commercials (e.g. webMD and Dokter Dokter). Only webMD allowed limited customisation and saving of functionality of user's conditions and drugs etc.

One study (66) reported detection of common HCI barriers which included poor navigation, unnecessary medical jargon on GUI and a lack of concise medical information. However, study (65) advocated for interface design using HCI principles (e.g. Simplicity, Consistency and Feedback) after conducting evaluation of symptom checkers using the System Usability Scale (SUS) and the Usability Metric for User Experience LITE (UMUX-LITE).

User experience was generally positive in both primary care settings (26,30,31,77,196,197,199) and non-primary care settings (44,47,65,66,174). The difference is that eligible studies in primary care settings captured patient's user experience and mainly focused on overall user experience and user satisfaction, whereas non-primary care setting studies captured consumer's specific user experiences and usability such as HCI barriers and navigational issues (65,66).

Nine out of 12 user experience studies (75%) were for observational cohort and cross-sectional studies (30,31,44,47,65,66,77,196,197). Of the 9 studies, 6 were rated as fair quality (30,31,47,77,196,197), 2 as poor (65,66) and only 1 as good (44). One study was appraised using the JBI checklist for text and opinion papers (174) and 2 reports were not assessed as they were reports produced by the NHS (199) and industry (26). Out of the 10-quality appraised

user experience studies, 6 studies (60%)) were rated as fair indicating that the majority of the user experience studies were susceptible to some bias.

Generally, the user experience of symptom checkers was reported positive irrespective of study quality ratings or settings. However, the only 1 good rated study (44) which focused on older adults reported participants had navigation difficulties as well as difficulty with the Internet tools.

3.3.8 Doctor-Patient Relationship

Only 3 eligible studies (32,175,176) explored the potential impact of symptom checkers on the doctor-patient relationship. Study (176) argued that the effect of self-diagnosis apps on doctor-patient encounters was still largely unknown. However, using critique of technology (200), study (32) argued that the use of symptom checkers can distort the doctor-patient relationship by limiting doctor-patient communication which is vital to determine how to proceed together with treatment and delivery of high-quality health care. Study (32) also argued that judgement, intuition, compassion, physical examination and familiarity with patients' history were all unique human attributes, playing a crucial part in medical diagnosis and treatment. This contrasts with automation and the database approach of symptom checkers which are lacking important human qualities such as empathy and feelings. For example, study (176) proposed that symptom checkers' algorithmic approach delimits the way symptoms are interpreted and treated, whereas human doctors can adapt to individual patient's needs, pick up subtle social and psychological cues or see the patient's health and well-being holistically as reported in study (32), which is an essential component of a holistic health service. Study (176) reported that the use of symptom checkers before diagnosis may cause disagreements between patients and doctors, potentially challenging the authority of the doctor and detrimentally affecting the doctor-patient relationship.

Out of the 3 studies reporting doctor-patient relationship, only 1 study (32) analysed the impact of symptom checkers on the doctor-patient relationship in the primary care environment. Nevertheless, there was a consensus with all studies (irrespective of context) that symptom checkers may potentially have a negative impact on the doctor-patient relationship.

All 3 studies reporting doctor-patient relationship satisfied all of the JBI checklists for inclusion: 1 study (32) were appraised using the JBI checklist for text and opinion papers, and 2 studies (175,176) was appraised using the JBI checklist for qualitative research.

3.4 Discussion

The aim of this systematic review was to synthesise evidence about user perception, experience and the impact on the doctor-patient relationship.

3.4.1 Summary of eligible studies

Overall user perception, user experience and impact on doctor-patient relationship was under-explored and it appears the emerging phenomenon of utilising symptom checkers to facilitate self-diagnosis is still a relatively nascent phenomenon.

Although the studies included in this review encompassed a wide range of research methods and designs, a substantial majority of them were identified as observational studies with inherent methodological limitations. Additionally, the predominant approaches employed in these studies were either mixed methods or quantitative, leading to the prevalence of surveys as the primary data collection instrument, as opposed to semi-structured in-depth interviews (see Table 4-Table 6).

Most of the studies included in this review were conducted in the years 2018 and 2017, which highlights the recent surge in interest and research activities in this particular field. Furthermore, these studies were carried out across various countries (see Table 7 for more details), necessitating the consideration of disparities in healthcare systems among different nations. Moreover, since studies beyond primary care were included, the use of symptom checkers has been observed in various healthcare settings, including emergency departments. Although contextual variations complicate the process of comparison, it can be argued that they could also enhance the generalisability of the findings. Consequently, it is advised to interpret the outcomes of this review with a certain degree of caution.

Outcomes of interest

User perception

The perception and attitude of users have a significant impact on the effectiveness, acceptance, and sustained usage of digital health interventions. While there is a scarcity of research specifically focusing on user attitudes as a standalone outcome, available evidence indicates a positive correlation between user attitude and self-efficacy, as well as between the intention to comply and the actual compliance with self-diagnosis advice. Notably, a study (196) revealed that unfavourable user perception is likely to decrease adherence to self-diagnosis advice, thereby potentially diminishing the effectiveness of symptom checkers in reducing patient demands within the healthcare system.

Although the user attitude was generally reported as positive, caution must be exercised due to the predominantly fair or poor-quality ratings of the eligible studies. Nevertheless, the overall positive user attitude reported in this review aligns with findings from other studies in the literature that have examined similar digital health technologies (164,201). For instance, Nadarzynski et al. (202) investigated attitudinal variables, such as acceptability and perceived utility, and found that most internet users would be open to using health chatbots. However, the same study also identified specific user concerns (e.g., AI hesitancy, cyber-security, lack of empathy) that could potentially impact users' willingness to engage with AI-led health chatbots. It is worth noting that these aspects were not extensively explored in the included studies of this review.

In this review, it was found that clinicians, in general, exhibited a positive attitude towards symptom checkers. However, a study conducted by Palancia et al. (180) revealed that while clinicians acknowledged the potential usefulness of chatbots in providing health information and scheduling appointments, more than 70% of them expressed concerns that this technology might not be capable of addressing all the patients' needs. Furthermore, there was apprehension regarding the possibility of inaccurate diagnoses, which could pose a risk to patients.

The findings of this review indicated that users perceived chatbots as a convenient tool for facilitating online self-diagnosis, particularly for minor health concerns that do not necessitate

a physical examination. These findings were consistent with other studies on similar chatbot technologies (164,201,203) reported in the literature.

By considering user perceptions, it is possible to predict the acceptability of symptom checkers and gain insights into their feasibility within healthcare systems (164,167–169). Therefore, a deeper understanding of user perspectives, including the complexities and challenges associated with the use of symptom checkers within healthcare systems, is warranted. It is worth noting that the lack of qualitative studies exploring user perspectives, as reported in this review, has been extensively discussed in the literature concerning other comparable health technologies (164–166).

User experience

Overall, the available research on consumers' use, experience, and evaluation of online self-diagnosis lacks high-quality evidence. Although user feedback has generally been positive, indicating a high level of satisfaction, the studies included in the review did not specifically investigate ease of use as a component of the overall user experience or conduct usability testing. Existing literature on similar interactive technologies has consistently shown low ease of use (164,204,205).

No evidence was found regarding the development of tailored interface designs for patient groups with diverse needs. However, the adoption of generic designs resulted in navigation difficulties for older adults (79), while the utilisation of complex medical jargon (66) confused certain patient groups. These factors not only increased the likelihood of inaccurate diagnoses but also hindered the overall user experience and acceptability of the application. These findings align with previous studies examining interactive health tech apps, which have shown that negative user experiences tend to generate hesitancy among users and ultimately lead to low adoption rates of the intervention (206–208).

The importance of incorporating user-friendly design and interface in digital healthcare interventions has been underscored by 6 out of 16 studies, aiming to enhance the likelihood of user acceptance. However, there is limited evidence to indicate that developers have embraced patient-centric design approaches or that researchers have employed qualitative methodologies

to identify potential barriers to a positive user experience. The literature has consistently emphasised the significance of user-centred approaches in improving user experience and consequently optimising the adoption of digital healthcare interventions within healthcare settings (209,210). Moreover, the broader literature addressing similar health technology applications frequently advocates for the inclusion of explorative qualitative methodologies in user research to gain a comprehensive understanding of user engagement (211–213). The user experience studies reviewed herein failed to identify specific issues unique to automated health applications, such as the perceived lack of empathy and human presence, which could potentially impact the overall user experience for certain individuals (164,214,215).

Doctor-patient relationship

All four descriptive studies (32,174–176) have raised concerns regarding the use of algorithmic methods in medical diagnosis. This approach possesses the capacity to not only undermine the medical authority of doctors by assuming a position of authority itself but also has the potential to disrupt the conventional doctor-patient relationship by restricting communication and reducing the frequency of in-person consultations. Additionally, the majority of the studies emphasise the significance of empathy and compassion as distinct human qualities that are vital to patient care and treatment, cautioning against the replacement of human doctors.

The findings of this review are consistent with previous studies that have examined user interaction with chatbot technologies. These studies have consistently reported that responses provided by chatbots are perceived as impersonal and lacking in empathy (164,201,214,216). Additionally, Nadarzynski et al. (202) discovered that although most participants were open to using chatbots for minor health concerns and recognised the potential for anonymity, they still regarded chatbot usage as inferior to consulting with a doctor. Concerns were also expressed by participants regarding the potential negative impact of health chatbots on the overall quality of healthcare, particularly if they were to replace healthcare professionals. However, Ly et al. (178) demonstrated the efficacy of a fully automated conversational agent in promoting mental well-being and noted that some participants developed a distinct 'digital relationship' with the chatbot. These findings underscore the need to investigate the effects of health chatbots, such as symptom checkers, on the doctor-patient relationship.

3.4.2 Limitations of this review

There are limitations that need to be considered when interpreting the results of this review. Firstly, the search terms were broad with extensive inclusion criteria. A more in-depth analysis would have been obtained if it was focused on fewer outcome of interests. The first two outcomes of interest were closely linked; however, the impact on the Doctor-Patient relationship outcome could be deemed as distantly related.

For observational studies, an established critical appraisal checklist was used to assess risk of bias. However, eligible studies were heterogenous and difficult to categorise, therefore it was not feasible to conduct a meta-analysis. Although grey literature was commissioned by organisations with a standing in the field of expertise, they were still classified as low-quality studies. This review made use of studies limited to the English language and developed countries. However, search results revealed some relevant studies conducted in India and other countries, which indicates a wider body of evidence and valuable insights might have been missed. The second independent reviewer looked through only 10% sample of research results from title to full paper. Although there is no fixed rule, 10% is typically considered on the lower side. Increasing this percentage would further reduce the risk of bias and enhance the reliability, rigour, and validity of the review process (217,218).

Overall Strength of Evidence

This review possesses certain limitations that warrant careful consideration when interpreting its findings. Firstly, due to the scarcity of research in this emerging field, all types of studies were included irrespective of their quality. For example, two sources from grey literature were included in this review, originating from reputable institutions like the NHS. However, lower-quality studies tend to yield more inconclusive data, thereby impacting the overall results and weakening the evidence base. The heterogeneity in study designs made it impractical to conduct a meta-analysis; merging results obtained from disparate methods would not produce meaningful insights. Consequently, it is crucial to consider all these limitations, caveats, and inherent weaknesses when interpreting the evidence.

Notwithstanding these limitations, this study is the first systematic review exploring user perception, experience, and the impact on doctor-patient relationships regarding the use of symptom checkers. As such, it serves as a potentially valuable guide to steer future research on online symptom checkers.

3.5 Literature Update June 2024

An up-to-date literature search was conducted in June 2024 and found four publications that would have been eligible for this systematic review since June 2022. These four studies covered user perceptions (219,220), experience (219–222), and impact on the doctor-patient relationship (220). In terms of study design, two studies were qualitative (220,221), one was a quantitatively led mixed-method study (219), and one was a systematic review (222). A range of methods was employed, from surveys (219) to semi-structured interviews (220) to usability testing (221) to gain a deeper understanding of the topics of interest.

Regarding user perceptions, Muller et al. (220) highlighted the varied perceptions with online symptom checkers, noting advantages like reassurance and guidance, as well as disadvantages like anxiety from inputting incorrect symptoms. Kujala et al. (219) reported that online symptom checkers positively influenced healthcare professionals' work and usability was linked to their support. Only Muller et al. (220) discussed potential negative effects on the doctor-patient relationship, emphasising the loss of personal dialogue and non-verbal cues.

All four studies discussed aspects of user experience and usability of online symptom checkers, though two were in the context of Finland's primary care (219,221). In addition to identifying user barriers similar to other eligible studies, such as restricted input methods (222) and lack of personalisation (220), several recommendations were provided, such as conveying human empathy (222) and ensuring good information architecture (222) to improve the user experience. Only one study (221) looked at the user experience of vulnerable groups, such as older adults. Savolainen et al. (221) reported that vulnerable groups encountered a number of challenges. For example, qualitative usability testing revealed that vulnerable groups were overwhelmed with excessive information and put off by the use of complex medical terms. Like previous studies, there were calls for more research on user experience to explore user

needs in context, incorporating users with diverse characteristics and capabilities, such as older adults. The findings of the up-to-date literature do not alter the conclusions of the review.

3.6 Conclusion

This systematic review has revealed that user perceptions and experiences of symptom checkers are generally positive. However, it appears that symptom checkers have the potential to adversely affect the doctor-patient relationship more than they positively contribute to it. Nonetheless, it is important to exercise some caution when interpreting these findings since the majority of eligible studies were rated as fair or poor quality. Methodological issues such as small sample sizes and inadequate reporting, including a lack of sample justification, have resulted in inconclusive findings and an overall weak evidence base. Furthermore, the inclusion of non-peer reviewed studies in this review further diminishes the overall strength of the evidence presented.

The review highlights a significant disparity between the potential benefits of symptom checkers as promoted by technology providers and their practical implementation, particularly in primary care settings. The increased use of symptom checkers for seeking health information online, coupled with technological advancements, has spurred research activity in this area. However, further research is necessary, particularly utilising qualitative methodologies, to gain deeper insights into user perceptions, experiences, and the perceived impact on the doctor-patient relationship, especially with vulnerable user groups. Such research is vital for informing the development and implementation of this emerging technology in healthcare settings.

Chapter 4 Methodology

4.1 Introduction

The core of any research lies in its methodology, guiding data collection, analysis, and interpretation. This chapter justifies the adoption of a qualitative approach as the most suitable methodology to address the research questions. It examines the factors influencing this choice and delves into the underlying epistemology and theoretical frameworks supporting the methods employed in this research project.

4.2 Philosophical Foundations of Proposed Studies

Since this exploratory research focuses on perspectives and experiences, it aligns with interpretivist epistemology from a philosophical standpoint, which addresses subjective experiences. Therefore, this project employs an interpretivist approach (223,224) to study users' perceptions and experiences with online symptom checkers.

As this research focuses on capturing the lived experiences of participants, it adopts a phenomenological methodology (225) guided by interpretivism principles (226), which seeks to understand subjective experiences and uncover the essence of their lived realities to enhance comprehension of the phenomenon under study. Interpretivism, in contrast to positivism, views knowledge as socially constructed and rooted in diverse and intricate interpretations of experiences, primarily analysed through qualitative methods. This stands in contrast to positivism (225), which considers knowledge as objective and attainable through empirical research and quantitative analysis.

This research combines inductive and deductive methods to thoroughly investigate the use of online symptom checkers. Employing both approaches enables a multifaceted exploration, capturing the intricacies of the research context (227). Inductive methods facilitate theory generation and deep contextual (e.g., GP settings) understanding through observation, while deductive approaches offer a structured framework (e.g., user engagement) for validation, ensuring methodological rigour and bolstering the credibility and validity of the findings (228).

This research employs a qualitative approach to explore the perceptions and experiences of older adults and GPs, an area previously under-researched. Qualitative research enables investigation into personal accounts, descriptions, and opinions (229). More specifically, the study employs qualitative research methods, such as user interviews and think-aloud protocol, to gain insights and identify potential usability issues (230). This research employed thematic analysis (230) to analyse the qualitative data. The rationale for using thematic analysis is detailed in section 4.6.

The philosophical foundations underpinning this research project are summarised in Table 8.

Paradigm worldview: Interpretivist epistemology
Theoretical lens: Explicit (constructivist lens)
Methodological approach: Qualitative approach
Design: Phenomenology
Methods of data collection: Semi-structured interviews, think-aloud protocol and UX ideation workshops
Data analysis: Thematic analysis

Table 8: Study philosophical foundations

4.3 Qualitative research approach

The proposed studies utilised qualitative methods to investigate the experiences and perceptions of older adults and GPs regarding online symptom checkers in primary care, with a specific focus on their perceived impact on the doctor-patient relationship.

Qualitative research is a scientific approach to observation, aiming to gain a profound understanding of a phenomenon (225). This method goes beyond merely assessing frequency and delves into the underlying reasons and motivations behind the observed phenomenon. By adopting a broader perspective, qualitative research offers valuable insights into the how and why certain phenomena occur (231). Additionally, qualitative research serves as a means to generate hypotheses for potential areas of study and enables the generalisation of findings to a larger sample population (226). Furthermore, it provides a solid foundation for analytically generalising specific theories or theoretical propositions (232).

Qualitative methods, such as user interviews and specific usability tests such as the think-aloud protocol, primarily function as exploratory tools, allowing individuals to freely express their perspectives and experiences through open-ended communication. These methods enable researchers to delve into new questions and obtain further elaboration from participants, fostering spontaneous adaptation during the research process. The outcomes of qualitative studies typically involve non-numerical findings, often centred on identifying emerging themes or categories derived from textual data. The use of qualitative methods is crucial as it yields valuable information that may be overlooked or remain unquantifiable when relying solely on quantitative methods (233,234). On the contrary, quantitative techniques such as surveys and simulations, focus on measuring various aspects of user behaviour in a numerical manner, facilitating mathematical analysis and the development of models, theories, and hypotheses related to specific phenomena (235).

Qualitative research is effective in uncovering prevalent trends in thoughts and opinions, but its outcomes can be influenced by the researcher's interpretation of participants' perspectives, introducing inherent bias to the data. Consequently, the findings may lack complete objectivity and reproducibility (236,237). Despite these limitations, qualitative research offers practical advantages, such as requiring fewer resources and less time compared to quantitative methods. This aligns well with the constraints often faced in doctoral programs, where time frames and resources are typically limited. Furthermore, qualitative studies can complement quantitative findings by providing deeper insights and understanding, such as exploring the reasons behind the use or non-use of technology.

In the realm of Information Systems, quantitative methods have traditionally held a dominant position. Nevertheless, there has been a recent shift towards employing qualitative research methods to explore technology usage and acceptance (238). Significantly, an increasing number of publications have adopted qualitative designs to investigate acceptance, leading to a deeper understanding of the intricate interplay among acceptance constructs (239), and unearthing previously overlooked factors of influence that quantitative empirical data fails to capture (240). These newfound influences, including technology-specific factors (241), serve as valuable resources for theory-building and the development of novel acceptance constructs (239).

Unlike quantitative methodologies, qualitative approaches like user interviews and participant observation are more appropriate for examining intricate connections, especially the dynamic interplay between individuals and technology (239). These methods are also adept at unveiling unexpected insights (242–244), offering a more comprehensive understanding of the subject matter. Additionally, qualitative techniques such as interviewing, yield in-depth insights into the doctor-patient relationship (245), which is a pertinent outcome of interest for this research project.

Overall, in-depth qualitative techniques, such as interviews, are especially suitable for investigating topics with limited existing knowledge, such as online symptom checkers, or for addressing exploratory research questions, such as the one posed in this study. These techniques offer rich insights, facilitate contextual understanding, and focus on participant perspectives, contributing to knowledge development.

4.3.1 Qualitative Validity

To assess the quality of qualitative research, researchers commonly employ alternative criteria, including dependability, transferability, and credibility. These criteria help to appraise the robustness and trustworthiness of the research outcomes. Despite the differences between qualitative and quantitative research in their evaluation methods, both approaches share the goal of producing reliable and valid results.

Validity in research refers to the extent to which the study accurately corresponds to the real world and successfully measures what it aims to measure (246). On the other hand, reliability pertains to the overall consistency of a measurement or a set of measurements (247). While various interpretations of reality may apply to a given situation, and each is valid in its own context (248), some qualitative researchers argue that the concepts of reliability and validity are not directly applicable to qualitative research.

In qualitative studies, validity is concerned with whether the research has been conducted thoroughly to ensure credibility (249). To assess credibility in a qualitative study, it is essential for the findings to accurately reflect the phenomenon being investigated (250). However, demonstrating credibility in qualitative research can be challenging. To improve credibility,

researchers are advised to employ several recommended methods, each requiring the judgement of both the researcher and the reader of the findings. These methods include triangulation (involving multiple researchers), respondent validation, providing a clear description of data collection and analysis procedures, reflexivity, fair handling of data, and paying attention to negative cases (251,252).

Yardley (253) proposed a checklist for evaluating the quality of qualitative research, with a focus on credibility and dependability. The key factors to consider are as follows:

- Sensitivity to context, commitment, and rigor: This relates to the credibility of the research, ensuring that the study accounts for the specific context, exhibits dedication to the research objectives, and maintains a rigorous approach throughout.

- Transparency and coherence: These factors pertain to dependability, ensuring that the research methodology and findings are transparently presented and logically coherent.

- Importance and impact: This aspect emphasises the significance and potential impact of the research outcomes.

To achieve high-quality and reliable results that can be applied and reproduced effectively, it is essential to uphold the standards of quality at every stage of the research process.

4.3.2 Reflexivity

Throughout the qualitative research process, from design to execution, certain errors and biases can arise, such as unintended researcher bias (254). Unlike quantitative research, where data collection is typically detached from the researcher, in qualitative research, the researcher becomes the primary instrument for data collection (255). The researcher's personal background, values, beliefs, and attitude may influence the research outcomes. This introduces concerns about objectivity, reproducibility, and replicability of the results, as well as the validity of theoretical inferences and broader generalisations drawn from the findings.

To address these concerns, the practice of reflexivity, involving continual reflection on potential researcher bias, becomes paramount in ensuring the transparency, credibility, and overall quality of qualitative research results (242). The three proposed qualitative studies incorporate reflexivity and adhere to the 'Four-Dimensions Criteria' (FDC) introduced by Lincoln and Guba (256). These criteria serve as a robust and distinct alternative to quantitatively oriented standards for ensuring the trustworthiness of qualitative research (257). The FDCs utilised in the context of qualitative health research encompass credibility, dependability, confirmability, and transferability.

Having a knowledgeable and proficient researcher is crucial for this study, as they must be well-versed in the subject matter. However, it is essential to acknowledge that their expertise may inadvertently introduce expert bias (258). Additionally, the researcher must possess the competence to effectively engage with older individuals in discussions that might not always align with the semi-structured interview guide.

Although the researcher is committed to maintaining objectivity and minimising biases, it is important to recognise that they are a millennial with a computer science background. Consequently, unconscious biases, such as a pro-technology inclination, might impact the results. Certain user experience (UX) features, which the researcher may take for granted, could pose challenges for older participants.

Therefore, acknowledging these potential biases and employing rigorous methodologies to mitigate their influence is essential in ensuring the integrity and validity of the research findings.

Several measures were employed to establish the validity and reliability of the qualitative results in this research project:

- Pilot Study: Pilot studies were conducted for each participant-involved study to identify and address improvements, including revising interview guides. Participant feedback was sought to assess the content validity of interview questions. This process aided in developing clear instructions and ensuring the collection of valid and reliable qualitative data (259), which is essential for addressing the research questions (260).

- Objective of Qualitative Research: In qualitative research, the aim is not to generate standardised results that can be easily replicated by other researchers. Instead, the primary objective is for the researcher to provide coherent and consistent descriptions of the study, encompassing local conditions and research design, while acknowledging changes in context. For each conducted study, a thorough and consistent description was included, along with any aspects during implementation that might have influenced the findings. In addition to the researcher's reflections and participant feedback, this approach enhances the dependability and transferability of the findings beyond the specific study settings (261).

- Use of Pre-Validated Interview Guide: In addition to revising the interview guides after the pilot study, a substantial number of questions were included from a pre-validated interview guide used in previous studies focused on user perception, user experience, and doctor-patient relationships. This increased content and construct validity, bolstering the reliability.

- Internal Validity: Internal validity refers to the credibility and trustworthiness of the results obtained within the research process itself, independent of external factors (247). To ensure internal validity, a well-defined study protocol with specific procedures was adhered to for all research methods, particularly for think-aloud protocols and UX ideation workshops. Consistency was maintained, and no participant were treated differently. Moreover, both inductive and deductive thematic analyses were applied to ensure that important issues were not overlooked, even those that may not fit into pre-existing designated themes.

- External Validity: The study's external validity and generalisability to other settings were enhanced (262) by diverse sample selection and the conduction of two ideation workshops, which included an IT specialist from an external organisation. The insights gained from these workshops provided a broader perspective on the research topic.

- Data Saturation: Data saturation was achieved, indicating that gathering additional data is unlikely to provide further value-added insights. The definition of data saturation

adopted in this study is rooted in grounded theory (263). This approach further bolsters the confidence in the generalisability of the proposed studies.

By implementing these measures, the study aims to produce valid and reliable qualitative results, contributing to the overall rigor and credibility of the research findings.

4.4 Qualitative Research Methods

This research utilised the following qualitative methods: semi-structured interviews, think-aloud protocol, and UX workshops.

4.4.1 Semi Structured Interviews

Semi-structured interviews represent a highly versatile form of primary research and are widely utilised as a data collection method in qualitative research (264). In these interviews, a researcher poses open-ended questions to participants and records their responses. In contrast to quantitative research designs, which involve gathering statistical data from large participant groups to generalise findings across populations (237), semi-structured interviews with open-ended questions enable the researcher to guide the participants effectively. This guidance ensures that topics of interest are explored in greater detail (265), facilitating a comprehensive understanding of the subject matter.

Despite the smaller sample sizes typically associated with qualitative interviews, their primary objective is to 'explore' and gain novel insights while obtaining an in-depth understanding of specific areas of interest. This approach also allows the interviewer to delve further into relevant issues to address the research objectives through probing techniques. In the context of the present research project, semi-structured interviews were employed to gain a profound understanding (265) of older adults' perceptions, experiences, and their perception of the impact on the doctor-patient relationship.

The advantages of utilising semi-structured interviews are as follows:

- Enhanced probing capabilities: These interviews allow interviewers to delve deeper into respondents' answers, enabling them to deduce response validity and gain more profound insights into specific objectives.
- Facilitation of meaningful discussions: Online semi-structured interviews enable interviewers to explore emerging themes in a conversational manner, a feature not attainable in self-completion methods like surveys and questionnaires. This is particularly beneficial for identifying new constructs concerning acceptance and other frameworks.
- Access to non-verbal communication cues: Through online interviews, the detection of non-verbal cues such as body language and facial expressions becomes possible. This aids in understanding user perception and satisfaction, especially for older adults who may refrain from expressing negative opinions in front of others due to personality or politeness.
- Utilisation of stimulus material and visual aid: The presence of an online symptom checker application during interviews serves as both stimulus material and visual aid, enhancing the overall interview experience.
- Enhanced participant commitment: Online semi-structured interviews foster greater commitment from participants, leading to increased attention and engagement during the interview process. Additionally, the flexibility of extending the interview duration if needed further enhances data collection possibilities.

Although semi-structured interviews serve as an effective method to explore user perceptions and experiences, they come with certain drawbacks. For instance, the process of organising interviews, including recruitment, and conducting, can be both costly and time-consuming. Extracting high-quality information from user interviews requires a rigorous approach, involving well-thought-out and purposeful questions while considering specific participant needs, such as health requirements. Moreover, ensuring the eligibility of participants through thorough vetting is essential to minimise biased responses, albeit being a time-intensive endeavour.

In Studies 2 and 3 of this research, participants were given the choice between online and face-to-face semi-structured interviews. The reasons for offering online interviews varied, such as recognising the vulnerability of older adults, minimising the risk of spreading Covid-19, and accommodating busy GPs.

Advantages and disadvantages of online interviews compared to face-to-face interviews (F2F) include ((266–268):

- Accessibility: Online interviews allow participants to join from anywhere, but technical issues like poor internet or hardware problems can disrupt the conversation compared to F2F interviews.
- Costs: While online interviews eliminate travel expenses, there may be initial costs for reliable video conferencing tools and equipment.
- Comfort: Participants can interview from home, reducing stress and travel time. However, potential distractions may affect focus, and F2F interviews allow for better non-verbal communication and a more personal connection.
- Recording: Online platforms often enable easy recording for review, but this raises privacy concerns, and some candidates may feel uncomfortable being recorded.

As an alternative approach to semi-structured interviews, focus groups can be employed, either in a single session or through a series of discussions. Focus groups offer several advantages, particularly in capturing and cataloguing a diverse range of individual perceptions related to the use of symptom checkers in general practice, generated explicitly from group interactions. Individual interviews may also complement the process, delving further into personal perceptions and usage experiences, or filling in any gaps that may have emerged from the focus group discussions.

However, for the three proposed studies, the use of focus groups was deemed unsuitable due to the specific purpose of capturing personal experiences and opinions, rather than stimulating debates. Furthermore, dominant personalities within the focus groups might inhibit discussions for others and influence participants to adopt a 'me too' stance, while more reserved individuals may refrain from expressing their views to avoid upsetting others. In contrast, semi-structured interviews ensure that each participant is provided with an equal opportunity to articulate their own perspectives and provide in-depth feedback. Additional drawbacks of using focus groups involve the need to coordinate the presence of multiple participants simultaneously, potentially limiting the depth and intricacy of discussions on specific topics. In contrast, interviews offer the opportunity for a more in-depth investigation of each participant's insights and experiences.

Maintaining uniformity in question delivery in a group context can be challenging compared to standardised questions in individual interviews. Furthermore, scrutinising data from focus groups can be more challenging due to the multitude of interactions and varied perspectives compared analysing data from individual interviews.

4.4.2 Think-aloud protocol

The think-aloud protocol is a widely recognised method for conducting usability testing, aimed at capturing the real-time thoughts of participants as they interact with a device or application under examination (269). The basic idea is to have participants verbalise their thoughts as they progress through a task, providing insights into their cognitive processes, emotions, and decision-making (270). This, in turn, offers a deeper understanding of user behaviour and helps identify pain points or usability issues. Such insights play a crucial role in understanding both the psychological and practical aspects of the user experience (271), ultimately leading to actionable redesign recommendations (220) and enhancing the iterative process of product development (270).

In this research, participants were asked to verbalise their thought process while entering health symptoms into the online symptom checker, as outlined in the pre-verified vignettes (272). To foster effective think-aloud responses, observers may employ standard prompts, including non-verbal cues, to encourage participants to express their thoughts without interrupting their actual task performance.

The think-aloud protocol (270), offers inherent advantages and disadvantages, as succinctly outlined in Table 9.

Advantages	Disadvantages
Low financial costs to organise.	Unnatural situation. Talking out loud on their own can appear to be unnatural for many participants.
Robust. Direct exposure to user's raw feedback where they are free to say what they like without interference.	Filtered statements. Participants may give an edited commentary to appear smart.

Flexible. This method can be used at any stage in the product design and development process.	Cause bias in user behaviour. If not correctly provided, prompts from the facilitator can easily change user behaviour.
Easy to learn. The concept is easy for participants to understand and easy to implement without the facilitator needing advanced training.	Time consuming. Analysing all the users' thought processes including the observers' notes can take a long time.

Table 9: Think-aloud protocol advantages and disadvantages

Vignette Technique

The vignette method is a valuable approach in healthcare research, involving the presentation of short descriptive hypothetical scenarios, either written or in pictorial form, to engage participants and gather responses to typical situations (273). It proves particularly beneficial in encouraging participants to share their thoughts on sensitive areas, such as personal health, and fosters a sense of comfort in divulging responses for specific situations (273).

Moreover, the vignette method serves as an effective ice breaker technique, especially in situations where participants may lack experience in envisioning themselves facing hypothetical health conditions (28). However, it is essential to acknowledge that inferences drawn from participants' actions in imaginary scenarios may not necessarily translate to real-life behaviours (274).

In this research, the vignettes will not be employed to initiate conversations directly; instead, they will be utilised as an ice breaker to encourage participants to interact with the symptom checker application. Participants will be prompted to enter symptoms described in standardised patient vignettes representing common medical conditions (179). This approach seeks to leverage the vignettes' engagement qualities to facilitate participants' involvement in capturing user experience and testing the application's functionalities.

4.4.3 UX Workshops

In the later stages of the design process, UX workshops offer an effective means of actively engaging relevant stakeholders in collaborative sessions to address UX challenges and generate

actionable UX goals through hands-on activities. Although the involvement of older adults in such workshops has been relatively limited, recent studies increasingly highlight their significance, particularly in comprehending and tackling issues associated with the complexities of aging (275).

The existing literature suggests that designers who conduct participatory UX workshops and incorporate user feedback are more likely to generate innovative ideas and designs (276,277). Notably, older adults, like their younger counterparts, possess the capabilities to assess the relevance of new products or services to their individual needs and express their personal preferences (278).

4.5 Theoretical Frameworks

Theoretical frameworks provide a structured approach to research, guiding design and interpretation while linking studies to existing knowledge, which enhances coherence and strengthens validity and reliability (257). Despite ongoing research on technology acceptance, the usage and acceptance of technology by older adults remain underexplored, with insufficient attention to age-specific factors (140,170). Consequently, there is limited understanding of technology acceptance among older adults in the literature (171). The literature review identified relevant components of technology acceptance models pertinent to this research.

The Senior Technology Acceptance Model (STAM), initially developed to explain older adults' mobile phone adoption, incorporates theoretical constructs from various technology acceptance models, such as TAM and UTAUT (see Appendix 10 for more details). STAM addresses age-related aspects not covered by previous models, including physical, psychological, and social characteristics that influence older adults' interactions with and acceptance of gerontechnology.

As there is no dominant model for user experience (UX) and usability in the literature, a range of UX approaches were considered in Appendix 10. No specific UX frameworks for older people were found, so elements from generic frameworks were apprised. The link between UX and TAM models was explored, revealing similar constructs (e.g., perceived usefulness) that provide rich insights into the uptake and use of technology.

The literature review found no specific frameworks for the doctor-patient relationship, except for a conceptual framework deemed relevant to this research. This framework includes mutual knowledge, trust, loyalty, and regard (279). These elements are crucial for older adults and greatly influence their satisfaction with general practice.

A comprehensive examination and evaluation of each respective conceptual framework can be found in the appendices (see Appendix 10).

The following theoretical frameworks are relevant to the proposed studies:

	Study 2: Older adults' experiences and perspectives	**Study 3: GPs' perspectives.**	**Study 4: Ideation Workshop**
Senior Technology Acceptance Model (STAM). STAM (280) has been described in-detail in Appendix 10.	✓		
Elements of User Experience (UX) and Usability Framework (281).	✓		✓
Conceptual framework of the patient-doctor relationship (282).		✓	

Table 10: Theoretical frameworks

The study aims to employ elements from the conceptual frameworks presented in Table 10 to structure and develop the interview guides. This approach ensures that the interviews are not

only methodologically sound but also aligned with the theoretical foundations identified and articulated in the aforementioned table.

4.6 Data analysis methods

Thematic analysis, a widely recognised method for qualitative research, has been chosen as the analysis method for qualitative data (283). It facilitates a detailed examination of data, enabling researchers to capture complex phenomena and nuanced insights. Commonly used to gain insights into subjective perspectives, experiences (284), and participants' behaviours, actions, and thoughts (285), thematic analysis provides a structured approach. This involves reading transcripts, identifying patterns, applying codes, and developing themes and sub-themes that emerge from the data (286). The systematic process ensures thorough analysis, with clear steps enhancing transparency and reproducibility, which are critical for credible qualitative research (228). Thematic analysis is highly adaptable to various research questions, data types, and theoretical frameworks, making it suitable for a wide range of studies (226). It accommodates diverse data forms, including interviews, workshops, and usability testing (283).

This research employs a hybrid approach, incorporating both inductive and deductive thematic analysis to interpret the qualitative dataset (287). Inductive thematic analysis identifies themes emerging from the data, while deductive thematic analysis uses predefined codes based on existing theories. A systematic approach, using splicing and linking techniques, identifies emerging themes and sub-themes relevant to the research questions. Major themes are explored inductively to uncover subthemes, allowing researchers to identify additional overarching themes within the qualitative data.

Thematic analysis has been used in the analysis of chatbot design and user experience (142,288), usability studies involving mHealth and smartphone apps (289–291), and user perceptions of mobile health apps (212,292). Alternative forms of thematic analysis, such as framework analysis (293), interpretive phenomenological analysis (IPA) (294), and template

analysis (295), were also considered for this study, but found limited applicability to the diverse range of methods used in this study.

4.7 Studies outline

Study 2 (Chapter 5) involved the use of think-aloud protocols and semi-structured interviews to explore the experiences and perspectives of older adults regarding the use of online symptom checkers in general practice. The study particularly focused on usability, usefulness, and the potential impact on the doctor-patient relationship. The subjects of this study were older adults who had some previous experience of using online symptom checkers as part of their GP service. Additionally, a usability test was performed to assess the effectiveness of the online symptom checkers. The interview topic guide was influenced by the STAM model, which takes into account senior age-related aspects not covered by previous technology acceptance models (see Appendix 10).

Moving on to Study 3 (Chapter 6), this phase aimed to explore GPs' perspectives on the potential impacts of online symptom checker use on older adults and how it influenced the doctor-patient relationship. The subjects for this study were GPs whose practices incorporated the use of online symptom checkers. In-depth interviews were conducted to gather insights into the advantages and disadvantages of online symptom checker use concerning older patients and the perceived effects on the doctor-patient relationship. Additionally, the interviews aimed to explore broader impacts of the application within the general practice setting.

Lastly, Study 4 (Chapter 7) focused on enhancing the usability and effectiveness of online symptom checkers in primary care, considering the viewpoints of both GPs and older adults. To achieve this, UX Ideation Workshops were held, facilitating collaboration between older people, GPs, and domain experts. The workshops sought innovative ways to improve online symptom checkers and their utilisation within the general practice context. Study 4 included analysing specific data from studies 2 and 3 that were fed into the workshops.

Chapter 5 Older adults' perspectives on the use of online symptom checkers in general practice

This qualitative study explores the perspectives and experiences of older adults on the use of online symptom checkers in general practice, including how older adults perceive the impact on their doctor-patient relationship, to answer the research question RQ2. The initial part of this chapter outlines the reasons and justification behind conducting this study. It is followed by a comprehensive explanation of the study's design, the method used for data collection, and ethical considerations. The subsequent section presents the outcomes derived from thematic analysis, supported by representative quotes extracted from interview transcripts, which capture the diverse perspectives shared by the participants. Lastly, the concluding section encompasses the discussion and final conclusions drawn from the study, referencing existing literature and earlier research findings.

5.1 Introduction

In the United Kingdom, older adults are more likely to have complex and long-lasting health problems that require frequent visits to their General Practitioners. Research indicates that older adults can benefit from using e-health technologies in healthcare settings (37). However, integrating these digital health tools into the lives of older individuals remains challenging. Many older adults are hesitant to adopt e-health technologies, especially when they are unsure about the potential benefits or relevance of such tools (104–106). Nevertheless, if older adults perceive these technologies as useful and suited to their needs and lifestyle, they are more willing to consider their adoption (103). Additionally, online symptom checkers, classified as mHealth apps, are more likely to be accepted and embraced by older adults if they demonstrate high reliability (296), strict safety measures (297), and a positive user experience with a user interface designed to accommodate their specific challenges and requirements (298,299).

The viewpoints and encounters of older adults regarding online symptom checkers are extremely important for the widespread adoption and acceptance of this service in general practice. However, there is a significant lack of research in the existing literature on this topic,

particularly in understanding their perspectives on the potential impact on the highly valued doctor-patient relationship.

The aim of this exploratory study is to gather in-depth data to aid in understanding the experiences and perspectives of older adults regarding the use of online symptom checkers in a general practice setting. This includes exploring how they might influence the doctor-patient relationship.

The specific objectives of this study, which align with the overall research objectives stated in section 2.8, were as follows:

- To investigate the experiences and perceptions of older adults regarding the use of online symptom checkers in the general practice setting, including perceived advantages and disadvantages.

- To gain insights from older adults about how online symptom checkers may affect the doctor-patient relationship.

- To examine how older adults perceive the broader impacts of using online symptom checkers in general practice.

The findings of this study will contribute to either supporting or tempering the enthusiasm surrounding online symptom checker tools in general medical practice, while also guiding future efforts to better cater to the requirements of older adults. Additionally, these findings establish the groundwork for further research into the factors that influence older adults' willingness to use and adopt online symptom checkers.

This chapter deliberately excludes user barriers and design recommendations provided by older adults in the semi-structured interviews and think-aloud protocol for enhancing the use of online symptom checkers in general practice. Instead, these insights are presented in Chapter 7, where they are compared with suggestions from GPs on similar themes and subthemes. Additionally, Chapter 7 includes findings from the two UX workshops that further explored,

validated, and prioritised these user experience improvements and adoption strategies. Since user experience greatly impacts older adults' acceptance and adoption of the tool in general practice, presenting it in a consolidated manner in one chapter is considered more effective for comparing, contrasting, and validating these suggestions, which form a significant contribution of this research.

5.2 Study Design and Method

Since the use of online symptom checkers in general practice is a relatively new phenomenon and given the paucity of published literature on this topic, an exploratory qualitative approach with two phases was adopted to elicit older adults' views and experiences on the use of online symptom checkers including its potential impact on doctor-patient relationship.

The initial stage involved conducting moderated think-aloud protocol, where older adults were asked to use online symptom checkers while verbalising their thoughts. The moderator's responsibility is to guide the process effectively, ensuring the participant remains focused and offers valuable insights. Simplified vignettes from a prior study were employed to capture their real-time service experiences (300).This method helped understand user experience and identify barriers and facilitators to using online symptom checkers in general practice.

The second phase comprised semi-structured interviews with older adults, where open-ended questions and probes were used to explore their perspectives on the advantages and disadvantages of online symptom checkers in general practice. Additionally, participants' views on the impact of online symptom checkers on the doctor-patient relationship were captured in the final part of the interview. The interview topic guide was developed based on the research objectives, prior research such as (135), and was influenced by the UX guidelines outlined in Chapter 2, as well as the STAM model (see Appendix 10). The STAM model incorporates characteristics associated with influencing older adults' interactions and acceptance of gerontechnology through experimentation and exploration. The think-aloud protocol and individual interviews were conducted until data saturation was achieved (301).

5.2.1 Participants

Population and setting

The population of interest comprised older adult patients aged 60 years old or above, affiliated with an NHS GP Surgery. Data was gathered from May 2022 to August 2022. This research was conducted in Sheffield, England.

5.2.2 Setting

This study involved working with older adults who are considered vulnerable participants immediately following the Covid-19 pandemic. To ensure their safety, the older adults were given the choice between conducting the interviews and think-aloud protocols through video conferencing using Google Meet or in person through traditional face-to-face meetings. The option of online interviews was provided to address potential discrimination against older adults facing issues such as mobility problems and transportation constraints. The study adhered to established guidelines for conducting remote interviews with older adults, as recommended by ethical standards (302–304). Several challenges associated with online interviews were identified and addressed, as explained in section 5.6. However, most older adults expressed a preference for face-to-face interviews over online ones, and the researcher followed the Sheffield University research guidelines to minimise the risk of spreading the virus. Details regarding the face-to-face meetings and safety assessment can be found in the appendices (Appendix 4).

5.2.3 Sampling

The original plan of the study was to focus on recruiting older adults using a specific sampling method called stratified purposive sampling (305). The intention was to have an equal number of male and female participants and, if possible, include at least two individuals from Black, Asian, and minority ethnic backgrounds to represent 16% of the UK population (306). However, given the restricted access to older adult participants during the Covid-19 crisis, snowball sampling technique (307) was applied instead. Snowball sampling is a non-probability method that has certain drawbacks, such as potential selection bias and limited generalisability to the entire population. Despite these limitations, it is a popular and efficient sampling method in qualitative research due to its cost-effectiveness, simplicity, and speed (237,307). Recruitment continued until data saturation was reached, which involved recruiting a total of 13 older adult participants.

5.2.4 Eligibility Criteria

The criteria for selecting participants for the study were as follows: individuals who were older adults aged 60 or above, diagnosed with at least one chronic health condition, and had previous exposure to online symptom checkers within the context of general practice. The reason for including chronic conditions is that these individuals are more likely to visit their GP and, therefore, more likely to use online symptom checkers compared to someone with a clean bill of health. Participants self-reported at least one chronic condition, with no official proof requested to protect their medical privacy. The inclusion of participants with prior experience was essential to gather valuable and comprehensive perspectives regarding the use of online symptom checkers based on their real-life encounters. Participants with experience can provide more insightful and detailed feedback. This aspect was identified as a research gap in section 3.7.

Participants were expected to have some basic computing skills as defined by the ICAS Computer Skills Assessment Framework (308). The reason behind this expectation was the anticipation that a significant number of older adults in the future would possess at least fundamental IT skills due to their exposure to various technologies integrated into nearly every aspect of contemporary life (309,310). This requirement aimed to enhance the significance and durability of the study's results while ensuring that any challenges related to user experience and usability encountered were primarily attributed to shortcomings in the design and development of online symptom checkers, rather than to participants' insufficient IT skill (309).

Although the study relied on participants' self-assessment of their IT skills, the researcher conducted a considerate initial telephone conversation with each participant to discuss whether they possessed essential computer skills, such as checking emails or browsing the internet as defined by ICAS. If participants encountered challenges during the study but still wished to continue, they were given the opportunity to do so because their data was deemed valuable, representing a significant portion of the older population.

Effective communication was crucial for obtaining detailed qualitative data. As a result, older adults with limited proficiency in the English language or those unable to provide consent were not included. To determine participants' ability to give consent, the researcher conducted a face-to-face discussion before the interview, following the guidelines of the Mental Capacity

Act (MCA). Consequently, individuals with significant learning disabilities, dementia, severe mental health conditions, stroke, or brain injuries were excluded from the study. Additionally, individuals with other types of cognitive impairments that could hinder their ability to provide informed consent or give detailed responses to open-ended questions were also excluded. In the event that a participant experienced severe depression or suicidal thoughts during the study, they were encouraged to seek assistance from their general practitioner or a suicide support line. Relevant mental health charity information, such as that provided by MIND, was readily accessible.

5.2.5 Participant Recruitment

To minimise barriers to recruitment and maximise the retention of older adults in research studies, the recommended guidelines were followed (311,312). To attract a diverse range of participants and ensure the reliability of the results, recruitment posters were created using straightforward language. These posters were distributed electronically through various suitable recruitment channels and promoted on specific social media platforms, including the following:

- Sheffield AgeUK
- Sheffield Churches Council for Community Care (SCCCC)
- Community social groups (e.g., foodbanks) and via community leaders (e.g., Councillors)
- Personal network
- Social media posts (Twitter (313) and Facebook community pages ((314))

Many organisations had responded positively to help with recruitment, partly because they were contacted at the early stages of the research, which informed them about the aims and objectives of the proposed study.

To obtain official data on the number of older adult patients registered with GP surgeries in Sheffield, the NHS website (315) was utilised. This dataset facilitated the identification of surgeries with a higher-than-average number of older adult patients, enabling targeted outreach on specific Facebook community pages. Furthermore, potential eligible participants from the

researcher's personal network were approached in adherence to ethical guidelines, and they were encouraged to introduce their friends and colleagues to participate.

As a contingency plan, a local NHS surgery was available to assist with recruitment. However, obtaining ethical approval from the Health Research Authority (HRA) would have been necessary. For more information on the advertising methods employed, please refer to Appendix 4.

If a prospective participant indicated interest either directly or via one of the above organisations, they were contacted to arrange a pre-study telephone or video call to explain the study activities and what was required of them in more detail, as well as discuss the consent procedures. Before the phone call, all interested individuals received a study information pack written in easy-to-understand English, either in printed form or electronically via email. To ensure that the information pack was written in accessible English, the researcher had it reviewed by PhD supervisors, the ethics committee, and a few older adult friends within the researcher's circle.

The researcher took great care to adhere to consent procedures, ensuring that participants provided informed written consent and had ample opportunity to enquire about the study. To enhance convenience, a digital consent form was generated using the Qualtrics XM software platform (316). Additionally, participants received an email containing a link to Calendly (317), an online platform for scheduling appointments, allowing them to select an interview time that suited their schedule.

The involvement in the study was entirely voluntary, and no monetary rewards were provided except for travel expenses. Instead, the emphasis was placed on highlighting the significance of the research project and its potential to reduce health inequalities faced by older adults. These recruitment methods mentioned earlier effectively attracted a sufficient number of eligible older adults, ensuring that enough data was gathered until the saturation point was reached.

5.2.6 Number of Participants

The aim was to continue recruiting older adult participants until data saturation was reached. An initial analysis of the data was performed after every second interview starting from the sixth interview to ensure that enough information had been collected. After the thirteenth interview, it was observed that no new themes or fresh data and ideas were emerging, indicating that data saturation had been achieved.

5.3 Data collection plan

The study gathered data using two qualitative research methods: the think-aloud protocol and in-depth semi-structured interviews. Initially, the think-aloud protocol was employed, where participants engaged in usability testing with age-appropriate vignettes to gain insights into how older adults experience online symptom checkers. Following this phase, open-ended questions were used to delve into participants' overall user experience based on the think-aloud protocol, as well as their individual perspectives on usability, acceptance, the therapeutic relationship with the technology, and the impact on their doctor-patient relationship. These questions specifically focused on their real-life usage of the tool in a general practice setting. The semi-structured interviews were conducted immediately after the think-aloud protocol on the same day, with a short comfort break.

To avoid influencing participants' attention towards specific features or issues, the interview portion was intentionally conducted after the observation phase of the study, which involved the think-aloud protocol.

P1: Think-aloud protocol

During the first phase of the study, a think-aloud protocol was conducted. The participant used the Doctorlink symptom checker and verbally articulated their thought processes regarding their user experience and usability of the user interface. If the interview was conducted remotely, participants were instructed to log in to their Doctorlink account and share their screen using a suitable software, such as Google Meet (318) with screen sharing functionality.

Initially, participants were given the opportunity to freely explore the online symptom checker based on their own previous health experiences. Subsequently, they were asked to enter symptoms according to a clinical vignette selected randomly (see Figure 6), which were intentionally simplified using everyday language. Participants were gently reminded that there was no rush in completing the tasks. However, they were encouraged to interact with the online symptom checker and provide comments using standard think-aloud prompts, such as asking what they were thinking and how they were finding the tool, etc.

Diagnosis	Vignette simplified (added symptoms)
Deep vein thrombosis	65 years old / Female 5 days swelling, pain in one leg, recent hospitalisation, leg painful, tender, swollen, red

Figure 6: Example of a simplified vignette (179)

P2: In-depth semi-structured interview

During the second phase, participants were asked about their opinions and experiences concerning the use of online symptom checkers in general practice, including their thoughts on the potential of these digital health tools to act as a primary point of contact.

Subsequently, participants were asked enquired about their perceptions of the perceived advantages and difficulties associated with employing online symptom checkers specifically with older adults in general practice. The participants were asked to rate statements (see Appendix 13) on a 5-point Likert rating scale from strongly agree to disagree adapted from a prior study (319) and given the opportunity to elaborate on their responses. Lastly, they were asked about their perspectives regarding the potential impact on the doctor-patient relationship. For more detailed information regarding the interview questions, please consult Appendix 6.

5.3.1 Representative online symptom checker

The main aim of this study was to explore the overall utilisation of online symptom checkers in general practice, rather than focusing on a specific tool. While these online symptom

checkers shared similar functionalities, several proprietary software programs have been used in general practice, such as askmygp (320), econsult (321), and Doctorlink (322). Some online symptom checkers have been implemented independently, while others have been were integrated into other e-health services associated with primary care, such as video consultations, online prescriptions, and GP appointment scheduling (24). Participants were required to have prior experience using symptom checkers in general practice, although their familiarity could have been with any of the deployed tools.

To carry out user experimentation, the researchers chose to use Doctorlink as a representative online symptom checker. This decision was primarily based on the fact that, at the time of the study, Doctorlink was the most widely utilised symptom checker in the NHS. It had established partnerships with over 1,350 GP surgeries in 42 Clinical Commissioning Groups (CCGs) across England. Additionally, many GP surgeries in Sheffield, including the University of Sheffield Health Service, were using Doctorlink (22). This made it more feasible to recruit local participants who had prior experience with an online symptom checker in a general practice setting.

Although other online symptom checkers like 'GP at Hand' were more frequently mentioned in the literature (323), they had only a few associated NHS surgeries utilising the tool. This would have made it even more challenging to recruit participants with some prior user experience.

It is worth noting that few participants mentioned having prior experience with other online symptom checkers that were available at the time. Although the design aspects differed, there are several significant similarities among most online symptom checkers deployed. For example, they all shared the same goal and operated in a similar manner, which was to encourage patients to check their symptoms by answering a series of questions based on their health concerns. They would then provide verified self-help information to learn more about possible conditions if they could be identified based on the responses. Additionally, they would offer recommendations on where to seek further help if necessary. For the purpose of this research project, participants with prior experience using multiple online symptom checkers were considered equivalent to those with experience using a single online symptom checker, due to similarities in functionalities.

5.3.2 Transcription

Since English serves as the country's official language and is commonly used in everyday interactions, the think-aloud protocol and interviews were carried out in English. These interviews were digitally recorded and later transcribed verbatim. The transcription aimed to preserve the authenticity of the data, including any colloquial language or local Yorkshire accent used by the participants. Only necessary additions were made to ensure comprehension.

To ensure privacy, the transcripts were anonymised using a unique ID. Participant names and study codes were separated and securely stored in an encrypted, password-protected file on the University's secure filestore, following the approved data management plan.

5.3.3 Quality Criteria (validity of research)

To improve the credibility and dependability of this study, several measures were implemented:

- Sensitivity to context: The study accounted for the diverse healthcare needs and socio-cultural environments of older adults. This included participants from various backgrounds, living arrangements, cultural and religious affiliations, age groups, and socioeconomic statuses. The researcher was considerate of these factors during the study.

- Extended engagement with the subject matter: The credibility of the data was strengthened by the researcher's in-depth literature review, regular interaction with participants, and thorough analysis of the collected data. Regular communications with participants were maintained through regular contact to build trust, rapport, and engagement. During interviews and think-aloud protocols, gentle prompts were used to elicit in-depth data. After the study, interview transcripts were verified with some participants. Regular interactions allowed researcher to gather richer and reliable data.

- Reflexivity: The researcher provided a transparent account of their own background, experiences, and role in the research. This self-awareness helped acknowledge potential biases and influences on the research findings.

- Creation of an audit trail: The research process was well-documented, including the analytical steps. This transparency ensured the research design and methods aligned appropriately with the research question and philosophical perspective.

- Data saturation: The data collection and analysis were comprehensive to achieve data saturation, where no new information emerged from the participants.

- Cross-checking transcripts: To enhance credibility, 10% of randomly selected transcripts were verified with the interviewees to ensure accurate representation of their responses in the report.

- Use of validated vignettes and semi-structured interviews: The study employed established vignettes from previous research and conducted semi-structured interviews, ensuring consistency while tailoring the approach to each participant's unique characteristics (231).

By incorporating these measures, the study sought to enhance the trustworthiness and reliability of its findings.

In order to bolster the credibility of the study, a comprehensive and transparent account of the data collection and analysis processes is provided. This includes a detailed description of how sub-themes evolved into more abstract themes, along with the inclusion of relevant quotations to support the proposed interpretations (253,265).

To strengthen the validity of the findings, particular attention was given to negative cases or elements in the data that did not align with the emerging patterns. This critical examination allowed for a refinement of the identified patterns and ensured a more robust analysis.

Additionally, to ensure fair representation, a diverse range of perspectives was incorporated in the findings. This approach, known as fair dealing, helps to avoid over-representation of any single viewpoint, contributing to a more balanced and comprehensive study (249,251,252,324).

Furthermore, to enhance the overall credibility of the results, a process of peer debriefing was undertaken. Through discussions with a research supervisor, who was less involved in the analysis process, emerging themes and preliminary findings were scrutinised for external validation and consensus (252). This rigorous examination and validation process contribute to the overall reliability of the study's outcomes.

If participants are required to provide verbal protocols after finishing tasks, it is recommended that the verbalisation occurs promptly after the task is completed (325). In general, a concurrent thinking-aloud protocols are considered more valid compared to a retrospective report (325).

Quality of think-aloud protocol

To increase reliability and consistency of the thinking-aloud data, the following steps were taken:

- Along with the researcher's active presence and note-taking, a high-quality digital audio recorder was used to ensure accurate capturing of verbalised thoughts.

- Careful consideration was given to the researcher's instructions provided to the participants, ensuring they did not interfere with or alter the participants' cognitive processes while performing the tasks. For instance, using prompts like ‘please keep talking’ instead of phrases like ‘so why did you do that’ reduced interference.

- Participants were encouraged to articulate their thought process concurrently while performing the tasks, following the concurrent thinking-aloud protocol, rather than relying on retrospective descriptions.

- The transcription of the recorded sessions was carried out by the researcher, who is a native speaker of the participants' language and possesses a strong familiarity with the local Sheffield accent.

5.3.4 The role of the researcher

In qualitative studies, the researcher plays a significant role as both the instrument and producer of knowledge. This means that the researcher's background, beliefs, and values can potentially influence the data collection and analysis. Therefore, it is crucial to consider these aspects to understand how they may impact the researcher's interpretation of the findings.

In this specific study, the researcher's academic background in Computer Science and Mathematics could have influenced the entire research process, including the way they interpreted the data results. Despite efforts to remain impartial, there is a possibility that the researcher's unconscious biases, such as assuming the usability of certain apps, may have had some influence.

Another potential concern is that participants might provide answers that do not accurately reflect their true views or experiences. Sometimes, they might offer responses they believe the researcher expects or ones that would please the researcher. This could be due to social desirability bias, where participants want to be seen as embracing modern technology, even if they have reservations about using online symptom checkers in general practice.

To address these potential biases, the researcher took several measures. They informed all participants at the beginning of the interviews that there were no right or wrong answers, emphasising that they were interested in each individual's unique perspectives and experiences. Additionally, the researcher asked probing questions during the interviews to delve deeper into topics and obtain more accurate data.

Moreover, the researcher's knowledge and familiarity with the reality of general practice may have created a more comfortable and open environment for participants. This shared understanding likely encouraged participants to share and elaborate on their thoughts more freely than they would have with a researcher lacking such knowledge.

According to Guillemin & Heggen (326), establishing a good rapport and relationship with participants encourages them to provide more candid and open responses to open-ended questions. This approach also prompts participants to share spontaneous information, leading to deeper insights and enriching the data obtained.

To build rapport with the participants and establish a positive relationship, the researcher began the interviews with friendly small talk about general topics like life, weather, and their day. The researcher also shared some information about their own background and experiences, while being mindful of the participants' time. These ice breakers helped to build trust and create a comfortable atmosphere, encouraging the interviewees to freely express their true feelings and thoughts about the use of online symptom checkers in general practice.

During the interviews, the researcher maintained a neutral stance and refrained from expressing any personal opinions or beliefs about the use of online symptom checkers in general practice. This was done to prevent influencing or biasing the participants towards any specific viewpoints. To ensure objectivity, the researcher kept a record of their personal feelings in response to each interview, noting if these feelings might be affecting their interpretations or the recording of participants' responses consistently.

Furthermore, the researcher took additional steps to reduce potential bias. They regularly discussed the interview process, data collection, and findings with their PhD supervisor. This allowed for an outside perspective and served as a check to ensure the research was carried out objectively.

Despite efforts to reduce bias, the researcher's personal background and life circumstances may have influenced how they interpreted the data. This is because researchers might relate to certain aspects of participants' perspectives and experiences (327).

To encourage participant involvement with the online symptom checker and to gather their thoughts, the researchers used standard think-aloud prompts (328) during the think-aloud protocol. These prompts included gentle reminders (e.g., ‘what are you thinking now?’) when participants stayed silent for a long time or became distracted (309).

5.3.5 Piloting the interview and think-aloud protocol

In order to enhance the quality of the research, a preliminary face-to-face interview and usability test employing the think-aloud technique were carried out with three volunteers from the target population in a mutually convenient location.

The purpose of this exercise was to identify and resolve any issues related to the tasks and procedures of the study. Additionally, it aimed to ensure that the questions were formulated using language suitable for older adults, without complex medical terminology. The test also examined the appropriateness of audio and video settings, especially for participants with age-related hearing impairment, and aimed to identify any unforeseen technical problems. Timing issues, particularly during the think-aloud phase, were carefully observed. Furthermore, the remote interviews and usability testing were evaluated to determine if they aligned with the goals and objectives of the proposed study.

This main reasons for carrying out a pilot study were as follows:

- Ensure that the consent form and participant information sheet accurately conveyed intended information and was understood by older adults.
- Check how long participants needed to respond to questions.
- Assess if there are questions which could be removed from the interview guide, and likewise, if there is a need to rearrange question order or add new questions into the interview guide.
- Evaluate if the planned interviews met the aims and objectives.

The pilot study resulted a review of the interview schedules and questions to ensure their relevance and appropriateness for older adults, while also addressing the main objectives of the study and answering the research question. The pilot study resulted in modifications in the arrangement of the questions to foster a more natural and fluid conversation where questions seamlessly connect and relate to one another.

For example, the order of the following questions was changed:

'Do you feel the use of online symptom checkers gives you more (or less) control of your health? If so, how?'

'How do you feel about the use of online symptom checkers in general practice, as potentially the first point of contact for your health concerns?'

The wording of some questions was changed to make them more free-flowing and easier to understand. For example, 'In what ways might you benefit most from using online symptom checkers in general practice?' was changed to 'How can online symptom checkers in general practice benefit you the most?' Certain individual words and phrases were modified to improve clarity for the participants and promote open and unrestricted responses.

All three pilot interviews were completed within the anticipated timeframe. Recognising the time constraints of the main interview session, the researcher diligently managed time by utilising a digital stopwatch and allocating an appropriate amount of time for each question. The three pilot interviews were not included in the final count of thirteen interviews.

5.4 Data Analysis

The primary objectives of this study are twofold: firstly, to explore the experiences and attitudes of older adults towards using online symptom checkers in general medical practice and how these tools affect older patients. Secondly, the study aims to investigate the potential impact of online symptom checkers on the doctor-patient relationship. To achieve these goals, the researchers transcribed digital audio recordings of user interviews and think-aloud protocols.

These qualitative data were then subjected to a hybrid approach to thematic analysis as described and justified in section (4.6). Before starting the thematic analysis, the researchers performed preliminary analysis to collect demographic details like age and gender, but all personally identifiable information was removed to ensure ethical compliance. The transcripts were thoroughly read multiple times to familiarise the researchers with the content.

The initial draft codebook for deductive thematic analysis was informed by conceptual frameworks associated with the main outcomes of interest, as outlined in (329). These themes encompassed participants' general expectations regarding the use of online symptom checkers

in a general practice setting. Additionally, the study explored participants' perceptions, knowledge, and acceptability of online symptom checkers in the same context. Usability and usefulness concerns of the participants were also taken into consideration. Furthermore, the study aimed to understand how participants perceived the impact of online symptom checkers on the doctor-patient relationship.

The hybrid approach involved first conducting a top-down deductive thematic analysis, followed by a bottom-up inductive, data-driven process as suggested by (330). The initial draft codebook for deductive thematic analysis was informed by conceptual frameworks associated with the main outcomes of interest, as outlined in (329). To examine the dataset thoroughly, a systematic approach using splicing and linking techniques identified key themes and sub-themes relevant to the research questions, which were then explored inductively to uncover further insights. This systematic inductive assessment method allowed the researchers to identify additional overarching themes within the qualitative data.

To enhance the dependability of the qualitative results, 20% of the transcripts (331) which were randomly selected, were subjected to independent analysis by two researchers. The second researcher was a fellow PhD student. Through discussions, these researchers reached a mutual agreement on the coding framework. The primary researcher (IU) then utilised these standardised codes for the remaining transcripts.

Alongside the digital recording of the interviews, the researcher also maintained handwritten field notes. These notes captured significant observations, including any unusual or atypical occurrences, to offer a more comprehensive context for the data.

While there are limited guidelines available for determining non-probabilistic sample sizes, it is generally accepted that conducting 6-12 interviews is typically enough to achieve data saturation, as suggested by Guest et al. (223). In this study, data saturation was assessed after conducting research with 6 participants, and the iterative process of collecting and analysing data continued with each new participant until no new themes emerged.

To facilitate coding, analysis, and gaining insights from qualitative data, NVivo (QSR International Pty Ltd) software (332) was utilised.

The study identified UX barriers and solutions, as well as suggested strategies to enhance the adoption of online symptom checkers. These findings were separately analysed and integrated into the results of Study 4.

5.5 Ethical issues

Prior to commencing this study, ethical approval was obtained from the ethics committees at the School of Health and Related Research (SCHARR) of the University of Sheffield (see Appendix 5).

Participant recruitment was conducted in the general population but was not under the purview of the NHS, thus exempt from NHS ethics. Nevertheless, since the study involved working with vulnerable older adults, strict adherence was followed to Sheffield University's ethics guidelines for research involving vulnerable participants (333). Detailed information regarding potential adverse events, potential harm to participants, and participant vulnerability can be found in the appendices (Appendix 4).

Informed consent

In this study, all participants were given full and accurate information about the research before providing their consent. The informed consent process involved the following key steps:

- Participants were provided with all the study materials, including the consent form and information sheet.

- Participants demonstrated a clear understanding of the study's purpose, as well as the potential benefits and risks of their participation. Participants' understanding of the consent document was checked with simple questions.

- Participants were aware of their roles in the study and understood what was expected of them.

- Throughout the process, participants had multiple opportunities to ask questions and seek clarifications. They received satisfactory answers in a manner that was easy for them to comprehend. On the day of the consent, they were given further chances to ask any remaining questions.

- Participants were informed about the study's complete details, including the timeline and the tools and equipment that would be used, such as a video camera.

- Participants were made aware of their rights to withdraw from the study at any time and to request access to or deletion of their data.

While older adults preferred paper forms, some used the online platform to give consent. Each participant received a digital copy for their records.

Data recording procedures

At the outset of the interview, explicit consent was obtained from all participants before commencing the recording. Participants were given the opportunity to raise any queries or concerns prior to proceeding with the interview. In addition to audio recordings, which were preferred over note-taking due to their higher accuracy (334), the researcher also took handwritten notes to record non-verbal cues, such as body language, and immediate reflections following the interview.

5.6 Assumptions, risks, limitations and mitigation

The present study faced some distinct risks and assumptions, which will be outlined below.

Covid-19 risks and implications

Given that older individuals were at the highest risk of vulnerability to the coronavirus (Covid-19), virtual interviews were introduced as an alternative option to in-person meetings. The objective was to minimise the risks associated with the virus for this high-risk group.

Challenges of conducting interviews with older adults

Conducting interviews with older adults can present unique challenges due to various factors such as age-related changes, health issues, and generational differences. To address these challenges, age-sensitive interviewing techniques and tips from the literature were applied (335–337). This included being patient, building rapport, and using clear communication with older adult participants.

Older adults exhibit varying levels of technological proficiency. While some are adept and actively engage in online interviews, others may struggle due to limited familiarity or health-related constraints. To tackle this issue, researchers made efforts to recruit participants from diverse sources and backgrounds. They also provided sanitised IT equipment, such as iPads with previous data erased, to ensure a level playing field for all participants. Additionally, participants' family members were encouraged to assist with the online setup when possible.

5.6.1 Privacy and Confidentiality

Compared to face-to-face interviews, the online nature of the format posed a challenge in maintaining complete control over the physical environment of participants, as there were possibilities of interruptions or the presence of others (such as caregivers) in the background. This situation had the potential to compromise participant confidentiality. The researcher scheduled interview times that were convenient and least likely to have disturbances, which necessitated flexibility on the part of the researcher.

In conducting online interviews, ensuring strict confidentiality posed a significant challenge. To address this, researchers chose the Google Meet video conferencing platform for its secure environment. Before implementation, the platform underwent a thorough risk assessment and received approval from Sheffield University IT services, ensuring compliance with security standards

Reduction in non-verbal cues

When conducting interviews, it is easy to overlook or misinterpret both visual and non-verbal cues. By recording the interview and taking notes, the researcher has the opportunity to review the interview and identify any missed cues.

5.6.2 IT equipment challenges

The study made assumptions about older adults having the necessary IT equipment, like smartphones or tablets with internet connectivity. However, it's important to note that poverty is common among older individuals, which needs careful consideration. To address this concern, participants were made aware of the availability of sanitised iPads and internet dongles provided by the researcher's research group (338) to mitigate the issue.

Video calls posed typical challenges, such as technical difficulties leading to video feed interruptions. This could increase participants' online insecurity and stress. To counter this, the study allocated sufficient time in interviews and test sessions to resolve any technical problems that arose.

Think-aloud protocol

Due to the higher prevalence of fatigue among older individuals (285), there was a potential risk of user fatigue during the think-aloud exercise tasks. To address this concern, the think-aloud exercise was intentionally limited to a 30-minute duration, and only one randomly selected vignette was used. The vignettes themselves were intentionally designed to be easy to follow, with clearly defined steps.

The study followed the recommendations and guidelines outlined in the literature for conducting moderated remote usability testing, including challenges and strategies for addressing them (339,340). To ensure participants understood the think-aloud exercise clearly and to prevent any potential confusion, the introductory materials provided a chance for participants to practice a mock exercise involving screen sharing. Additionally, the study adhered to the recommendations and guidelines (341) provided for conducting moderated remote usability testing.

Building rapport and presence

To cultivate a positive rapport, the interviewer adopted a professional appearance and strategically blurred the background to minimise distractions. Additionally, they maintained clear and articulate speech to demonstrate a sense of presence and cultivate a strong rapport with the participants. In the context of participant engagement, establishing a connection with individuals was found to be more demanding when conducted through remote platforms as opposed to face-to-face interactions. Despite this difficulty, remote interactions provided the benefit of better discerning non-verbal cues, as body language became more observable.

5.7 Results

Participants

A total of 13 older adults were interviewed over a period of 2 months until data saturation was achieved. The participants included 4 females and 9 males, with an average age of 68 years. Male participants had an average age of 67, while female participants had an average age of 72 (see Table 11). The interviews lasted, on average, just over 2 hours.

Regarding ethnic background, 31% of the participants (4 out of 13) came from a BAME (Black, Asian, and Minority Ethnic) background, which was notably higher than the national UK average of 16% (306). However, 69% of the participants (9 out of 13) were from a white British ethnic background, which was lower than the UK population average of 85%.

Nearly one in four participants (23%) spoke English as a second language, which contrasts with 91.1% of the UK population who spoke English as their primary language.

The recruitment process involved the use of snowball sampling, with the most common method being recruitment through word of mouth (31%), followed by recruitment through local voluntary organisations and response to social media advertisements in community pages. All participants had prior experience using Doctorlink.

Participant Characteristics

Pseudonym	*Gender*	*Age*	*Ethnic Origin*	*Language*	*Recruited via*	*Online Symptom Checker*
P1	*Female*	*66*	*British Pakistani*	*English 2nd language*	*Roshni Asian Womens Resource Centre*	*Doctorlink*
P2	*Male*	*77*	*White British*	*English*	*Local Foodbank*	*Doctorlink*
P3	*Male*	*62*	*White British*	*English*	*Word of mouth*	*Doctorlink*
P4	*Male*	*68*	*British Bangladeshi*	*English 2nd language*	*Local Mosque*	*Doctorlink*
P5	*Female*	*66*	*White British*	*English*	*Social Media*	*Doctorlink*
P6	*Male*	*67*	*White British*	*English*	*Social Media*	*Doctorlink*
P7	*Male*	*69*	*British Pakistani*	*English*	*Thalassaemia South Yorkshire*	*Doctorlink*
P8	*Male*	*65*	*White British*	*English*	*Word of mouth*	*Doctorlink*
P9	*Male*	*67*	*White Scottish*	*English*	*Labour party*	*Doctorlink*
P10	*Female*	*72*	*White English*	*English*	*Word of mouth*	*Doctorlink*
P11	*Male*	*65*	*British Bangladeshi*	*English 2nd language*	*Local Mosque*	*Doctorlink*
P12	*Male*	*61*	*White British*	*English*	*Word of mouth*	*Doctorlink*
P13	*Female*	*82*	*White British*	*English*	*Labour party*	*Doctorlink*

Table 11: Characteristics of the older adult's sample

5.7.1 Result of Thematic Analysis

The thematic analysis results are divided into three sections. The first section discusses older adults' views on using online symptom checkers in general practice. The second section focuses on how online symptom checkers affect older adults. The third section explores the potential impact of online symptom checkers on the doctor-patient relationship.

To establish the coding framework, major themes and sub-themes were developed as the foundation. These are as follows:

- Views and attitudes of older adults toward the use of online symptom checkers in general practice, including a topic related to the impact of Covid-19.
- The impact on general practice derived from the experiences of older adults, with sub-themes related to the advantages and disadvantages of using online symptom checkers, as well as broader impacts on general practice.
- The impact on the doctor-patient relationship from the perspectives of older adults, including a sub-topic on the implications of changes in general practice.

These are presented in Table 12, showing the key emergent themes and sub-themes identified from interviews with older adults and their think-aloud protocols.

An outline of the results now follows.

Theme	Sub-theme	Topics
General views and attitudes	Introduction of SC in general practice	• General technology • Online symptom checkers • Access to technology • Emotions • Covid-19 impact

Impact in general practice	Perceived advantages and disadvantages	• Manage own health • Personalised treatment • Travel time to GP • Unnecessary visits to GP • Disclosure of health information • Access and timeliness to care • Diagnostic accuracy
	Broader impacts in general practice	• Healthcare quality • Health inequalities
Doctor-patient (dr-pt) relationship	Impact on dr-pt relationship	• Importance of dr-pt relationship • Adversely impact dr-pt • Enhance dr-pt
	Implication of dr-pt changes	• Trust • Interaction • Power-dynamics • Regards • Adherence to treatment • Relationship formed with online symptom checkers

Table 12: Older adults' themes

5.7.2 Older adults' attitudes towards online symptom checkers in general practice

This section explores the overall opinions and perspectives of older individuals regarding the use of online symptom checkers in general practice. The interview session commenced with questions about the attitudes of older adults towards health-related technology in general, followed by specific questions about their views on the practicality and usefulness of online symptom checkers in a general medical setting.

General attitude towards health technology

Many older adults mentioned that, while they were generally cautious, they were open to trying new technologies, including mobile health apps, particularly if they have been in existence for a few years and have gained widespread popularity.

'Generally, yes, after the technology has been around for a few years and is mainstream, I am willing to give it a go' [P3]

'I'm a little tiny bit technology phobic, but not terrible. You know, if I can see that, it's in my interest, I will give it a go' [P5]

While a few considered themselves 'early adopters' most preferred to wait until a technology became popular before considering it if they even considered it at all. Some relied on younger family members to keep them informed about modern technologies. One participant liked using technology in healthcare and considered himself an early adopter in some respects, but he was cautious about trying new health technologies if their benefits were unclear.

'You could say, early adopter' [P7]

On the other hand, some participants expressed hesitancy in embracing new technologies, saying it's beyond their generation and era.

'I think the answer to that one, I'm not from the digital age' [P9]

Some participants pointed out that they rarely attempt to use new health apps due to the significant difficulty they face in operating both the smartphone devices and the apps.

'No actually because I'm bit old. I'm old fashioned. And it's hard for me to use phones. So it's hard to get used to the new apps' [P4]

'Because it's too hard for me to try that [apps]' [P11]

While many older adult participants expressed a willingness to give new technologies a chance, the majority also indicated that they have not yet integrated health technology into their daily lives. The most common response when asked about trying new technologies was 'not very often' or 'not as often as I should.'

'Once a year, maybe?' [P10]

'Not very often' [P12]

One participant specifically mentioned that she does not perceive a need to use or familiarise herself with new advanced technologies because she already manages well using a combination of traditional and existing technological tools.

'At the moment, I don't think I would bother with new technologies. Surely I can manage…without trying to learn new ones' [P13]

However, a participant who openly admitted to being a technology enthusiast reported that he actively seeks to learn about potentially useful technologies from the early stages of development.

'New to the world, but not new to me' [P6]

Many older adult participants viewed online symptom checkers as inherently safer and better regulated compared to, for example, searching for health information on Google. One

participant specifically pointed out that using Google could lead to unreliable search results, including potentially risky alternative health practices. In contrast, online symptom checkers provide health information that has been pre-verified by qualified doctors and medical experts.

'I think it is (online symptom checkers) more trustworthy. I think when I'm using Google search its bit risky. I don't know what to believe' [P1]

'What I don't like is getting all the quote unquote, alternative health solutions, coming up online.' [P6]

Although Google can yield contradictory and misleading search results, some participants felt that Googling can occasionally provide quicker guidance, especially in emergency situations, compared to online symptom checkers that require users to go through a lengthy series of questions before producing an outcome.

'I think when you check something on Google, it comes straight away' [P1]

Instead of using Google for medical advice, a few participants have stated that they prefer to visit specific recommended websites such as the NHS or well-known American sites like WebMD (53). Notably, some participants mentioned that they seldom search for health information online, which limits their ability to make comparisons. Additionally, one participant shared that due to their chronic health conditions (e.g., Parkinson's disease (342)), they are physically unable to access any form of online health information.

'So, I can't compare it because I don't go googling things' [P2]

'So for me, I got health problems. So I can't do it. I can't even keep my hand still for too long' [P11]

Attitude towards online symptom checkers

The older adult participants' attitude towards the use of online symptom checkers in general practice was predominantly negative rather than positive. Regarding the benefits, a considerable number of participants regarded the application as more reliable and secure compared to searching for health information online, given that it is maintained and managed by experts.

'The immediate thought is, they've probably got a long way to go. But the other bit is that lots of people now search online. So you know, it would be quite nice if we had something that was maintained and managed properly, and reliably' [P6]

Some participants mentioned that if the tool effectively fulfilled its intended purpose, they would not have to rely on doctors as frequently, either for themselves or their family members, especially for minor ailments.

'Very helpful for somebody like my dad, who would have had lots of symptoms, and worried about them. Whereas I can see that something like this potentially, could give him helpful feedback and pointers' [P5]

Many participants expressed concerns about the reliability of triage advice provided by online symptom checkers in comparison to that of a qualified human general practitioner. Many participants regarded the online service as substandard in comparison to seeking advice directly from their GP in a face-to-face consultation, with one participant perceiving it as being more oriented towards benefiting the doctors rather than the patients.

'This online symptom checker, I would not rely on it because I'd rather see my doctor face to face. I would get a better check-up and all that, better result' [P11]

Chapter 7 will delve further into the various barriers older adults face in terms of usability and access when utilising online symptom checkers in general practice.

5.7.3 Access to technology

Except for one participant, all older adults interviewed stated that online symptom checkers require technology that they may not possess. Many mentioned their peers' lack of devices like smartphones, hindering their use of online symptom checkers.

'A lot of my friends still do not have smartphones' [P3]

Moreover, some stressed that many older adults, especially pensioners, living in poverty would struggle to afford IT devices and internet connectivity due to the ongoing cost-of-living crisis.

'Definitely you need the free Wi Fi because what's happening on the wallet is too expensive' [P4]

'Now, since we've got this cost-of-living crisis. People are literally worrying about topping up their meters. And if that's the case, it's a struggle, but it's a choice to use online symptom checkers' [P7]

Nevertheless, a self-proclaimed technology enthusiast among the participants pointed out that the perception of technology's impact varies based on the age of older adults. He emphasised that individuals in their early 60s exhibit notable distinctions from those in their late 80s.

'It depends how old the older adults are, you know, we all think oh, that is 60 to 75? I'd say it's a different group from 75 to 100. Totally different. And even then, you know, 95 to 100 is very different from yours' [P6]

5.7.4 Emotions associated with the use of online symptom checkers

During the interviews, older adults conveyed a broad spectrum of emotions, largely negative, regarding the use of online symptom checkers in general practice setting. The majority of older adults found the lengthy procedure of inputting symptoms into the online tool to be cumbersome and labouring, especially when compared to the alternative of contacting or visiting their GP surgery. Additionally, some older adults found the protracted process of eliminating potential diagnoses to be frustrating.

'Usually frustrating' [P6]

'Well, to begin with, frustrating' [P10]

Furthermore, certain individuals felt that the questioning posed by the online symptom checker lacked human-like qualities and appeared robotic, in contrast to the interpersonal skills exhibited by a human GP.

'There's no feeling of contact with a human being' [P10]

A significant number of participants voiced concerns and unease regarding the requirement of precise description of symptoms and accurate inputting of information into the online symptom checker. They were worried that incorrect inputs could potentially result in a delay in receiving appropriate medical treatment. Several participants found certain questions, including the presence of medical terminology, to be confusing. This confusion sometimes deterred them from using online symptom checkers altogether.

'Worried about my health, you know, when something is happening to you. Lengthy questions can cause confusion' [P1]

'I was confused. I don't know what to do. I don't know what to say, what term they are using. It's a doctor term. I hardly understand what they are saying [on the app]' [P11]

Some older adult participants expressed their fear of using online symptom checkers, fearing that they might receive false red flags. They were concerned that such false alarms could unnecessarily contribute to additional stress and anxiety, especially when they are already feeling unwell.

'If I'm honest I was a little scared that it will give me a bad result putting in these symptoms…causes me anxiety' [P3]

One participant mentioned that the triage outcomes did not align with their expectations, leading to a loss of confidence in the application.

'It was just a waste of my time. And it was quite sad really all this technology, you know, putting your finger on screen it could cure you, you know, but it doesn't. Your just told at the end of it, you know to contact your GP, it's quite deflating' [P2]

5.7.5 Covid-19 impact

Despite the Covid-19 restrictions that limited access to GP surgeries, older adults still exhibited relatively low levels of usage of online symptom checkers. Many of the interviewed older adults mentioned that they were unaware of the service introduced within the triage pathway during the pandemic, particularly at the beginning, until they were directed to it by surgery staff or family members.

'To check the symptoms of Covid-19. Actually, I did after four days of coughing, runny nose etc., I wanted to check for Covid' [P5]

Older adults had mixed experiences using Covid-19 symptom checkers, with varying levels of success and satisfaction. Some appreciated the benefits of these automated tools, recognising their role in minimising virus spread compared to visiting a GP in-person.

'If it had said, you've probably got Covid Stay at home. That would have saved the GP potentially getting Covid?' [P5]

'I used them during Covid' [P8]

Some older adults noted that using online symptom checkers during the pandemic motivated them to get the Covid-19 vaccine.

'I did actually go to have my last booster for Covid which was about four or five months ago' [P13]

However, some participants refrained from using online symptom checkers for Covid-19 due to the lengthy process and difficulties in understanding some of the questions. One participant expressed frustration that the app did not thoroughly enquire about specific Covid-19 symptoms.

'It doesn't seem to link to whether or not it's night or day. I've had a bit of a temperature or but that doesn't mention having a temperature' [P5]

Furthermore, another participant mentioned that the repetitive recounting of their symptoms on the app, followed by discussions with healthcare professionals, was highly annoying and off-putting.

'You shouldn't have to explain everything over and over again' [P8]

Out of all the participants, only one continued to use the service as soon as the restrictions were lifted, while the majority reverted to the traditional method of accessing their GP services.

5.7.6 Impact in general practice with older adults

Advantages and disadvantages

This section presents the advantages and disadvantages of using online symptom checkers in general practice from the perspectives of older adults. It also includes references to conflicting viewpoints among the older adult participants.

Overall observations

The majority of older adult participants disagreed with the perceived benefits of using online symptom checkers for patients, as adapted from (319), to be rated and applied in the context of general practice (see Appendix 6 and 13). However, notably, all older adult participants agreed with the perceived challenges associated with using online symptom checkers for patients.

Manage own health

The majority of older adult participants who were interviewed expressed the belief that online symptom checkers do not effectively assist patients in improving their own health management. Most of the older adult participants strongly believed that online symptom checkers are insufficient in adequately addressing the complete range of patients' needs. Older adults emphasised that managing their health requires guidance and input from their GP, and technology alone cannot provide the solution.

Some older adults further explained that online symptom checkers do not take into account their current health conditions or medical history, which makes them unable to effectively manage their health.

'I have a history of illnesses. That history always linked to my current conditions. And the symptom checker won't be able to take that into account. So, I need to speak to my GP to get that across' [P3]

'To the full extent of my healthcare needs? I'm gonna say neutral. I don't think I can judge that or what I've seen so far' [P6]

A few participants mentioned that these automated tools fail to provide the reassurance they typically receive from their GP and, in some cases, can even cause unnecessary panic and anxiety, making self-health management more difficult. However, a few participants also acknowledged that their anxiety about online symptom checkers was partly due to their limited experience with using them.

'In the current form, it might increase anxiety of users. Poor overcrowded NHS system could save them time. But it could also be a problem if it's creating a lot more panic than needed' [P5]

On the other hand, some participants believed that utilising health apps could help them take control of specific aspects of their health from the comfort of their homes. In particular, one participant mentioned that such a tool offered them additional options to explore and address

their health concerns, complementing the existing methods and online resources available to them.

'It would give options for what you needed to do. And I think it could be really brilliant' [P5]

Personalised treatment

Based on the responses, many older adult participants did not believe that online symptom checkers could offer personalised treatment. They felt that the health advice provided by online symptom checkers were generic, lacking the tailored triage necessary for individual patients. Some older adults found a significant portion of the questions to be generic and unrelated to their specific health concerns.

All the older adults interviewed unanimously agreed that online symptom checkers were incapable of understanding or displaying human emotions which would have, in their view, helped to personalise their treatment. When asked to elaborate further on why online symptom checkers cannot offer personalised treatment, many older adult participants expressed that they could not imagine it based on their experiences with online symptom checkers thus far.

'I think this is more a provides general advice rather than something specific' [P3]

'Because a lot of questions are not applicable or they don't fit in. You know, they're not 100% accurate?' [P10]

Furthermore, a few older adult participants highlighted that at the end of the consultation, the online symptom checkers typically directed them to their GP, which they felt did not constitute personalised treatment. One participant mentioned that the online symptom checkers did not offer any actual treatment. From their perspective, the online symptom checker's triage recommendations suggested visiting the nearest A&E department if the patient had X. However, it didn't clarify if the patient truly had X, leaving the decision-making responsibility to the patient.

'What we're doing this for, only to be told to make an appointment with a doctors? ' [P2]

Travel time to GP and health care providers

There were mixed opinions among older adults regarding online symptom checkers' impact on reducing travel time to their GP. Some believed it could save time but did not elaborate, while a few mentioned it could be beneficial if the online symptom checker accurately assessed their condition and directed them to other healthcare providers, like A&E, without visiting their GP first. One participant shared an example of how it could save a GP visit, especially for mild Covid, and help prevent virus spread.

'If they are telling you to go to hospital then yeah. But if it's something you've got to go to a GP, it's not gone reduce any travel time' [P2]

'I mean, it would all depend on what the symptoms were. So my example, if it had said, you've probably got Covid, stay at home. That would have saved the GP potentially getting Covid?' [P5]

However, some participants believed that it would not reduce travel time because patients are often advised to visit their GP surgery.

'Because we still have go down to the surgery' [P9]

One participant mentioned living near their GP surgery, so it would not affect their travel time.

'My GP 50 metres from my house' [P8]

Time to use online symptom checkers

The majority of older adults found online symptom checkers time-consuming. Some believed that using them should be faster than contacting their GP for a recommendation, but this was not the case. One participant occasionally gave up midway due to the lengthy process and their mood influenced their willingness to continue.

'Well, if I'm sitting at home, you know, and miserable and I could be doing it, you know, so then time isn't an issue. Except that if I get fed up with it, yeah, partway through, you know, if it's taking too long, and I'm feeling tired and grumpy and all the rest of it, then I might well not go forward with it' [P10]

' I think it did take a long time to use' [P13]

Another participant mentioned that app crashes added to the overall time-consuming experience.

'I thought it wasn't too long when the app was running when it didn't crash' [P3]

Unnecessary visits to GP and health care providers

In general, older adult participants who took part in the study shared the opinion that online symptom checkers are ineffective in preventing unnecessary visits to GP and other healthcare providers. Moreover, many of these older participants emphasised that online symptom checkers lack access to their medical records, which causes them to continue relying on their GP surgery as their main point of contact. Some participants also mentioned that online symptom checkers do not provide them with the level of reassurance they need, unlike their GP. Importantly, one participant noted that even if the online symptom checker suggested otherwise, they would still consider consulting their GP.

'I want to speak to someone because I want reassurance. That history always linked to my current conditions and the symptom checker won't be able to take that into account' [P3]

'I know several friends who if they were told they had to go to A&E would still want to talk to their GP first' [P3]

'I know when I need to visit GP, do not need an app to tell me the answer' [P8]

A few participants suggested that use of online symptom checkers could potentially reduce the need for visits related to minor ailments.

'Because if it's only minor, you're worried and you can go check at home and that's it. You're not going to see the doctor then. Its helps' [P1]

However, one participant mentioned that using online symptom checkers might indeed discourage visits to the GP surgery, but they also acknowledged that some of those visits might have been necessary, perceiving it as a disadvantage.

'I'm thinking it will force people not to make those trips. Rather than it being an advantage. You see what I mean? [P7]

Disclosure of health information

Many older adults believe patients prefer sharing information with a GP rather than an online symptom checker. They have trust issues and express concerns about the privacy, confidentiality, and security of their data. They worry about potential data breaches when using online symptom checkers. These concerns make older adults less likely to share information with online symptom checkers. Some also feel that having to input their symptoms from a narrow choice limits the information they disclose. A few participants were reluctant to disclose information to online symptom checkers due to potential unauthorised sale of their data to third-party companies without consent.

'These apps, you know, sometimes they hack your data, and you know, these things happen. It can be leaked. So that's what why I'm worried about it' [P1]

'I'd rather believe a doctor than a machine that might have got it wrong' [P2]

'I am not comfortable with it because I don't know where my data will be stored. Whereas with the doctor, I have the patient doctor confidentiality' [P3]

A few participants mentioned that their decision to disclose health concerns depends on the nature of the issue.

'I think it depends so much [on the issue]' [P6]

One participant stated that if the matter is highly sensitive or confidential, they would only share it with a GP.

'I just want to see the GP and talk to the GP about it' [P6]

A few participants mentioned that their individual interaction with the application would not compromise their privacy.

'Yeah, well, you're on your own' [P9]

Nevertheless, a small number of individuals expressed that they were not excessively worried since they already face a significant risk of data breaches due to their use of technology and their current healthcare provider. Additionally, some participants believed that privacy was a lesser concern for them when it came to seeking medical help from healthcare practitioners or using mHealth applications.

'Well, I don't see talking to a doctor as invading my privacy' [P10]

'I wouldn't care about privacy if it was my health' [P5]

Access and timeliness to care

The older adults expressed diverse opinions regarding whether online symptom checkers could enhance access to and timeliness of care. Those who were sceptical mentioned that they still had to consult a general practitioner or healthcare professional in the majority of cases. As a result, they considered the use of online symptom checkers as a possible waste of time rather than a method for improving the timeliness of care.

'It's not helping, because you still got to go back to square one, which you could have done 20 minutes before you started doing the app. You could have picked up the phone, listened to some crappy music and talk to a health care professional' [P2]

Diagnostic accuracy and reliability

The majority of older adults found online symptom checkers lacking in intelligence and knowledge to evaluate patients accurately. Some acknowledged a certain level of "computer" intelligence but believed it fell short of their expectations. Participants expressed frustration with generic and irrelevant questions and felt that the intelligence of these tools relied solely on patient input. They highlighted limitations such as the inability to conduct physical examinations or access medical records, which compromised the accuracy of assessments. One participant noted the lack of nuance in the questions, hindering accurate diagnoses. Another mentioned the option of using Google for obtaining similar health information, which they deemed quicker and easier than using the online symptom checker.

'It's got intelligence because it's on a computer thing. But it's not accurately assessing patients… they're not going to say to me lift your shirt up and let me have a look. And that's what your doctors are gonna do. It's always intelligent as the person's punching the symptoms into the thing'' [P2]

'It doesn't have the full history of other conditions that people may have had in the past or currently' [P3]

'But not only because it's not subtle enough as it currently is' [P5]

5.7.7 Broader impacts in general practice

Healthcare quality

Most older adults felt online symptom checkers did not improve their healthcare quality. Some mentioned the lack of a human element and how simply directing patients where to seek help did not enhance their care. They believed healthcare professionals' expertise and professionalism were crucial for quality care.

'It's missing that human factor. So, telling us how to go to somewhere doesn't affect the quality of the care in my opinion' [P3]

However, a few participants saw potential in online symptom checkers when integrated with GP practices. They believed these tools could help address health concerns promptly, saving time for both themselves and their GP.

'I'd say agree, with the caveat that assuming it's integrated into the health service and the GPs practice and things like that' [P6]

One participant even mentioned that it could empower them with medical vocabulary to effectively communicate with their GP, leading to improved care over time.

'And it would give me more vocabularies about how to talk about health' [P5]

However, many older adults found online symptom checkers to offer insufficient health advice. Some participants criticised these tools for frequently recommending visits to the emergency department, which they deemed unreliable guidance. Others complained about ambiguous triage outcomes and a broad range of health conditions, which they found unhelpful. While some participants admitted lacking experience to judge, one person speculated that these tools could potentially improve healthcare quality in the future.

'I think if it is an emergency case then the app should advise go to the A&E, but I think it says go A&E all the time which is not right' [P1]

'I haven't had enough experience to make up my mind on that' [P3]

Health inequalities

The majority of older adults believe that online symptom checkers will not alleviate health disparities in general practice. Many see online symptom checkers as an added barrier for older adults to access healthcare, especially if they are the only means of reaching a GP service without other options.

'It could increase the inequalities. If that was a sort of gatekeeper' [P5]

Older adults face unique accessibility challenges, such as visual impairments and affordability of technology, which significantly disadvantage them compared to younger patients. This situation makes it even harder for older adults to access GP services and could further increase health inequalities.

'If it became a barrier that you had to go through, then it would actually yes. Then it would increase the inequality. But young people would find it easy to go' [P10]

One participant suggested that better healthcare support would encourage older adults to use online symptom checkers more, reducing health inequalities. However, some older adults felt that increasing the number of GPs was essential to address health inequalities, rather than relying solely on an advisory app.

'We need more GPs, not a symptom checker. Just telling us to go to A&E is not helpful' [P3]

'So actually, it may mean that the practice has more time to deal with people who need a bit more serious health concerns' [P6]

5.8 Impact on doctor-patient relationship

A significant number of older adults who were interviewed expressed concerns about the negative effects of using online symptom checkers on the relationship between doctors and patients. The majority of older adults indicated that fundamental aspects of the doctor-patient relationship would be negatively influenced, including the power dynamics between them. However, further examination of these issues will be provided in subsequent sections.

According to older adults, the use of online symptom checkers could lead to a decrease in in-person appointments. They believe this could negatively impact the consistency of healthcare and diminish certain interpersonal elements of consultations that are vital for developing relationships.

The majority of participants emphasised the significance of trust in fostering a positive doctor-patient relationship. They expressed that this trust is established gradually over time through consistent interactions with a familiar doctor whom they have seen before.

'Well, it's to do with trust. And trust is sort of built up on a number of different things. They got to give me the time that I need. And they look like they're listening.' [P6]

Several older adults expressed the importance of openly discussing their health condition and being heard, but they also emphasised the significance of participating in the decision-making process and engaging in conversations about their prognosis with the doctor. This active involvement positively impacted their doctor-patient relationship.

'I want to be treated as an adult. And to have things discussed and talk through, so I'm part of the decision making in whatever care plan' [P1]

Some older adults also highlighted the significance of a doctor's kindness and compassion in their doctor-patient relationship. They believed that the caring and empathetic nature displayed by doctors held a special value, surpassing what online symptom checkers could provide in terms of reassurance through personal interaction and verbal confirmation.

'Good doctoring is medicine plus kindness. And that's what I think, is the sort of thing that doctors should be after. And it's a bit hard for an app like this to do that kindness' [P5]

A few older adults indicated that their doctor being aware of their previous medical background and tailoring the consultation to their specific healthcare needs had a positive impact on their relationship with the doctor.

'Having that length of time to get to know my history, and my prior past health issues and current health issues and just being you know, being able to talk to human being and give my concerns in private and in full trust, that they will use that to give me a diagnosis. Having a familiar face to go and see every time that creates a relationship over time' [P3]

5.8.1 Importance of the doctor-patient relationship

Most of the older adults interviewed expressed the significance of the doctor-patient relationship and held it in high regard. Some older adults noted that a strong relationship with their doctor provided them with added assurance and self-assurance. One participant highlighted the importance of this relationship, considering their health issues and frequent visits to their general practitioner, stating that it may be one of the most crucial connections they have during their later years.

'Because of my health concern, my doctor is one of the most important people in my life, of course. So, for me, it's very important that I keep up to date and any concerns that I have I go and see my GP as soon as I can, and then they can give me a reassurance or guide me to the relevant specialist that I need' [P3]

'I've always liked doctors that I've seen. And I always trust doctors. So yeah, I think it is important that you like your doctor' [P5]

However, some older adult participating in the study expressed their concerns regarding the increasing difficulty of maintaining consistent visits with the same doctor, which they believe was more prevalent in the past. Moreover, they felt overwhelmed by the involvement of numerous healthcare professionals, which created a fragmented system that hindered the development of a strong doctor-patient relationship. As a result, they observed and felt a gradual erosion of the doctor-patient relationship, and they believe that the utilisation of online symptom checkers will only intensify this issue.

'Well, one of the problems is when you go to a doctor practice, you get the next available doctor. Yeah, so you don't actually build up our patient doctor relationship. So you know, when I had my blood pressure thing, I seen somebody down at the surgery, somebody else phoned me up what to do about it, and then somebody else will ring up about the results of them. So it wasn't necessarily built up over. Whereas when I was younger, I had the same doctor from when I was eight' [P9]

Adversely impact the doctor-patient relationships

Most older adults who were interviewed expressed concerns about the use of online symptom checkers in general medical practice, believing that it would have a negative impact on their relationship with their doctor. While many acknowledged that the integration of such technology would eventually become unavoidable, they felt that the current versions of online symptom checkers would create additional barriers for them and other individuals in their age group when trying to access healthcare services from their GP. Consequently, this would likely lead to a decrease in face-to-face interactions between older adults and their GPs, which they believed would harm the doctor-patient relationship.

'I can just see as for me creating an additional barrier that I don't really want' [P3]

'It won't improve the relationship. You have to feel confident that you can contact the GP and they can help you' [P8]

Some older adults even mentioned that apart from the adverse effects on the doctor-patient relationship, reduced contact with their GP could have detrimental effects on their mental health, potentially exacerbating feelings of loneliness and social isolation among older individuals.

'There's a mental health crisis alongside all of this' [P7]

'What if I had got mental health. That's telling me wait another seven days, I may become suicidal.' [P2]

'The first person that might have supported you might have been the reception at the doctors. Yes, you're taking that away from them as well and it doesn't help relationships.' [P8]

Enhancing the doctor-patient relationship

However, a small number of participants expressed that if alternative options were available alongside online symptom checkers, it could improve their relationship with their doctors. One

participant emphasised that using online symptom checkers could empower patients by providing them with more knowledge about their potential health conditions and the field of healthcare. This knowledge could then be utilised during their consultations, allowing patients to be better informed. The participant believed that a well-informed patient would require less time for the doctor to arrive at a diagnosis, thereby enabling the doctor to allocate more time to address the patient's emotional needs. As a result, the doctor-patient relationship would be strengthened. Another participant stated that contrary to popular belief, the online symptom checkers' cautious approach of recommending patients to see their doctors would actually increase contact with GPs. In their opinion, this increase in contact would not only enhance the doctor-patient relationship but also facilitate the early identification of health conditions.

'If it saves the doctor time. So, they don't have to start from a very early stage of information, then that's good, because it means that they already have a bit of an idea of what's going on with you [..] and that will help the doctor to be kinder and more thoughtful and adapt what they're saying to the kind of emotional needs of the patient' [P5]

Trust

The majority of older adults stated that their trust in their GP would not be impacted by the use of online symptom checkers in general medical practice. Many older adults expressed their lack of complete trust in an automated computer program compared to the expert judgment and advice of their GP. In contrast to online symptom checkers, older adults pointed out that GPs not only have access to their medical records but also possess medical instruments for physical examinations, along with years of training and practical experience. Due to their high level of trust in their GP, older adults believed that they would be more compliant with treatment recommendations during a face-to-face consultation with their GP rather than relying on online symptom checkers. One participant emphasised that both the patient and the GPs must have trust in the application for it to be beneficial in general medical practice.

'I'd be more likely to trust the judgement of professional with X amount of years' experience over a generic computer programme' [P3]

'I don't think it would affect it. But, in the end, it would be the app that I would not trust' [P10]

'Trust the human being more than I trust the computer' [P8]

Interaction and communication

The majority of older adult participants believed that incorporating online symptom checkers in general practice would likely impact their interaction and communication with their general practitioners. While many older adults thought it would lead to changes and a decrease in personal communication with their GPs, some older adults had a contrasting view, believing that their overall interaction and communication with their GPs would improve. However, there was one older adult who expressed concerns about losing the traditional form of communication and interaction with their GP, fearing it would be replaced by a more functional and transactional approach facilitated by online symptom checkers.

'It will change interaction' [P1]

'*It might give me more words to use. It might give me more language to talk about symptoms' [P5]*

'They'll be functional. It'll be transactional. I think that's the modern term' [P7]

'The communication will be reduced. And it will all be online. All my questions and answers will be given by that symptom checker' [P12]

Power Dynamics

Based on the responses of older adults, the introduction of online symptom checkers in general medical practice would not have a significant impact on the power dynamics between patients and doctors. Nonetheless, a few older adults expressed uncertainty about the potential effects on these dynamics. Certain older adults mentioned that such services could potentially empower patients by providing them with more medical knowledge and information, thereby giving them the confidence to question their doctors. This, in turn, might lead to an improvement in the doctor-patient relationship. However, the majority of older adults still believed that GPs should maintain the upper hand in the relationship, as it has traditionally

been the case. Notably, they felt that the GP's authority and superiority should be preserved as long as they are treated like an adult in the relationship.

'Yeah, I'm of the generation where we were told 'trust me I'm a doctor'. You trust them because they're qualified. I don't want to have a power relationship with doctor. I go to the doctor to get me well, really'[P9]

'I want to be treated as an adult.' [P10]

Regard (comfort and liking)

The majority of older adults individuals indicated that the utilisation of online symptom checkers in primary healthcare settings would not significantly influence their level of comfort and satisfaction with their general practitioners. Older adults pointed out that if they could have regular access to their GPs without the interference of online symptom checkers, they would maintain a strong appreciation for their healthcare providers.

'I hope that I will be able to see my GP as regularly as I do now. So as long we are still on good terms, then it won't affect my regard for them' [P3]

Some older adults felt the use of online symptom checkers may in fact increase their regard for their GP. They viewed the tool as a form of empowerment for patients to access to health information. They also perceived that this would make it easier for patients to understand and engage with their GPs, as well as giving confidence to appropriately question them.

'I think when you are empowered when you have more knowledge.' [P1]

'Not at all. I would see, especially if it was explained that it was a way save time and make it more convenient for you as a patient to access health information as well do it from home' [P5]

However, one participant expressed the belief that employing privately owned online symptom checkers within general practice was a covert strategy to privatise the national health service, a notion strongly opposed by this individual. As an unintended outcome, individuals like him, who hold strong reservations against privatisation, may inadvertently develop negative sentiments towards GP practices, consequently diminishing their esteem for general practitioners. It is worth noting that this participant recognises their inability to prevent this situation from unfolding.

'[..] you start questioning the motives of your practice. And then you have this issue where, you know, practices are actually forming cartels almost. Privatisation. So, I think it will actually affect trust as well. This will be another brick in the wall' [P7]

Adherence to treatment

Many older adults interviewed believed that utilising online symptom checkers would not affect their health results or their adherence to treatment. This perception stemmed from their continued preference for receiving instructions from their GPs and reading the information on medication labels rather than relying on instructions provided by online symptom checkers. Older adults emphasised their high regard for direct human interaction, the opportunity to ask questions, and the emphasis placed by GPs on crucial aspects of the instructions. Additionally, they expressed a general lack of confidence in technology and had concerns about their own ability to navigate the application, which could potentially have a negative impact on their health outcomes. One participant specifically mentioned that a simple accidental touch of the wrong button could lead to receiving an incorrect recommendation. Another participant noted that while the use of online symptom checkers could have resulted in positive health outcomes if they functioned properly, there was a risk of frustration and increased stress for patients when these tools failed to perform as expected.

***'**I would take the word of my doctor over that of a symptom checker' [P3]*

'The emphasis they [GPs] can put on things is critical' [P7]

'Sometimes you don't know with this technology, what you are putting in, you know, so sometimes, you can touch the wrong button as well. So you learn sometimes, and it can make you feel more worse' [P1]

5.8.2 Relationship formed with online symptom checkers

In the study, all older adults mentioned that they were unable to imagine establishing any kind of connection with the online symptom checkers, and as a result, it would not affect their relationship with their GPs. A significant number of older adults emphasised that their interactions were solely with human beings, and a considerable portion of their communication with their GPs involved non-verbal cues such as gestures and facial expressions. These aspects of communication, which are not replicable by the current form of online symptom checkers, were highlighted by many older adults.

'I don't see how you can form a relationship with a computer app. That is just to give you symptoms, you know to give you the outcome of what are symptoms you enter, it's not a human being and it won't likely be anytime soon so my relationship would still be with my doctor' [P3]

5.9 Discussion

The following are main topics of interest from the interview guide to answer RQ2:

The specific objectives of this study were as follows:

- To explore older adults' attitudes towards online symptom checkers.
- To explore how older adults perceive the advantages and disadvantages on the use of online symptom checkers in general practice with older adults.
- To understand the potential impact of online symptom checkers on the doctor-patient relationship from the older adults' perspectives.
- To explore how the increased usage of online symptom checkers in general practice during the Covid-19 pandemic influenced their perceptions of the application.

Older adults' attitudes

This study aimed to explore the experiences and perspectives of older adults, considered a vulnerable group, on the use of online symptom checker in general practice including how it may impact their doctor-patient relationship. The experiences and attitudes of older adults are crucial in determining the acceptance, adoption, and utilisation of online symptom checkers in general practice settings (219,343).

Despite perceiving online symptom checkers as safer than searching for health information online, older adults' overall attitude towards using these applications in general practice became predominantly negative after some user experience. Digital health applications had not yet been integrated into the daily lives of older adults, and they still remained uncertain about using them in healthcare settings.

Older adult participants expressed a range of perceptions and emotions that contributed to this negative attitude, particularly feelings of anxiety and frustration. Older adults were frustrated with the accessibility and affordability of the technology, as well as their lack of skills and confidence to use the application effectively. Many participants also experienced anxiety about entering incorrect symptoms into the online symptom checker, fearing that it could lead to delayed or incorrect medical treatment.

Overall, although older adults recognised the potential usefulness of online symptom checkers in general practice, they still considered them inferior to seeking advice from their familiar and trusted general practitioner in the traditional manner. They suggested that online symptom checkers could serve as an additional service rather than a replacement or sole gateway to access general practice. Older adults expressed a preference for in-person consultations, during which doctors can perform physical examinations, provide advice and prescriptions, and address their questions.

Overall, there is limited research on this topic specifically from the perspectives of older adults using qualitative approaches. Therefore, directly comparing the findings of this study with previous studies was challenging. However, some related findings regarding m-health apps (79), which were relevant to this study, were referred to. The overall slightly pessimistic viewpoint expressed by older adults regarding the use of online symptom checkers in

healthcare settings aligns with previous research conducted in this field (79,127,344). For example, Miller et al. (345) reported that, although older adults found online symptom checkers helpful, it did not influence their care-seeking behaviour. Luger et al. (45) found that older adults often rely on existing medical knowledge and past experiences for self-diagnosis, rather than using online symptom checkers. Furthermore, the National Healthwork Network's survey revealed that older age groups exhibited less enthusiasm and willingness to utilise online symptom checkers compared to other age demographics (346).

While this study's finding is consistent with this survey, the emotions and perspectives conveyed by older adults were slightly more pessimistic compared to previous studies. This difference may be attributed to the fact that most earlier studies were conducted without the involvement of actual older adults and were hypothetical in nature, taking place during the initial stages of developing the technology. Furthermore, many of these studies were conducted prior to the introduction of online symptom checkers in general practice.

Obtaining a deeper comprehension of how older adults perceive and approach online symptom checkers enables a proactive approach in addressing negative perceptions and potentially fostering greater acceptance among users in general practice (219,319).

Participant characteristics

The inclusion criteria for the study were older adults over 60 and with at least one chronic health condition. Although participants were not required to fill in a questionnaire on demographics characteristics and health status, certain demographic information were picked up from the process of interviewing, both implicitly and explicitly from the participants' answers and observation recorded in the researcher's notes.

The characteristics observed in older adult participants who displayed favourable emotions and attitudes towards online symptom checkers were as follows:

Relatively Younger Age: The participants who showed positive views were typically in their sixties rather than their eighties. This suggests that younger older adults may be more receptive to using online symptom checkers.

Middle Socioeconomic Status: The participants belonged to a middle socioeconomic status, indicating that economic factors may play a role in their access to and acceptance of technology-based healthcare resources.

Native English Speakers: The participants were native English speakers rather than individuals with English as their second or third language. Language proficiency could influence their comfort and ease in navigating and understanding online symptom checkers.

Good Health: The participants generally reported being in good health, and the researcher also observed their overall health status. This indicates that individuals without complex age-related health issues may be more open to using online symptom checkers as a tool for self-assessment.

Good Computer Skills and Familiarity with Technology: The participants possessed good computer skills and were familiar with technology. This suggests that older adults who are comfortable with technology may be more inclined to use online symptom checkers effectively.

More Female Participants: Among the participants who expressed positive views, there were more females compared to males. This finding indicates a potential gender difference in attitudes towards online symptom checkers among older adults.

Advanced Degree Holders: Some participants who held advanced degrees, including PhDs, were in favour of using online symptom checkers. The study identified two such participants, suggesting that higher education levels might influence their perception and acceptance of online health resources.

It's important to note that these characteristics are based on the researcher's observations and conversations with the participants in this specific study. They may not necessarily apply universally to all older adults or in different cultural contexts. However, the aforementioned observations align with broader research in this area. Studies have revealed that users of digital health tools tend to have higher socioeconomic status (45,344,347), higher education levels (45,344), and are more likely to be young-old (e.g., 65-70 years) rather than old-old (85+ years) (44,45). For instance, Luger et al. (2014) reported that 29% of older adults aged 50-64 used online tools to diagnose personal symptoms years compared to 13% of online older adults aged 65 years or over. In terms of health status, Miller et al. (348) reported a larger proportion of

working-age individuals using online symptom assessment tools than the general population. Working-age individuals are less likely to have long-term health conditions than older adults (349,350). This correlation appears to also extend to different age-groups of older adults, where it seems that younger older users with relatively better health status are more likely to use online symptom checkers than senior older adults with more serious health conditions.

Advantages and Disadvantages of Online Symptom Checkers in General Practice Settings

The majority of older adults disagreed with the purported advantages of using online symptom checkers in general practice. While most older adults were sceptical about the ability of online symptom checkers to assist with self-care, a few believed that the tool's self-triaging feature could help them make quicker decisions about their health concerns and direct them to the appropriate healthcare services.

Given that older adults generally have complex healthcare needs and may be at a higher risk of misinterpreting symptoms through m-health apps (79), potentially making self-management unsafe for them. While most older adults expressed disagreement regarding the effectiveness of online symptom checkers in reducing unnecessary visits to GP services, a small number of participants recognised that the tool could be helpful for addressing minor health issues without requiring a scheduled appointment with a GP or any other healthcare provider.

This study found that older adults, who are more likely to suffer from chronic health issues requiring careful regular management, were more inclined to seek medical assistance by visiting their GP instead of relying on online symptom checkers (351,352). This finding is consistent with previous limited studies in this area, which have reported that older adults generally prefer in-person consultations over using digital healthcare tools (116). The preference for face-to-face consultations, built on habits and historical practices, will reduce the impact of online symptom checkers in reducing unnecessary visits to GP services.

Older adults also mentioned difficulties in accessing technology, a lack of confidence in using digital healthcare tools, and concerns about the reliability and potential risks associated with such platforms. These findings are consistent with previous studies (353,354) that have highlighted similar challenges and reservations among older adults.

Older adults raised privacy concerns about using online symptom checkers, particularly if these tools become the main way to access GP services. Participants emphasised the need for privacy literacy to build trust and ensure the long-term acceptance of mobile health technology in this demographic (353). Though most older adults had privacy concerns, a minority prioritised their health over such worries.

Impact on doctor patient relationship

All the older adults who were interviewed emphasised the importance of the doctor-patient relationship to them. However, many of them believed that the use of online symptom checkers in general practice could create additional barriers to accessing GP services, potentially having a negative impact on the doctor-patient relationship.

These older adults believed that online symptom checkers would affect the level and quality of interaction and communication with their GP. They expressed concerns that utilising general practice services would become more transactional and less personalised. Seeking clarification and asking questions were seen as crucial elements in establishing a positive doctor-patient relationship, aspects that they believed were particularly absent in online symptom checkers.

Most of the older adults interviewed felt that the use of online symptom checkers would not affect their adherence to treatment, as they still preferred receiving instructions from their GP and reading the information provided on medicine labels and patient information leaflets. Moreover, some older adults mentioned that relying on online symptom checkers could harm the doctor-patient relationship and exacerbate feelings of loneliness and social isolation among the elderly population.

Older adults expressed a general sense of trust in their GP that had developed over time. However, they had not yet established a similar level of trust in online symptom checkers due to the relatively recent introduction of this technology and their limited experience using it.

The majority of older adults, even with design improvements, cannot presently envision developing any kind of digital connection with online symptom checkers. The common

concern emphasised is the lack of human assistance while using these online symptom checkers.

The findings from the systematic review in chapter 2 indicate that there is a lack of extensive research examining how online symptom checkers affect the relationship between doctors and patients particularly from older adult perspectives.

These findings from this study in relation to the impact on the doctor patient relationship align with previous studies in this area which have highlighted how online symptom checkers can negatively distort the traditional doctor-patient relationship by potentially reducing the frequency of in-person visits to the GP surgery and impacting the communication between doctors and patients (32,174–176). However, contrary to the findings of previous studies, there were a few older adults in their sixties who reported that online symptom checkers might in fact improve their doctor-patient relationship. They believed that online symptom checkers has the potential to increase access to GP services, empower patients with more medical knowledge, and allow GPs to dedicate more time to listening to patients and develop relationships with patients.

Previous research in this field found that the use of algorithmic methods for medical diagnosis has the potential to challenge the authority of doctors by presenting itself as a form of authority (32,174–176). However, the findings of this study indicate that older adults do not believe that the power dynamics between a patient and doctor in general practice would be significantly impacted. The older participants recognised their limited health literacy or understanding compared to doctors, as supported by previous studies (100,355,356). As a result, older adults expressed a preference for GPs who possess clinical training to hold more power and decision-making authority over their health matters. While older adults desired to be treated with respect and have a voice in the decision-making process, they still believed that the overall control should remain with the doctors.

The desire for the human element expressed by older adults in this study is consistent with a study conducted by Aboueid et al. (58), which suggests that integrating human support into technology can enhance the effectiveness of the tool and promote better adherence. Previous studies examining user engagement with chatbot technologies have also found that online

symptom checkers are perceived as impersonal, indifferent, and lacking empathy. These studies consistently emphasise the importance of empathy and compassion as unique qualities of human beings, essential for patient care and treatment. Furthermore, they caution against the risk of replacing human doctors with automated systems (32,174–176).

The lack of trust among older adults aligns with previous research that highlights the challenging and multifaceted nature of building trust when it comes to adopting digital assistive technology among this demographic (357). Trust plays a crucial role not only in users' willingness to accept and embrace digital services but also in fostering a positive doctor-patient relationship (358).

Covid-19 impact

The Covid-19 pandemic did have some impact on the use of online symptom checkers within the triage pathway among older adults. Before the pandemic, many older adults were unaware of digital healthcare tools, such as online symptom checkers, and consequently did not utilise them. However, as lockdown measures were implemented and face-to-face interactions became restricted, older adults, like the general population, were encouraged to use online symptom checkers to remotely assess their symptoms and minimise the spread of the virus. These factors, including the higher risk of severe illness from Covid-19 among older adults, motivated some to overcome their fear and hesitancy in trying online symptom checkers (see the results section).

While most older adults appreciated the need for online symptom checkers during the Covid-19 pandemic, some also highlighted their frustration and the disadvantages of using the tool. Frustration ranged from online symptom checkers not being thorough enough in capturing symptoms to the inconvenience of having to repeat symptoms with healthcare professionals. It's important to note that there is a scarcity of research in this area due to the recent conclusion of the pandemic in the UK and worldwide. However, a recent study conducted by Mansab et al. (359), examining the use of Covid-19 symptom checkers, reported similar findings. Although the algorithm was complex, accurately diagnosing Covid-19 proved extremely challenging due to its similarity to other health conditions such as colds, flus, bacterial pneumonia, etc. Multiple-choice questions may not be the best for answering subjective and qualitative questions or picking up the subtleties necessary for a differential diagnosis. Some

older adult participants in this study also expressed concerns about the questioning style and vagueness of some questions.

It was hoped that the increased awareness and use of these services would have a long-lasting impact on older adults' usage beyond the pandemic. However, the majority of older adults reported that they returned to their preferred methods of accessing healthcare, which involved contacting or visiting their GP directly. The reluctance of older adults to adopt new technologies and their preference for traditional methods of accessing GP services align with findings in existing literature (110,360).

5.9.1 Strengths

This study was designed to investigate the opinions and experiences of older adults regarding the use of online symptom checkers in general practice settings. It had several notable strengths in its design, implementation, and assessment.

Firstly, this study is significant because it is the first of its kind to explore the viewpoints and experiences of older adults in relation to the use of online symptom checkers in the context of general practice. Secondly, it is also the first study where the older adults' participants had some real-world experience using online symptom checkers in general practice. These aspects underscore the novelty and cutting-edge nature of this research.

To gather data, the study utilised a combination of the think-aloud protocol and in-depth interviews as research methods. The think-aloud protocol allowed participants to express their thoughts and reactions while using online symptom checkers. This approach provided valuable insights into the cognitive processes and decision-making of the participants in real-time. In addition, in-depth interviews were conducted, offering participants a more extensive platform to freely share their perspectives, opinions, and experiences. By employing these qualitative methods, the study ensured that participants were not confined to closed-ended questions, leading to a more comprehensive understanding of their viewpoints.

Regarding data analysis, the study employed both inductive and deductive thematic analysis. Inductive thematic analysis involved identifying patterns, themes, and categories within the data without any preconceived notions or theoretical frameworks. On the other hand, deductive

thematic analysis used existing theories or frameworks to guide the identification and interpretation of themes. By using both approaches, the study was able to explore a wide range of interconnected themes while considering both participant perspectives and existing theories.

Overall, the study's design and methodology facilitated the collection of detailed qualitative data from older adults about their experiences with online symptom checkers in general practice settings. The combination of the think-aloud protocol, in-depth interviews, and thematic analysis added depth and breadth to the research, making it a valuable contribution to the field.

5.9.2 Limitations

Due to the qualitative approach employed in this study, the generalisability of the findings to the entire population maybe considered limited, despite reaching data saturation. The study utilised snowball sampling, which does not guarantee representativeness of the sample, posing another limitation. As the study centred around cutting-edge health technology, there was a concern about attracting participants with a strong inclination toward using health technologies. However, this concern was unfounded, as the majority of older participants exhibited little interest in technology beyond the basics. Two participants possessed extensive medical knowledge and advanced IT skills, potentially making the findings less applicable to the general population.

All participants had previous user experience with the Doctorlink brand of the online symptom checker, and a few had also used other brands. While the majority of online symptom checkers share similar functions and features, as discussed in section 2.4, a potential limitation is that most participants only had experience with one specific online symptom checker. This makes it challenging to separate views on online symptom checkers in general from views specific to a particular online symptom checker.

Participants with English as their second language encountered challenges expressing thoughts and emotions. Some older adults hesitated to acknowledge difficulties with the tool, potentially impacting the accuracy of their accounts. The researcher tried to mitigate this by employing strategies as widely advocated in literature such as building rapport, creating a comfortable environment, and reassuring participants that there were no incorrect responses.

5.10 Conclusion

The findings of this study indicate that older adults were open to trying online symptom checkers in general practice. However, based on their limited experience so far, they perceived more drawbacks than benefits in using these online tools. Currently, older adults still strongly prefer traditional methods to access healthcare services. They believe that utilising online symptom checkers may negatively affect the doctor-patient relationship by reducing in-person contact between patients and general practitioners. It is crucial to conduct further comprehensive research to investigate the impact on the doctor-patient relationship and ensure that the use of online symptom checkers in general practice does not exacerbate the health disparities faced by older adults.

Chapter 6 GPs' perspectives on the use of online symptom checkers in general practice

This qualitative study explores the perspectives of GPs on the use of online symptom checkers in general practice including how it may, in their views, affect older adults and possible impact on the doctor-patient relationship to answer the research question RQ3.

The first part of this chapter describes the aim and rationale of this qualitative study, followed by a clear presentation of the details of the study design, the data collection method, and ethical considerations to ensure transparency and rigour in the data analysis and credibility of findings. The second section presents the results of thematic analysis which are illustrated by representative verbatim quotes from the GP interviewees. The final section presents the discussion and conclusions with reference to the current literature and findings from the systematic review.

6.1 Introduction

Online symptom checkers are improving with advancements in technology, providing potential benefits for both doctors and patients. Nevertheless, there is a significant lack of research regarding how GPs perceive and use these automated tools in their day-to-day practice. Considering that GPs play a pivotal role in patient treatment, understanding their opinions is crucial in determining the appropriate application of online symptom checkers in healthcare. As this technology aims to support or even replace some aspects of their roles, it becomes essential to explore GPs' perspectives.

Exploring GPs' viewpoints and experiences with online symptom checkers is not only significant for optimising their integration into general practice but also for understanding how older patients, who often place high trust in their GPs, will adopt and use this technology. However, there is a notable lack of research concerning GPs' opinions about using these online symptom checkers with older patients. Furthermore, the potential impact of these automated tools on the doctor-patient relationship, which older patients highly value, remains largely unexplored.

As reported in the systematic review (see Chapter 3) continuous research is recommended to assess whether online symptom checkers progress on to have the capacity to artificially replicate doctors' empathy, judgement and intuition, all essential components of a face-to-face consultation and accurate medical diagnosis and treatment. As recommended by the systematic review, more research is required to explore the effects of online symptom checkers on the doctor-patient relationship from both doctor's and user's perspectives. Exploring these topics in-depth will provide a deeper understanding of the potential usefulness of this technology in general practice from GPs' perspectives and potential impact on the doctor-patient relationship.

By providing GPs with evidence-based research on the advantages and disadvantages of this emerging technology, they can make informed decisions about its appropriate use to enhance their practice rather than hinder it. The findings of this research will help to either justify or attenuate enthusiasm for online symptom checkers applications as well as direct future work to better align with the needs of GPs. The findings also lay the foundation for future investigations on the factors influencing GPs' adoption of online symptom checkers.

The primary objectives of this qualitative study were to gather in-depth data to explore and aid understanding of the experiences and perspectives of GPs on the use of online symptom checker in general practice with older adults including how it may impact the doctor-patient relationship. Online symptom checker is sometimes abbreviated as SC.

The specific objectives of this study were as follows:

- To investigate the experiences and perceptions of GPs regarding the use of online symptom checkers in the general practice setting, including perceived advantages and disadvantages.
- To understand how GPs perceive the impact of online symptom checkers on the doctor-patient relationship.
- To explore how GPs perceive the broader impacts of using online symptom checkers in general practice.

Similar to Chapter 5, this chapter intentionally omits user barriers and design recommendations provided by GPs for improving older adults' usage of online symptom checkers in general practice. Instead, these insights are presented in Chapter 7, where they are compared and analysed alongside suggestions from older adults, as well as the findings from the two UX workshops.

6.2 Study Design and Method

This study used a qualitative exploratory approach to elicit GPs' views and experiences towards the use of online symptom checkers in general practice with a particular focus on the potential impacts on older adults, and how this may affect the doctor-patient relationship.

Qualitative approaches involve collecting and analysing non-numerical data to explore a topic or a problem in greater details (26,28), typically with a small sample size. As well as the potential to discover common patterns and topics, this approach facilitates gathering in-depth insights into understanding concepts, opinions, or experiences such as those of GPs. Nevertheless, as discussed in Chapter 4, qualitative research findings cannot be easily generalised to other populations, and the generalisations of the findings are limited (23).

In this study individual qualitative semi-structured interviews were chosen as the most appropriate data collection method. The researcher first captured participant' insights about GPs' general experience with online symptom checkers followed by their views on the app potentially acting as the first point of contact in general practice. The second part asked the participants to rate and then expand on statements, which were informed by the literature review, in relation to the perceived advantages and disadvantages on the use of online symptom checkers in general practice with older adults. The final part of the interview focused on capturing participants views on the effect of online symptom checkers on the doctor-patient relationship.

6.2.1 Participants

Population and setting

The population of interest was GPs working in the NHS GP surgeries. Data collection took place between February 2022 and May 2022. While the researcher was in Sheffield, UK, the research was conducted using remote interviews with GPs located across the country via Google Meet. Due to GPs' busy schedules, the use of video interviews maximised the participation of GPs by providing added convenience and flexibility to arrange interviews. Good practice on video interviewing healthcare professionals was followed (361).

Participating GPs worked in small surgeries as well as increasingly common and government-favoured super-sized surgeries.

Sampling method

Recruitment was conducted using snowball sampling method (265) for practical reasons not least because GPs are well known to be difficult to access and engage in research (362). Snowball sampling is a non-probability sampling method, particularly susceptible to selection bias, and lacks transferability to the whole population. Despite these disadvantages, this method is still commonly used in studies because it is cost-efficient, easy, and fast (237,307). Sampling continued until data saturation was reached.

This was an observational study, and all participants underwent the same protocol.

6.2.2 Inclusion and exclusion criteria

The inclusion criteria for participant recruitment includes General Medical Council (GMC) registered GPs working in NHS GP surgeries with experience of working with at least one online symptom checkers in general practice for a minimum period of 6 months. The requirement of prior experience ensured participants were able to provide some meaningful insights about their experiences and perceptions on the use of online symptom checkers from actual ‘lived’ experiences in general practice context rather than from personal or hypothetical scenarios. This was identified as a literature gap in the systematic review (see section 3.7).

As qualified GPs working in the NHS, the participants would have possessed the necessary computing and English skills at an adequate level to take part in this research (e.g., engage in video conferencing), in addition to being able to speak and provide consent. Those GPs who did not meet the inclusion criteria were automatically excluded.

6.2.3 Participant Recruitment

Common facilitators to physician recruitment were followed such as those recommended by Johnson et al. (363) e.g. flexibility with interview scheduling including making time in evenings and weekends.

Due to the Covid-19 pandemic, GP recruitment strategies were reduced to mainly electronic methods. At the beginning GP contacts from the researcher's personal network were approached in accordance with ethical guidelines before getting them to introduce their GP colleagues from their professional network. Recruitment posters were designed with a brief description of the aims of the interviews and sent out electronically to minimise human-to-human transmission of Covid-19. Several GPs expressed interest to participate following a research presentation at the Academic Unit of Primary Medical Care which is part of the Sheffield University Medical School. The clinical lead for research for the Primary Care Sheffield and Sheffield Teaching Hospital also, on the researcher's behalf, circulated details of the study to GPs in Sheffield.

Several contingency recruitment approaches were planned in the unlikely event of not being able to recruit enough participants such as contacting local NHS surgeries or super GP hubs with a HRA approval.

Details of advertising methods are included in the appendices (see Appendix 4). The researcher assessed eligibility for research participation based on the selection criteria. If a prospective participant indicated interest either directly or via one of the above organisations, they were contacted to arrange a pre-study telephone or video call to verbally explain the study activities and explain what was required of them in detail, as well as answer any questions and discuss the consent procedures in detail. All interested prospective participants were provided with a study information sheet written in simple English and emailed over to them prior to the

telephone call. The consent procedures were carefully followed to ensure the informed consent was obtained as required by the ethics study approval. To make it convenient for busy GPs, a digital consent form was created on Qualtrics software platform (316) and emailed over to the participants. Participant had sufficient opportunity to ask questions concerning the study.

Participation was purely on a voluntary basis and no financial incentives were offered other than travel reimbursement. The above-mentioned recruitment approaches were successful in recruiting enough eligible GP participants to allow for data saturation to be reached.

6.2.4 Number of Participants

The initial aim was to recruit at least twelve GP participants for in-depth interviews which is in line with qualitative methodology recommendations (28–30). In their study, Morgan et al. (362) made the observation that the first 5-6 interviews provide novel data and concepts, and in the study conducted by Guest et al. (364), it was reported 6-12 interviews are normally sufficient to reach saturation. Therefore, preliminary data analysis was conducted every second interview after the sixth interview to check for data saturation. As expected, no new emergent themes or key findings were being expressed after the twelfth GP interview, that was, data saturation had been reached.

6.2.5 Interviews

Semi-structured interviews were chosen as the method of data collection for GPs as it is one of the most versatile forms of primary research as well as a widely used data collection method for comprehensive understanding particularly in qualitative research (264). During the interview, the researcher asked open-ended question and recorded their responses. Semi-structured interviews were conducted to gain in-depth understanding of GPs' views, experience, and perceived impact on the doctor-patient relationship. Alternative methods, such as focus groups, were considered but rejected due to the busy schedules and demands placed on GPs, particularly following Covid-19. Furthermore, according to Tausch and Menold (365), time constraints on clinicians could negatively affect group communication.

6.2.6 Interview Procedures

In accordance with ethics protocols, each participant was sent electronic consent form of the study via Qualtrics XM platform (316) to fill in prior to the online interview. They were also sent an email with a link to Calendly (317), an online appointment scheduling platform, to book an interview slot at a time of their convenience.

At the beginning of the interview, participants were given the opportunity to ask the researcher questions about the study and requirements of their involvement. The participants were first asked questions about their demographic characteristics including their employment status (e.g., salaried or locum) and years of GP experience. Then, the participants were asked questions related to their attitudes towards and experiences with the use of online symptom checkers in general practice including their thoughts and feelings about the app potentially acting as a first point of contact. Next, the participants were asked questions related to the perceived benefits and challenges in relation to the use of online symptom checkers in general practice with older adults. As part of this section, the participants were asked to rate statements (see Appendix 13) on a 5-point Likert rating scale from strongly agree to disagree and given the opportunity to elaborate on their responses.

Finally, they were asked questions related to their views about the potential impact on the doctor-patient relationship with older adults. For more details about interview questions, see Appendix 6. The interviews with GPs lasted on average 1 hour and 45 minutes, which is less than the average time for older adults. GPs, who in general were younger and more educated, were able to articulate their views much more quickly.

6.2.7 Transcription

The GP interviews were conducted using a semi-structured interview guide in English because English is the de facto official language of the country and English fluency is a GMC license requirement for doctors. These interviews were digitally audio-recorded and subsequently transcribed verbatim. To maintain authenticity of the data, the exact language used by the participants have been maintained in the transcription of data, including the use of complicated

medical jargon as well as use of any colloquial terms. Extra words were added only where it was essential for understanding.

The transcripts were anonymised by not including any identifiable personal information. Transcripts were anonymised with a unique ID and participant name and study codes were separated and stored safely on an encrypted password protected file on the secure University filestore in accordance with the approved data management plan.

6.2.8 Quality Criteria (validity of research)

The validity of qualitative research has been extensively discussed in Chapter 3, and it will be taken into consideration when assessing the quality of this qualitative study as well to ensure the findings are consistent, true, and accurate.

In addition to the measures in Chapter 5, sensitivity to context was demonstrated by acknowledging the socio-cultural environment in which the study was conducted. The GPs participated in remote interview sessions from diverse background settings, including their homes and GP surgeries. The group of GPs represented various cultural and religious backgrounds, and they also had different levels of experience, from newly qualified GPs to those nearing retirement after many years of service. The researcher was mindful of and respectful towards these diverse factors throughout the study.

6.2.9 Piloting the interview

The main reasons for conducting a pilot study were addressed in Chapter 5. The research team carefully reviewed the interview schedules and questions to ensure their relevance and appropriateness for GPs and to align with the main objectives of the study, aimed at addressing the research question. Given the context of acute staff shortages in the GP workforce and the even more challenging GP recruitment scenario in the post-Covid-19 world, the interviews were piloted with two allied NHS health professionals (one male and one female) from the researcher's personal network.

The primary purposes of conducting the pilot study were as follows:

- To ensure the clarity and accuracy of the consent form and participant information sheet, effectively conveying the intended information.
- To ascertain whether the interview questions were formulated in a clear manner, enabling participants, specifically GPs, to comprehend them appropriately.
- To determine the response time required by participants to answer the questions.
- To assess the suitability of including or excluding certain questions from the interview guide and explore the possibility of adding new questions that align with the study's objectives.
- To evaluate whether the planned interviews effectively fulfilled the intended aims and objectives.

As a result of the pilot study, several adjustments were implemented. The questions were reorganised to create a more natural and flowing discussion, with questions relating to each other seamlessly. Certain words and phrases were modified to enhance clarity and encourage open responses from the participants. Additionally, both interviews were conducted within the expected time frame, considering the time constraints faced by GPs. The researcher effectively managed the time during the main interview session by employing a digital stopwatch and allocating specific time for each question.

6.3 Data Analysis

For this qualitative study, the data analysis technique employed was identical to that used in the older people interview study. The reasons for its suitability and the rationale behind its selection can be found in Chapter 5.

Ethical considerations

Ethical approval was obtained before this study was conducted from the ethics committees at the School of Health and Related Research (SCHARR) of the University of Sheffield (see Appendix 5).

Informed consent

Informed written consent was obtained following the same method as described in Chapter 5 (see section 5.2). As GPs are extremely busy professionals, e-consents were obtained using Qualtrics Experience Management (XM).

Data recording procedures, evaluation of personal safety, challenges of conducting virtual interviews were discussed and appraised in Chapter 5.

Challenge of recruiting GPs

There are many barriers to recruiting and retaining GPs (366). In addition to the difficulty of accessing a closed community, GPs are usually overworked and have limited spare time. Common facilitators for physician recruitment were followed, such as those recommended by Johnson et al. (363), for example, offering flexibility with interview scheduling, including evenings and weekends. To increase the reliability of the findings, the researcher attempted to recruit as diverse and representative a sample of GPs as possible.

6.4 Results

Participants

In total, 12 GPs were interviewed over the course of 2 months. The gender distribution of participants was even, with 6 females and 6 male participants (see Table 13). All participants were practising GPs in the NHS with an average of 10 years of experience since GP qualification, ranging from 2 to 24 years. Within the NHS, most of the participants worked both as salaried and self-employed locum GPs, but 4 participants worked exclusively as self-employed locum GPs with no permanent sessional work. In this study, the GPs participants had the most prior experience with the Doctorlink symptom checker. Only one GP participant had some prior experience with eConsult, but this result was perhaps expected, as it was the least deployed across NHS GP surgeries.

Characteristics	Mean (range) or n(%)
Time since GP Qualification (Years)	10 (2 -24)
<5 years	4 (33)
5-9 years	3 (25)
10-14 years	3 (25)
>15 years	2 (20)
Gender	
Males	6 (50)
Females	6 (50)
GP Position	
Locum	4 (33)
Salaried + Locum	8 (67)
Symptom Checker Experience	
askmyGP	4 (33)
Babylon Health	1 (8)
Doctorlink	6 (50)
eConsult	1 (8)

Table 13: Characteristics of the GP sample

6.4.1 Result of Thematic Analysis

The emergent themes and sub-themes were developed to form the basis of the coding framework as follows:

- GP general views (including sub-theme of GPs' attitude)
- Impact in general practice (including sub-themes of patient journey and impact on face-to-face consultations)

- Impact on the doctor-patient relationship
- Broader impacts in general practice (including sub-themes of patient privacy and health inequalities)

These are presented in Table 14, showing the key emergent themes and sub-themes identified from interviews with older adults.

An outline of the results now follows.

Theme	Sub-theme	Topics
General views and attitudes	Introduction of SC in general practice	• Online symptom checking • Attitudes • Emotions • Profile of users • Covid-19
Impact in general practice	Perceived barriers and facilitators	• First point of contact • Patient triage • Manage own health • Quality of care • Personalised treatment • Travel time to GP • Reduce unnecessary visits • Improve access and timeliness to care
Impact on doctor-patient relationship	Important components of dr-pt relationship	• Adversely impact dr-pt • Enhance dr-pt • Trust • Communication • Loyalty • Regards • Doctor-patient power-dynamics

	Implication of dr-pt changes	• Adherence to treatment • Relationship formed with online symptom checkers • F2F consultation • Patient health outcomes
	Covid dr-pt changes	• Enhanced dr-pt • Negatively affected dr-pt
Broader impacts in general practice	Effect on existing services	• Complement existing systems • Overburden existing systems
	Manage demand	• Efficiency • Inefficiency
	Workload	• Reduce workload • Increase workload
	Role of GPs	• Traditional role change • Confidence • Power dynamics • GP career impact • Responsibility for clinical decision
	GP shortage crisis	• GP morale • Job satisfaction • Exacerbate staff crisis • Reduce staff crisis
	GPs' recommendations to older patients	• Patient dependent
	Data privacy and confidentiality	• Patient privacy • Disclose more information •
	Health inequalities	• Potential to reduce inequalities

		• Potential to increase health inequalities

Table 14: GPs' themes

6.4.2 GP attitudes towards online symptom checkers in general practice

This section presents GPs' general views and attitude towards the use of online symptom checker in general practice.

Attitudes towards online health information

GPs were accustomed to patients searching online for health information. Although searching health information online carries several risks including misdiagnosis and delay of treatment, GPs recognised that in most cases patients searched online to get an idea or a better understanding of the symptoms they were experiencing and to help them decide what course of action to take next. In addition, GPs noted some patients searched online to get an idea of the provisional medical management plan they are likely to be put on if they were to visit their GP.

'So they try to find out a bit about what they're going through, get the diagnosis and the management' [GP1]

Although GPs reported patients were increasingly making references to a variety of online platforms (e.g., the NHS website) in consultations, searching symptoms on Google were the most frequently mentioned method. The use of online symptom checkers was notably the least frequently mentioned.

'Patient often say they've looked up their symptoms on Google' [GP1]

Attitudes towards online symptom checkers

There was overall mixed views and attitudes expressed by the GPs interviewed towards the use of online symptom checker in general practice, with a slight trend towards the negative. Many

of the advantages and disadvantages raised in this section will be discussed in depth in later sections.

'I think there's pros and cons' [GP1]

'It could be both positive and negative, to be honest' [GP4]

With much of the population now having access to smartphones, GPs felt that the introduction of online symptom checkers was at some point inevitable in general practice, but perhaps more in the future than now. Many of the participating GPs stated the inevitability comes from patients' behaviour shift to mirror consumer behaviour for on-demand services, and the need to have constant access to online information. In many ways, GPs felt the introduction of online symptom checkers was an attempt to catch up to the modern way of life as well as a tool to reduce some of the pressures in general practice.

'I always felt like some of them would be inevitable. There'll be an inevitability about the way that their world is expanding with access to information online constantly. So, I would always think that it would be there' [GP4]

One GP, a self-confessed technology enthusiast, was closely following the development of the technology, and therefore, was not too surprised over the introduction in general practice.

'I mean, it was on it was coming. I guess. It was it was just sort of, oh, it's arrived now, and I can see them' [GP7]

Although some respondents were unsure, the majority of GPs interviewed understood the main intended purposes of introducing online symptom checkers in general practice was to help patients obtain a quick triage decision and direct them to the most appropriate health care service provider to meet their health needs.

'[...] patients can get access to information easily and be directed to the right services to deal with their problems' [GP1]

Many GPs have also captured mixed opinions from their patients particularly concerning reliability and accuracy aspects. Some patients, for instance, rely on the advice of online symptom checkers, whilst others solely rely on their GP's advice.

'So it's been a bit of a mixture,...some really rely on online symptom checkers, and others to their GP advices' [GP1]

Despite their many reservations, the convenience factor of online symptom checkers was the most commonly positive perception expressed by GPs as it in theory provides around-the-clock service in contrast to restricted GP surgery opening hours. This was followed by potential for patients to receive faster treatment if they were accurately triaged by the tool which GPs felt can lead to making the GP service becoming more efficient. GPs perceived online symptom checkers to be much better in terms of trustworthiness and reliability than patients googling medical advice which can easily steer patients to unverified sources. Some GPs felt online symptom checkers can give patients some reassurance when they cannot access their GP services. GPs noted this particularly useful during national emergencies (e.g., Covid-19 pandemic), and now at a time when GP services are under severe strain with the added post-Covid workload and getting harder to get an GP appointment.

'[…] patients have enjoyed the convenience of having the technology 24/7 at their fingertips and access to trusted medical information…online triage directing them to appropriate health care services' [GP6]

'It's better than googling things' [GP7]

Nonetheless, there were several reservations expressed by GPs on the use of online symptom checkers in general practice.

'But I think as clinicians, we have our own reservations about it' [GP2]

'Risky' was the most commonly mentioned negative perception associated with the use of online symptom checkers due to concerns about the possibility and dangers of missing vital 'red flag' symptoms. GPs also raised concerns about the (lack of) reliability of online symptom checkers, due to the possibility of diagnostic inaccuracies. They also highlighted 'limited'

nature of the service as it currently covers a small set of minor health conditions compared to the vast array of health conditions GPs must deal with.

Some GPs admitted they do not yet fully understand the intended role of the online symptom checkers in general practice. Some also went on to stress that the technology, in their view, should not be used in general practice in its current form.

'Not really. I don't think we should be using them in general practice anyway' [GP5]

In addition to different GPs expressing different views, some individual GPs themselves expressed some conflicting views. For example, GP9 reported online symptom checkers truly empowered old adults, but later in the interview, the same participant mentioned there was a realistic risk of health inequalities being increased amongst older adults by the use of online symptom checkers.

GPs reported the usage of the app is very much patient-dependent, appealing to certain demographics more than others like young people. GPs also highlighted online symptom checkers were not and cannot be a substitute for human clinicians.

'So it's quick, easily accessible for younger patients' [GP1]

'It's never going to replace GPs' [GP8]

Some of the GPs viewed online symptom checkers as a temporary stop-gap technology to help alleviate some of the interim strains but were not sure of their long-term viability in general practice. However, there were also some who GPs felt with the development of technology coupled with inclusion of important safety measures, the service may have a beneficial role in general practice.

'I'm just thinking that in terms of online symptom checks, I see them as a stop-gap' [GP4]

'Now I feel like it is something with the right technology and the right safety measures could be really, really useful to general practice' [GP2]

Profile of users

All of the GPs interviewed reported that the overall usage of online symptom checkers in their experience was very low. GPs reported that many of their patients particularly older patients were not even aware of the availability of online symptom checkers in general practice.

However, many of our patients are still unaware of online symptom checkers, particularly older patients [GP6]

Despite the low overall usage, many GPs reported that typically young people made the most use of the online symptom checkers. In contrast, they reported older adults (aged 60 plus) made the least use of the service. Most GPs cited convenience of having the app available 24/7 and at their fingertips via smartphones as one of the reasons why it particularly appealed to young people.

'Particularly during this pandemic, where younger patients have enjoyed the convenience of having the technology 24/7 at their fingertips' [GP6]

In addition to most users being relatively young, some GPs mentioned that they have noticed that the users were also tended to be from higher socioeconomic group, held higher qualifications and were generally more technology proficient.

'So it tends to be the higher socioeconomic groups, the ones who are educated, the ones who are professional or the ones who are a bit more sensible anyway, the ones who know which website to go to' [GP8]

A few GPs mentioned patients, especially those who have moved up from London or within commuting distance to London, were starting to use the online symptom checkers more than other patient groups. Some have referred them as 'metropolitan' patients.

'A really good mix of interesting patients, quite a lot of people in the last few years moving up from London, because of what's been happening and being able to still commute to London. So they were the ones who are starting to use the online checkers I noticed' [GP7]

6.4.3 Covid-19 impact

Innovative technologies for Covid

GPs were aware that innovative tools such as online symptom checkers were fast-tracked into general practice during the Covid-19 pandemic to minimise human-to-human contact, and patients were encouraged to use the app to assess Covid-19 symptoms and other health conditions.

'Well, some experience, yeah, it was only getting introduced into my practice as a partnership towards the end and then basically Covid hit' [GP7]

'We've had to get more imaginative about how patients can access us' [GP2]

Some of the GPs mentioned that having first-hand experience of online symptom checkers during Covid-19 had improved their perception of the technology and potential usefulness of it in the general practice setting.

'Yes, I think prior to pandemic, we would never have really accepted that it could be used. And seeing that it actually has been helpful in being able to get people seen' [GP2]

Covid shifted behavioural change

GPs believe the coronavirus lockdowns and restriction on face-to-face meetings in effect forced patients to use or at least consider using the online symptom checkers as a first point of contact including some who perhaps would not have done otherwise in normal circumstances.

'I think people are using them because of the pandemic has forced people to do that. Because it hasn't been in some cases easy to get to see a GP face-to-face. I feel like patients have been using online symptom checkers as a first point of call more recently' [GP1]

However, although patients were encouraged to use the app during Covid-19, most GPs highlighted older patients in general struggled to use the tool compared to younger patients.

'I think my experience during Covid has been that they (older adults) found it quite difficult actually and very frustrating' [GP2]

Although patients were encouraged to use online symptom checkers during Covid, GPs noted that most of the patients used and relied upon on the telephone service to access their GP surgery. GPs pointed out that talking to patients on the phone and hearing their voices and breathing (red flag symptom for Covid) provided important symptom information which are not possible to capture via online symptom checkers.

'[..] when you hear them you realise just how unwell they are, is these kinds of more softer aspects that I think that the symptom checker are really going to miss' [GP2]

6.4.4 Impact in general practice

Advantages and disadvantages for all adult patients

This section presents the advantages and disadvantages from GPs' perspectives on the use of online symptom checkers in general practice. Participants were asked to rate each of the perceived advantages and disadvantages adapted from a prior study (319) from strongly disagree to strongly agree, and then asked to elaborate.

As a general observation, most GPs either disagreed or were neutral with the perceived advantages on the use of online symptom checkers in general practice. However, the majority of GPs agreed with the perceived disadvantages on the use of online symptom checkers in general practice. The ratings are presented in the Appendix 13, but the complementary qualitative elaboration presented as follows.

First point of contact and triage

There was mixed opinion from GPs interviewed on the online symptom checkers acting as a first point of contact in general practice. Both advantages and disadvantages are discussed.

Overall GPs perceived online symptom checkers as an additional tool to the existing communication methods but should not be the exclusive option to access healthcare service. GPs felt that once many of the bugs are sorted and technology is further developed including more accurate triage and appropriate referrals then it will have a useful role in general practice. A few doctors mentioned that it has potential to alleviate pressure on GPs and reduce some of their burden, but this point-of-view was disagreed by other GPs. Some GPs said online symptom checkers were better than non-clinical reception staff who are prone to make mistakes. A GP mentioned that the use of app will be more cost effective than training health care professionals or reception staff to carry out triage assessments.

Most GPs perceived that online symptom checkers have the potential to direct patients to appropriate health service provider. This may reduce some unnecessary GP visits as well as reduce travel time GP surgeries. However, some GPs qualified their responses by saying the reduction in travel time will be dependent on the accuracy of triage provided by the online symptom checkers.

'So, patients can get access to information easily and be directed to the right services to deal with their problems' [GP1]

'Definitely, prevent some unnecessary visits' [GP3]

Access and timeliness to care

Although most GPs interviewed perceived online symptom checkers could improve patients access to general practice, many also qualified their responses by stressing if only usability was not a barrier. Some GPs highlighted how useful online symptom checkers were in improving access and timeliness to care during the Covid-19 pandemic.

'I think it could increase access, yes, if patients knew how to use it' [GP2]

Some GPs gave examples of the type of minor health conditions which could possibly get treated sooner by patients making use of the online symptom checkers and being remedied using self-care interventions or with the assistance of community pharmacies.

'So your simple, you know, skin rashes, your simple ear infections, eyes, I mean, it could take away some of the burden of treating those very small, simple conditions that can actually just be managed simply by going to your pharmacist, or going to the chemist yourself and picking something up' [GP4]

With the use of online symptom checkers, few GPs mentioned patients can potentially avoid the long GP telephone waits which they typically have to endure to reach their GP surgery. The queues can be up to 1 hour (367) in some surgeries.

'It overcomes long telephone waits' [GP7]

Manage own health

GPs interviewed have expressed mixed views on whether online symptom checkers helps to better manage patients' own health, with most GPs expressing neutral views. Some GPs thought online symptom checkers could be useful for minor conditions. The one participant who strongly thought the application would help patient better manage their own health so was a self-declared technology enthusiast and a former employee of Babylon (24), one of the leading developers of online symptom checkers and an industrial leader in telehealth solutions.

'I think it's good for minor conditions' [GP1]

'Yeah, I think yeah, potentially if they know how to use it' [GP2]

However, GPs were unanimous in believing that SC cannot effectively care to the full extent of the patients' needs. As mentioned before, GPs have said there is so much that goes into a doctor-patient meeting which is not possible to replicate with online symptom checkers. Furthermore, GPs have access to patients' electronic health records which allows doctors to

take into consideration of the patient's full health before deciding the best course of treatment. This includes family history of certain diseases including cancer.

'So I think because so much information that is gathered regarding their symptoms, and you ask about, for example, in someone with suspected cancer, let's say you might look for, like the family history and things. And I don't think, just as one example, these kinds of things are covered in online symptom checkers' [GP1]

'I will say see face to face more, you know, if somebody was seen, it's more attentive' [GP10]

A GP perceived online symptom checkers primarily as a tool to guide patients towards physical doctors, and nothing more. Therefore, he thought it cannot effectively care to the full extent of the patients' needs.

'[..] it's just a guidance system, nothing more than that, therefore, simply cannot care to the full extent of the patient's needs' [GP6]

Quality of patient care

Amongst GPs interviewed, most were unsure as to whether online symptom checkers help to improve the quality of patient care. However, during follow-up probes, some GPs did note that the service has the potential to improve the quality of care by stimulating patients to visit their GPs for health concerns which they might not otherwise have bothered with. Furthermore, the in-built low threshold for referrals due to medico-legal reasons might also encourage patients to visit GP surgery or other healthcare providers, again increasing the likelihood of health issues being potentially picked up early and contribute to positive health-related outcomes.

'Stimulated [patients] to come to their GP to get checked out or to discuss it with them' [GP4]

'They've obviously got a very low threshold for referring on. That's good in some way. Because you know, last thing you want them to miss some important' [GP3]

Some GPs viewed online symptom checkers have the potential to be more reliable at triaging than non-clinically trained receptionists, with the added benefit of being more cost effective.

'We're using people who aren't clinically trained like receptionists, who are already doing similar sort of symptom checking' [GP2]

GPs expressed mixed opinions whether online symptom checkers provide reliable health advice. Some GP participants felt online symptom checkers questions were very generic, and the most frequent outcome was referral to the patient's GP surgery, which in some ways defeats the purpose of the technology. They also emphasised that the advice given by online symptom checkers were too generic to be useful. GPs were also concerned that online symptom checkers cannot provide a holistic approach to patient care and patients may end up on unnecessary medications.

'The questions that I have been asked is very generic. The most often, you know, the most frequent outcome would be simply directing the person the patient to go to their GP anyway, so it doesn't actually provide any, you know, advice is just too broad' [GP6]

'I don't think online symptom checkers can take a holistic approach to assessing a patient the way that real human clinician can' [GP2]

Some GPs emphasised the quality of health-related advice also depends on the actions of individual patients, and whether they are capable of processing the jargon-filled advice to their underlying health conditions such as dementia or other cognitive impairments.

'I think that it's a good thing, then again, if they've got, you know, dementia, the forgetfulness and all that stuff, that can be misleading for them, and it can be silly for other people as well' [GP10]

A few GPs were under the impression that the online symptom checkers were programmed with built-in safety mechanisms and, therefore, could not offer unsafe advice. A GP mentioned that the online symptom checkers acted as a baseline assessment tool to rule out the need for emergency care which is a useful service on its own.

Visits to health care providers

GPs expressed mixed opinions on whether online symptom checkers prevented unnecessary visits to health care providers. For example, some GPs viewed self-treatment advice for minor health conditions and directing patients to the most appropriate health service (e.g., A&E) would help to prevent unnecessary visits to health care providers, and in effect, a better use of the primary care services.

'So patients can get access to information easily and be directed to the right services to deal with their problems' [GP1]

'I think basically, it could make better use of the primary care team' [GP7]

Some GPs have expressed online symptom checkers have the potential to not only reduce GP burden but also free up GP time to deal with more complex problems.

'So I think it has the potential to be a really useful tool to reduce some of the burden in general practice. We need to look at more innovative ways of reducing that burden' [GP2]

'I mean, in theory, if it's done correctly, it will take away the simple things from GPs that often are quite time consuming, or block other people with maybe more complex problems from getting into the GP' [GP4]

However, some GPs pointed out that online symptom checkers might have the opposite effect to what was intended and increase the number of unnecessary visits to GP surgeries due to the low threshold for referrals as mentioned earlier.

'Because it's so cautious, tends to recommend more people go to their GP anyway' [GP6]

'They might overburden general practice with sort of inappropriate appointments as well as directing patients inappropriately to a&e or other health care services' [GP2]

Usage time

The majority of GPs were of the view that online symptom checkers takes too much time to use. GPs specifically mentioned that there are too many questions a patient must get through to reach a triage recommendation, which they felt was cumbersome. A GP empathised that getting grips with the technology and understanding jargon-filled questions and answers would inevitably prolong the process.

'And it seemed like a quite a lot of questions' [GP3]

'Patients will, you know, need time to understand the questions and get to grips with the technology'[GP6]

Some GPs stressed that it will likely take even longer for older adults to use the service. A GP expressed concerns that using online symptom checkers might take longer time than a normal face-to-face consultation which usually takes around 10 mins. So, rather than saving time, it may add further time and stress.

'Yes, from the older adults I've spoken to. Yes, it does take too long' [GP2]

'Takes too much time to use? That could be the case in the elderly, I would agree that it does probably take time to use as opposed to a 10 minute if they can come in' [GP7]

Disclosure of health information

More than half of GPs interviewed thought patients were not more likely to disclose more information to online symptom checkers than to health care professionals such as GPs.

'Well, I strongly disagree. I think that they trust their doctor, when they see them face to face, especially older patients, I think they're more likely to be honest and open with their GP' [GP2]

Some GPs stressed that the doctor's individual rapport with the patient is an important factor, in their view, for getting patients to disclose personal health information. However, some GPs

noted online symptom checkers have the advantaged of ensuring consistent service is delivered for everyone, not dependent on the varying individual GP skillset. The anonymity factor of online symptom checkers was also emphasised.

'Depends if you've got a rapport with a patient that then no, they would delve more and let you know more. If they don't trust you, or you don't have a rapport with them, then they might in some cases reveal more personal information to an anonymous online symptom check' [GP4]

Human emotion and empathy

Some GPs noted that unlike well trained and experienced GPs, online symptom checker lacks the ability to ask open-ended probing or follow-up questions or apply empathy during consultations. GPs also stressed that applying empathy goes long way towards reassuring patients and putting their mind at rest, which sometimes is all required to help a patient.

'An empathic, openly questioning, well trained experienced… give them a little bit of human touch' [GP7]

'In my opinion, they cannot replace human intuition' [GP6]

'So having some reassurance from the GP to either put their mind at rest' [GP1]

Hence why GPs interviewed firmly believed online symptom checkers cannot replace human intuition or human clinicians anytime soon.

'We would, you know, view a symptom checker, or anything except a doctor, as not being as good as a doctor' [GP3]

'I think there's a lot of limitations. It's never going to replace GPs' [GP8]

Diagnostic accuracy and reliability

GPs interviewed believed online symptom checkers lacked the intelligence or knowledge to accurately assess patients. Some GP participants mentioned they do not regard the current versions of online symptom checkers possessing any real intelligence to weigh up possibilities and come to a decision like GPs do.

'I wouldn't regard it as intelligence at the moment from what I know' [GP3]

A few GPs went on further to comment that GPs had the privilege to access patient's medical records and their medical history which gave them a better understanding of the context of any issues presented by a patient.

'I think it probably has some of the knowledge. But I'm not sure it's not got the whole picture of the patient' [GP2]

'I can take a history and I know the medical history of the patient beforehand. So I can get, you know, a better understanding of the context of whatever issue they're having' [GP6]

Some GPs expressed mixed opinions, including the fact that they did not know enough about the service or the underlying technology powering it to make a worthwhile comment.

'I'm neutral on this one. Because I don't know enough about the tool. I'm not going to disagree with that one.' [GP7]

On the contrary, some GPs reported the differential diagnosis of online symptom checkers was fairly accurate and it did often match up. One GP said although he recognises online symptom checker's differential diagnosis does not always match up with his differential diagnosis, he sees the positive side that the tool could be useful to rule out life-threatening health conditions. Another GP was optimistic that the diagnostic accuracy will improve with time as more data will be fed into the system and the NHS has some of the best source of data in the world.

'The differential diagnosis is, is fairly accurate' [GP7]

'I don't think they've been prompted to come because they wanted investigations further for something more sinister, but actually ruled out the sort of simpler stuff first'[GP4]

Many GPs perceived online symptom checkers as being unreliable, and some were unsure about their reliability. GPs with their limited experiences were predominately hesitant whether the tool was trustworthy or performs consistently well. GPs' confidence, or lack thereof, in diagnostic accuracy affects GPs' perceptions about the overall quality and reliability of the service.

'I think they can be unreliable *from a clinician's point of view' [GP2]*

Potential to miss red flags

The majority of GPs interviewed expressed concerns about the diagnostic and triage accuracy of online symptom checkers. Many were worried about the possibility of online symptom checkers missing red flag symptoms which may have life threatening consequences. GPs felt online symptom checker cannot capture crucial softer aspects or non-verbal symptoms (e.g., breathing patterns), hence potential to miss red flag symptoms. GPs reported that the majority of the diagnostic and triage decisions provided by online symptom checkers have not matched up with their diagnosis and triage decisions in face-to-face appointments. In some cases, the diagnosis has been close but not close enough to administer medication and treatment. For example, one GP mentioned that a particular patient had a rash, and when they had used the online symptom checker, it had narrowed it down to fungal infections. Although in this instance it was fairly close, there are over 300 sources of fungi infections with different types of anti-fungal drugs.

As well as missing potential red flags, which will be discussed in more depth later, some GPs have also expressed concerns about the low threshold of referrals to A&E. This can cause unnecessary stress and anxiety for patients. Conversely, some GPs have also expressed concerns about failing to appropriately probe further into certain symptoms to rule out high-risk health conditions, which can have dangerous consequences.

Overall GPs felt the diagnostic accuracy was not a safe level to be used in general practice.

'We worry about how accurate it will be in triaging and diagnosing things, especially dangerous conditions which can be life threatening' [GP2]

'On majority of the times, it's not really matched. So, patient might have chest pain but in the symptom checker saying they've got chest infection when actually they needed A&E to go and rule out a cardiac course. So, the symptom checker doesn't always match up to what you think your differential is when you see the patient face to face' [GP5]

Due to their deep-seated concerns about diagnostic inaccuracy and unreliability of the service including missing out red flag symptoms, many GPs stressed the importance of incorporating robust safety measures into the system to win over their trust and confidence. However, some GPs believed due to medico-legal reasons online symptom checkers have already been developed as safe as possible.

'I think all of those [online symptom checkers] programmes are built with safety in them' [GP3]

Access to the necessary technology

All the GPs interviewed believed older adults in general will struggle to have access to the necessary technology for online symptom checkers. Although many GPs acknowledged technology usage amongst older adults was increasing, some elaborated to say that older adults are still less likely to have a smartphone or understand the technology compared to young people. A GP added that in his view older adults may not have the funds to buy new technologies. They viewed these were some of the additional barriers to adoption which often gets overlooked

'There is a generation that may not have a smartphone, may not understand the tech. And that's going to be the situation for at least 20 or 30 years' [GP3]

'So especially with the demographic we're talking about, they might simply not have the money either' [GP6]

Patient data, privacy, and confidentiality

All the GPs interviewed expressed serious concerns about patient data, privacy, and confidentiality. Based on the interview responses, GPs reported mixed opinions on whether online symptom checkers increases patient privacy. The respondents who thought it had increased privacy referred to the fact that any apps used in the NHS will have to be GDPR compliant and adhere to NHS digital's strict rules around confidentiality, data security and information governance.

'[..] concerns have been laid to rest by the strict guidance from GDPR, from NHS digital, and all the various different, encrypted, secure compliances that these services have to adhere to when providing patient care' [GP9]

GPs expressed concerns about how online symptom checkers, being developed and owned by third party proprietorships, will safeguard personal patient information. In addition to recognising the threat and danger of hacking, GPs have voiced concerns about the potential exploitation of confidential patient data for commercial gain by private profit-based companies.

A few GPs highlighted the threat and danger of hacking. They fear confidential patient data may get into the 'wrong hands' or exploited for commercial benefits.

'In a GP practice, you have systems in place for safeguarding information, but that might not necessarily be the case with these online symptom checkers' [GP1]

'In the world of IT and internet and hacking and everything, I'm not sure how completely safe that these patients' information can be. And how confidentiality can be assured. Particularly by these apps being created by a non-NHS sort of third party companies' [GP2]

Personalised treatment

Based on the responses, GPs did not believe the current versions of SC helps to provide more personalised treatment. GPs thought SC offers generic treatment rather than personalised treatment. With the benefit of full access to patients' electronic health records, GPs provide personalised patient care. One GP stressed that personalised treatment is particularly important to treat complex health conditions which older adults are more likely to have compared to younger patients.

'I think that these symptom checkers seem quite generic. I don't think they take a full holistic view, they don't have access, like I mentioned before, to things like their history, their medicines that they take, you know, their family history, all of these things. There's no way that they can personalise it. Not yet at least' [GP2]

'That is a massive thing that would be missing, because a doctor really, really can personalise things' [GP3]

6.4.5 Additional barriers

Older adults' resistance to change

GPs highlighted that the majority of older adults, in their view, preferred the traditional ways of accessing their GP surgeries and wanted to continue with the existing system without radical changes. GPs felt that some older GPs may also feel anxious and likely to be more resistant to this kind of technology being used in general practice compared to younger GPs who have grown up with technology. GPs also noted that many older patients had to already adapt to using GP telephone appointment booking system and having consultations over the phone, but they perceived the adaptation to online symptom checkers may be one step too far for many older adults.

'They don't want to change or move forward with the times. They want to stick with the traditional ways of accessing the GP' [GP1]

'And they used to live in a time where you didn't have to make an appointment, you could just come in. That's the way they like it' [GP8]

'I think there's there'll be a lot of anxiety around it. There's also almost like a two-tiered system where you've got young GPs who have grown up with technology and are more than happy and are very used to already in day to day life using things like symptom checkers and just online things. Whereas you've got the older population, established GPs, who are perhaps more resistant to that kind of change' [GP2]

Age-related difficulties associated with ageing

Most GPs interviewed mentioned at least one physical or mental impairment associated with old age which they perceived may act as a major barrier to using online symptom checkers. For example, some GPs mentioned visual impairment as well as cognitive impairment such as dementia and forgetfulness stopping older adults from accessing online tools such as symptom checkers.

'They might have a visual impairment or cognitive impairment that stops them from accessing these online tools' [GP1]

'If they've got, you know, dementia, the forgetfulness and all that stuff, that again, can be misleading for them' [GP10]

Home visits

Home visits constitute an integral aspect of GP services, with vulnerable patients experiencing multimorbidity and frailty relying on these visits more than others. Some GPs have mentioned a GP walking into a patient house is able to pick up important background information such as the state of the house (e.g., untidiness) and house smell (e.g., urine) to help with their medical assessment as well as social prescribing. GPs sometimes also get to see patient's family members, who may also be their patients, which helps them to build a bigger picture of the patient's family health history.

'But walking into a patient's house, even doing out of hours and going and doing a visit somewhere, will give you a huge amount of information which AI will not be able to pick up' [GP7]

Managing chronic diseases

Some GPs have reported if online symptom checker was effective in dealing with minor ailments, and then it can potentially free up more time for GPs to manage chronic diseases.

'And if it freed me up to manage the chronic disease more, then that's a positive' [GP7]

However, a few GPs expressed concern that the tool may not be appropriate for older patients particularly those who suffer from certain chronic illnesses such as dementia.

Inappropriate appointments and overburdening existing services

Some GPs have expressed worry about the potential for system manipulation to overburden the existing health services including GP services and A&E departments with inappropriate appointments. One GP reported an example of how online symptom checkers automatically referred patients with chest pain to A&E as a precaution when it's not always appropriate or needed to do so. A competent GP with access to patient's medical record would be able to assess the severity of the symptoms and see if the chest pains are caused by other medical problems that can be resolved without the need for an A&E visit. This has the potential to not only inappropriately refer patients but also risk overburdening the existing health services.

'I would also be worried that as a first point of contact, they might overburden general practice with sort of inappropriate appointments as well as directing patients inappropriately to A&E or other health care services. And so, there's a risk of it overburdening existing services as well' [GP2]

A small number of GPs have raised concerns of potential system manipulation whereby the patient may deliberately enter red flag symptoms knowing that will likely lead to an appointment. Some refer to this as 'gaming the system' to obtain a fast-tracked appointment. GPs believe this will particularly disadvantage older adults who are not able to use smartphones

and online symptom checkers as well as their younger counterparts. This may contribute to increasing health disparities.

'They'd (patients) be able to look up what things potentially need to be seen, and they can put those into a symptom checker and ensure that they get themselves an appointment' [GP2]

Potential to make patient more worried and anxious

A few GPs stressed that the overly cautious approach of online symptom checkers has the potential to make patients feel unnecessarily worried and anxious for health matters which they probably should not be worried about.

'Conversely, it might make people more worried about certain things that they might not necessarily be needing to do or are actually worried about' [GP4]

One GP has expressed concerns about mental health getting over-medicalised if face-to-face consultations are reduced.

'Mental health side of it's going to get quite medicalised' [GP7]

Impact trust between doctor and patient

Most GPs reported the use of online symptom checkers in general practice will adversely impact trust and the doctor-patient relationship. See section 6.4.6 for a more in-depth discussion.

'Where does that bedrock of trust get established?' [GP7]

Some GPs have expressed frustrations that the use of online symptom checkers has had made some of the consultations more challenging, and at times, confrontational particularly when the patient disagrees with their diagnosis, and they use the tool as a counterevidence.

'[....] challenging consultations where patients were adamant that they had a certain health condition or of serious nature, which in my professional medical judgement, they did not' [GP6]

Patient empowerment & patient decision making

Some GPs felt the online symptom checkers have the potential to empower patients by providing more patient centred care whereby clinicians and patients work together to make decisions. A GP highlighted that online system checkers particularly empowered patients when they were at their most vulnerable during the Covid lockdowns. However, others have mentioned for online symptom checkers to act as an empowering tool, it must be simple to use, make patients feel they are in control, otherwise it can have the opposite effect and make patients feel frustrated and overwhelmed.

'If we're talking about empowering patient or patient centred care, or a pair shared decision making, then online symptom checkers empowered this cohort of patients during a period when they were the most vulnerable' [GP9]

The majority of GPs mentioned that they have concerns some patient groups particularly older adults will struggle to articulate or describe some of their complex medical issues and enter them into the online symptom checkers. More specifically, they fear many of their patients may not know which words to use and which medical jargon best fits their symptoms. GPs felt this might unintendedly force patients to enter incorrect symptoms which, therefore, likely to result to incorrect triage outcomes. One GP said that GPs ascertain a lot of information from patients from non-verbal communications as well as performing medical examinations on the patients.

'Yeah, because they might not say it in the way but understand it…I'll just say come in I'll do a neurological examination on you' [GP8]

Doctors' recommendation to older patients

The majority of GPs reported they would not recommend the current versions of online symptom checkers to older patients without taking into consideration patient's age, frailty, health conditions, and technology proficiency. GPs highlighted it was more of a patient-specific recommendation instead of a blanket recommendation. However, one in three GPs categorically said they would not recommend the service to any of their patients without further advancement of the technology. In another words, nearly all GPs interviewed did not feel comfortable in recommending online symptom checkers to majority of their older patients without conditions. Only one GP interviewed acknowledged there would be bit of a learning curve for his older patients.

GPs emphasised that their recommendation on the use of online symptom checkers to older adult patients was very much patient dependent. GPs have said they must be sure the patient would benefit from the use of the app and not get harmed by it, and patient has the necessary IT skills and technology to use the app.

'Would recommend to only the ones who don't have any underlying, you know, comorbidities which can affect their ability to put their user symptoms and also have access to all these facilities' [GP10]

'Patient to patient I guess, based upon their capability, the technology or their knowledge' [GP11]

The few GPs who categorically refused to recommend online symptom checkers to their older patients in general practice raised safety as one of their main concerns. They also cited unreliability, and their lack in confidence in the effectiveness of the app. They also felt there was a lot of room for improving development of the app and technology was not mature enough to be rolled out in general practice.

'I think, personally, right now, I don't think it's suitable for older patients. I think there's a lot of room for development for older patients, to be able to use them in a safe and effective way' [GP1]

'At the moment I don't feel confident in my patients being able to use it, or the symptom checkers on the other end being able to provide any sort of reliable, useful advice for them' [GP2]

6.4.6 Impact on doctor-patient relationship

This subsection explores GPs' perspectives on how online symptom checkers may impact the doctor-patient relationship. It also considers the impact on the relationship between older adults and online symptom checkers from the viewpoint of GPs.

The majority of GPs interviewed felt the use of online symptom checkers will adversely impact the doctor-patient relationship. Most GPs reported the essential components of the doctor-patient relationship as well as the doctor-patient power dynamics will be adversely affected, but these are explored more in-depth later in this section.

'From my limited experience it would adversely impact it' [GP11]

'I think it will negatively affect it' [GP2]

GPs expressed that the use of online symptom checkers may result in a reduction in face-to-face consultations, which in their views, will affect continuity of care as well as take away some of the softer interpersonal aspects of consultations that are necessary to build relationships.

Adverse impact on doctor-patient relationship

GPs felt older adults were accustomed to seeing and speaking to their GP in-person. They usually have known their GPs for many years and have an established relationship with them. Many older adults tend to trust their GPs and any radical changes to these arrangements would likely to decrease familiarity, undermine their trust of the GP services, and ultimately lead to adversely affecting their doctor-patient relationship.

'If you don't have regular contact with the people, I think that reduces the trust, increases suspicion and you know, just because they're not familiar with each other. So, I think that could really get in the way' [GP3]

Although some GPs felt that the use of online symptom checkers might enhance patients' accessibility to information, the majority expressed concerns about the potential loss of patient contact. This loss could reduce the exchange of information, both verbal and non-verbal, between patients and GPs. Such exchanges are crucial for maintaining up-to-date health records, including notes from health professionals. GPs felt that reduced interaction between patients and their GPs might gradually have a detrimental effect on the doctor-patient relationship.

'It's essentially detracting from the relationship because this loss of patient contact. And, yeah, so I think it's a bit detrimental in that' [GP1]

'They'll speak to the doctor less. Yeah, certainly the less sort of information exchange. So yeah, I think it could decrease the doctor patient relationship' [GP3]

A few GPs mentioned online symptom checkers could make patients less dependent on the advice of their GP. The reduced dependency could reduce the connection between patients and GPs, hence adversely affecting the doctor-patient relationship. However, one GP noted that if the online symptom checker leads patients away from them to see another health care professional and they were less dependent on him, then he was comfortable with that.

'*So, I think it will affect the doctor patient relationship, and patients will have more trust in the online resources. And less sort of dependent on the advice of their GP' [GP1]*

GPs also stressed that a weakened doctor-patient relationship might lead some patients particularly older adults to delay getting a timely diagnosis and subsequently a delay in the care.

'Possibly, especially if something leads to a delay *in a timely diagnosis' [GP5]*

Most GPs believed it's difficult for patients to form a relationship of any sort with non-human entities. They felt patients like that human interaction in face-to-face consultations. They also believed the use of online symptom checkers will result in losing that empathetic personalised care approach which patients are used to and which form an integral part of the doctor-patient relationship.

'Yes, for older patients in particular is very difficult to form a relationship with an algorithm or through a screen. They like that human interaction and building relationship in person. So doing that for a screen with maybe an algorithm isn't the right way to do things for them' [GP6]

'You would lose that empathic personalised care approach' [GP8]

Impact on GPs

GPs reflected on what impact online symptom checkers will have on them and on their part of the doctor-patient relationship. As the usage has been low among older adults, most GPs felt it has not yet had any meaningful impact on the doctor-patient relationship. However, there is concern that reduced one-on-one interaction with patients and less frequent contact over time will make it more difficult for GPs to build and maintain relationships with their patients.

'Overall, in my experience, I think it will adversely impact the doctor patient relationship. And that is what they expect' [GP12]

GPs perceive in-person interactions with their patients felt more personal and intimate compared to having interactions over a screen. GPs have noted that it's not possible to convey emotions such as warmth and compassion over digital health platforms in the same manner as they can in a telephone or face-to-face consultation. GPs have also reported the use of online symptom checkers and such digital technologies may make it more challenging to pick-up on the nuances in their speech and fewer cues to pick up on.

'No, that will be my conclusion. If I'm unable to build a relationship with a patient, then I'm unable to have that one-to-one interaction with them. There's a world of difference between having interaction in a personal capacity and from a screen. You can't convey you know,

human emotions, warmth, compassion, etc. Or pick up patient vulnerability through an online symptom checker. There simply isn't that capacity. You know, knowing someone and meeting them in person and a lot of nuances, a lot of, you know, changes in human cues, and, you know, see that they're worried about something and, you know, there's just that barrier created by the screen' [GP6]

One GP mentioned it may also increase anxiety of the newly qualified GPs or those GPs who are not yet totally confident in their clinical ability or acumen. This will make it more difficult for doctors to build a relationship with their patients and earn their trusts.

'I think if you're not confident in your clinical ability and your clinical acumen, then yes, it will' [GP4]

Limited impact on doctor-patient relationship

Some GPs interviewed reported they do not feel the use of online symptom checkers at the moment will have much impact on the doctor-patient relationship including with older adults' patients. As mentioned before, many GPs reported low usage of the app, therefore do not expect much impact on the doctor-patient relationship including adversarial effects.

'I think at the moment, it's not affecting the doctor patient relationship with older adults' [GP1]

'I'm little bit neutral for the elderly. I suspect it might end up not enhancing it because of other problems with using it. If they can get to grips, then yeah. I'm a little bit neutral, I think' [GP7]

A few GPs have mentioned that the use of online symptom checkers in general practice has the prospects to enhance doctor-patient relationship in the future as the service improves and becomes more reliable. One GP noted it has the potential to empower patients to have online symptom checkers, which in turn could influence the doctor-patient relationship from his perspective. Interestingly, one GP said it may create a positive competition and encourage GPs to make more efforts with their patients. However, GPs felt the anticipated usability problems with older patients will limit the chances of enhancing the doctor-patient relationship.

'I think as it improves and becomes more reliable, it will definitely enhance the doctor patient relationship' [GP12]

'Could do. Potentially, because it's healthy to have a little bit of a challenge' [GP4]

Important components of doctor-patient relationship

Trust

The majority of GPs reported that older adults do not yet trust online symptom checkers in the same way they trust their GP. With less potential contact and dependency on GPs, some GPs were worried this will not only likely to reduce patient's trust, but also make patients less likely to accept their diagnosis and management without extra questions particularly if the GP disagrees with the online symptom checker's diagnosis and triage decision.

'I think it will affect the doctor patient relationship, and patients will have more trust on the online resources. And less sort of dependent on the advice of their GP. And so it might be more difficult to, you know, as GP give your thoughts about diagnosis and management if patients are relying on online symptom checkers' [GP1]

'If my judgement is different to what the symptom tracker says […] and if they don't have a relationship with me in the first place, then who are they to trust?' [GP6]

GPs felt older adults' lack of trust means they may not be as open and honest with online symptom checkers as they would do with a GP. Some GPs expressed that the lack of trust might also increase their hesitancy to use and adopt this technology. GPs noted if the patient's trust does indeed improve then this might come at a detrimental cost to patient's trust with their GPs.

'I think that they wouldn't be as open and honest with online symptom checkers, as they would do with a doctor that they trust, and have been speaking to for years' [GP2]

'I think they're gonna have a lot of hesitancy when it comes to online symptom checkers…I don't think they're going to trust it' [GP2]

Communication

Many of the GP participants interviewed felt the communication and interaction between doctor-patient will be potentially reduced, and therefore will likely result to adversely impacting the doctor-patient relationship.

GPs have noted older adults generally tend to have a higher degree of disabilities and comorbidities, and many GPs have expressed concerns about their vulnerability as well as being able to articulate their health symptoms on a digital health platform. Some GPs felt older adult patients not knowing who they are speaking to may discourage them from seeking medical help, and therefore potentially could result to delay of treatment. This is contradicting the view expressed by some GPs in section 6.4.2 that the use of online symptom checkers can result to quicker treatment.

GPs highlighted that older adult are used to sitting down with their GPs and having things explained. However, many GPs perceived online symptom checkers potentially acting as a barrier for older adults to speak with a GP. With decreased communication and interactions, GPs felt it is more likely to make the doctor-patient conversation more like a one-way interaction and less collaborative way of making decisions and patient management plans. Furthermore, GPs felt if older adults cannot communicate their health concerns, then this will have a significant impact on their usage and acceptance of the service.

***'**It affects communication in many ways. I mean, our patients who are older, they may have disabilities, they may not be able to communicate exactly what they mean. And so, symptoms, they may not be able to explicitly put down in a symptom checker what it is that they mean, so things might be get missed. Whereas we'd be able to because we may be have known them for a while or met them before. So, I think it will seriously affect communication. I think, ultimately, I think it won't feel like a doctor patient relationship per se, it will feel like quite a one-way interaction' [GP2]*

Loyalty and Regard

With the current low usage of online symptom checkers, many GPs have reported the use has had very little impact on patient's loyalty and regard for GPs. Indeed, GPs have reported the extent of the decline in their view will dependent the length and quality of the relationship between patient and doctor. However, most GPs have mentioned that patients' loyalty and regard including older adults was already on the decline due to difficulties on getting GPs appointments and getting appointments with the same GP. Although GPs expressed a wide range of opinions on how patient's loyalty towards them will be affected, most GPs felt with higher usage will likely result to further decrease patient's loyalty towards GPs, and therefore, adversely affect the doctor-patient relationship.

In addition to creating a possible disconnect between patients and GPs, GPs believe patient may over time become more reliant on online symptom checkers which will impact their loyalty and regards for GPs. Furthermore, GPs believe prior usage of online symptom checkers may influence some patients to come into the consultations with an altered and unrealistic expectation. And if the expectations are not met, patients will likely feel more frustrated and upset. GPs have cautioned that if online symptom checkers are rolled out prematurely and hinders patients' access to clinicians, this will further impact patient's loyalty. A few GPs did, however, mention there are some circumstances when online symptom checkers may enhance the doctor-patient relationship, at least momentarily, particularly when online symptom checkers agree with the doctor's diagnosis and recommendations.

'Both increase in loyalty and possibly decrease in loyalty. It depends on how their relationship is with their GP' [GP1]

'I mean [liking and regard] would go down as well, because, you know, they just don't have as much contact. And they don't know anything about that doctor. So yeah, I think the general sort of niceness and friendliness term would probably be less' [GP3]

Doctor-patient power-dynamics

GPs participants have noted the traditional power-dynamics between patient and clinician has been in decline before the introduction of online symptom checkers in general practice. Some GPs compared to the power-dynamics, say 20 years ago, where GPs were very much dominant

partner in the relationship, but now they perceive themselves closer to health advisors who know a lot about health rather than leadership roles. Nevertheless, GPs were aware patients highly trust and rely on their judgement particularly older patients.

Many GPs believe online symptom checkers were written in a way which purports a more equal relationship between patient and clinician which empowers patients and will likely to have some influence on the power dynamics. GPs have no issues with patient empowerment if it is done in the correct way and does not contradict their clinical judgements. Some GPs felt empowering patients with more health information will keep GPs on their toes and might even remove some of the less competent doctors. Contrary to the common perceptions, one GP reported he believes it may even enhance GPs authorities if the judgement is supported by the application or patients have some prior information.

'As long as it's sort of empowering them in the correct way. I think that sort of, like, power dynamic will probably decrease as time goes on, hopefully. I try and reduce that power dynamic as much as I can' [GP3]

Implications of the changes in the doctor-patient relationship

Adherence to treatment

Most GPs reported they have not yet noticed any real effect on patient's adherence to treatment, due to low usage of online symptom checkers. However, with more widespread usage, most GPs felt patients, particularly older adults', adherence to treatment will be negatively affected, as older adults rely on seeing GPs rather than getting advice from a screen. Older adults have complex health needs and multiple comorbidities. Thus, if required older adults can ask questions and seek clarifications on their medical treatment plan and medication instructions in an in-person consultation. And unlike online symptom checkers, GPs can explain in detail instructions tailored to patient's language capabilities (e.g., in plain English if required). Furthermore, GPs can demonstrate instructions using hand gestures, eye contact and movement akin to sign language. As a result, older adults were more likely to understand and remember the instructions.

GPs also felt older adults were more likely to trust and follow instructions from their GP, and likely to feel more reassured if told by a doctor compared to online symptom checkers. GPs reported that older adults may feel confused if medical treatment plans were given in isolation as they were on online symptom checkers. This may also indirectly affect patient's adherence to other existing treatment plans which could have serious knock-on effects.

However, some GPs noted some benefits of having written medical treatment plan and instructions on online symptom checkers. Patients can go back to the written advice and refresh their memory which is particularly useful for older adults with memory loss or mobility issues. A few GPs believe this may negate some of the disadvantages, and therefore, older adults' adherence to treatment will not be significantly affected.

'I think it's more likely to negatively impact because if they don't have a GP explaining something to them, regarding the symptom, or their condition that they're suffering from. So I think it's not going to have a good impact on the doctor patient relationship' [GP1]

'Less likely adherence to treatment, if we tell them face to face, likely to have a better impact than for computer or online symptom checkers tells them. Older patients still rely on face to face consultations. They trust you, they know you, you know them. So they're going to rely on that rather than the online symptom checker' [GP5]

GPs felt that, in an ironic way, some patients have become more appreciative of having face-to-face contact in the post-Covid era, something patients missed during the Covid-19 lockdowns. Thus, in some ways, the Covid-19 pandemic has enhanced the doctor-patient relationship.

'They were pretty cross at not being able to see doctors, at the moment they're very happy to see me' [GP7]

6.4.7 Broader impacts in general practice

Effect on existing services

There were mixed opinions amongst GPs on the effect of online symptom checkers on existing services. Although no significant effect has been noticed by GPs yet, some GPs believed that if online symptom checkers becomes a reliable digital health tool, and patients are able to use it, then it has the potential to complement and work together synergistically in GP settings.

'I think, synergistically, they could work together quite well. But I don't think the technology is at that stage yet. Also, I'm saying it could actually reduce the burden on GPs in order to allow them to see more complex patients' [GP4]

It could help to better manage the demand for GP service and improve efficiency by directing patients to the most appropriate health service provider. A few GPs even noted that if online symptom checkers can take away some of the burden of treating minor health conditions, for example using over the counter medicines, then it could lead to better utilisation of GP time and GP resources. This includes freeing up time to see patient with more complex patients' needs and patients who need more time for explanations.

A self-confessed tech enthusiast GP expressed the use of online symptom checkers could ultimately increase GP productivity in general practice. This participant went on to highlight that patients' confidence in GP services could also improve if they saw a well-run health system complemented by online symptom checkers.

'If patients are able to use online symptom checkers, and if the online symptom checker is reliable, that it can direct patients to go to the place they need to go more quickly, whether it's A&E or to a pharmacy. A bit more efficient that sense' [GP1]

However, some GPs were worried that the use of online symptom checkers might overburden general practice and other health care services with inappropriate appointments. Thus, it could potentially have the opposite effect and make the entire health system more inefficient by creating more unnecessary work, contrary to its intended purpose.

'I would also be worried that as a first point of contact, they might overburden general practice with sort of inappropriate appointments as well as directing patients inappropriately to A&E or other health care services' [GP2]

Although online symptom checkers may have a part-role in general practice, GPs have noted the responsibility to look after patient's health and well-being ultimately lies with them.

'That's where you, you remain forever, this little independent practitioner, because the buck stops with you' [GP7]

GP workload

GPs have mixed opinions on whether the use of online symptom checkers could reduce GP workload. Some GPs felt the use of online symptom checkers could, for the reasons mentioned above, possibly reduce GP workload which could lead to improving GP's work life balance (e.g., leave on time) and their mental health.

'I think it can be used as a something to take the load off, which can be a good thing. But only in circumstances' [GP8]

One participant reported that by freeing up GP's time by dealing with minor ailments, this would GPs the opportunity to get their admin work completed on time which may help them to leave on time, and as a result, boost morale amongst GPs and make staff happier.

'We get our admin work done on time, we leave on time, our staff are happy, morale is high' [GP9]

However, due to the overly cautious approach of online symptom checkers, some GPs have stressed that widespread usage of online symptom checkers could also have negative unintended effect and increase their workload.

'They've obviously got a very low threshold for referring on. But obviously, what that can do is generate more work' [GP3]

GP crisis

GPs have expressed mixed opinions on the role of online symptom checkers in tackling some of the crisis in general practice. GPs highlighted some of the factors which are exacerbating

the crisis including how there are not currently enough GPs to serve the ever-growing population and how GPs are leaving the profession in droves and how the NHS is facing real terms cut in funding. Many GPs felt it is unlikely there will ever be enough GPs to serve the growing population. Some GPs felt innovative digital technologies such as online symptom checkers could with refinements help to reduce some of the burden in general practice including assisting with the staff shortage. Some mentioned how online symptom checkers may have more medical knowledge than say for example receptionists at the surgery who are not clinically trained but in some instances triage patients.

'I think it has the potential to be a really useful way to reduce some of the burden in general practice, because I'm sure you know, there's a huge shortage of GPs, and we need to look at more innovative ways of reducing that burden' [GP2]

Many GPs highlighted online symptom checkers are never going to replace GPs. Nonetheless, a few GPs reported some health care professionals in general practice may feel threatened and intimidated by use of the technology and some may even feel anxious and fearful for their jobs. Those GPs who are resistant against technology, particularly experienced GPs, may be pushed into retiring early. GPs reported this may make morale even lower, reduce job satisfaction and may exacerbate the staff crisis in general practice.

'I think, some will feel a little bit threatened by it, as it potentially being a way to remove their job roles or take away their responsibilities or their autonomy in how they work. And particularly in time, like now, where the workforce is struggling, and GPs and staff morale are so low, I think there's there'll be a lot of anxiety around it' [GP2]

'It has its place, but it's never going to replace GPs*' [GP8]*

'I just don't know if I would have the confidence at the end of my working life' [GP7]

Health inequalities for older adults

Overall GPs felt the use of online symptom checkers in general practice is likely to exacerbate health inequalities for older adults and mentioned a variety of reasons to justify this view. GPs felt older adults in general are likely to be more resistant to change from the traditional way of accessing GP services, and therefore, may find it difficult to adapt to not seeing their GP in the same way. GPs expressed concerns that the inability to create any meaningful relationships with online symptom checkers may put off older adults from seeking help with their medical needs. These concerns are likely to put off older adults from using online symptom checkers or visiting their GP, and therefore likely to increase existing health inequalities faced by older adults.

'I think some patients will find it difficult to adapt to that if they're, you know, visiting their GP' [GP1]

'Whereas you've got the older population who are perhaps more resistant to that kind of change' [GP2]

'And I agree with the likely exacerbation of health inequalities' [GP7]

GPs felt that older adults will be disadvantaged from using online symptom checkers because of health conditions associated with old age such as visual impairments, mobility issues and deteriorating cognitive functions. This will for some older adults act as a barrier and reduce their access to using online symptom checkers.

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'Disadvantages that I can see, for my patients who have health conditions such as visual impairments, mobility issues, perhaps mental health capacities might not be quite there, they will have lowered access to the technology, if at all. So, I see that that just creates another barrier to access for them, you know, leading to have more a wider health inequalities [GP6]

Some GPs were particularly concerned for older patients who might not have access to appropriate technology or have low literacy rates. These types of patients, in their view, will be further excluded, thus increasing health inequalities.

'I think there are so many issues with being able to access this, you know, money, having access to appropriate technology, being able to read, having mobility problems, all the things we talked about before. So I disagree, that is gonna in fact, I think it might increase inequalities' [GP2]

'Vulnerable groups not being able to really have access to it' [GP4]

GPs felt patients particularly older adults are likely to lose contact with their GP which may result to having determinantal effect on older adults' health outcomes.

'So, I think the online symptom checker will lose patient contact with their GP' [GP1]

Some GPs stressed the use of online symptom checkers may potentially help to create a two-tiered general practice particularly for older patients.

'Why are we creating more barriers and creating more inequality for the older population?' [GP5]

Potential to reduce inequalities

However, a few GPs mentioned some older adults could in fact benefit from the use of the service particularly those older adults with mobility issues. Therefore, for some older patients, it has the potential to reduce health inequalities.

'[…] it might also benefit some people, you know, using it from home. When they can't get to the doctor, etc' [GP3]

Some GPs did mention that online symptom checkers have the potential to empower older patients and facilitate pair shared decision making with patients.

'This has opened up this is if we're talking about empowering patient or patient centred care, or a pair shared decision making, then truly this empowered this cohort of patients during a period when they were the most vulnerable' [GP9]

6.5 Discussion

The qualitative study was conducted to gain insights into the experiences and perspectives of GPs on the use of online symptom checker in general practice with older adults including how it may impact the doctor-patient relationship.

Results from this study indicates that the experience and perspectives of GPs can be divided into four overarching themes: (i) Overall GP attitudes towards online symptom checkers (ii) Advantages and disadvantages (iii) Impact on doctor-patient relationship (iv) Broader impacts in general practice.

These results provided insight into the experiences of GPs from a wide range of backgrounds in describing the use of online symptom checkers in general practice settings.

6.5.1 GPs attitudes

GPs' perceptions and attitudes play an important role in promoting adoption of online symptom checkers particularly amongst older patients in clinical settings (219,343). In general, although GPs had a slightly negative attitude towards the use of online symptom checkers in general practice, most had not yet noticed any real and meaningful impact from their actual day-to-day experiences of working in surgeries making use of an online symptom checker. This is probably because, despite the encouragement from the UK Government and push from the health technology developers, the overall usage of the apps amongst all groups of patients including older adults were reported to be very low. Whilst an increasing number of patients were making references to online symptom checkers in both telephone and in-person consultations, GPs felt it was too early at the time of study to learn the extent of the impact in general practice settings. GPs expect as time since deployment length increases coupled with increased usage, the effects will be more noticeable.

The slightly negative attitude expressed by GPs on the use of online symptom checkers in healthcare settings is supported by and consistent with prior research undertaken with HCP's perceptions (109,219,368,369). For example, a study conducted by Palanica et al. (319) exploring the perspective of practicing medical physicians on the use of chatbots in health care

reported physicians had a wide variety of positive and negative perspectives. However, a closer inspection of the cross-sectional survey data revealed the perceptions were, like the findings of this study, slightly on the negative side. For instance, 53% of the respondents thought there were considerable challenges for patients to make use of health care chatbots. Unlike this study, the participating physicians were not required to have prior experience with symptom checkers and the USA's mixed healthcare system is different to the UK's universal healthcare system. A greater understanding of GPs' perceptions and attitudes towards online symptom checkers will allow a proactive approach to addressing negative perceptions and potentially increasing user acceptance in general practice (219,319).

Profile of users and low usage

GPs reported that the typical profile of online symptom checker users, based on their observations, has thus far been educated, young metropolitan adults with a middle socioeconomic status. Young adults as typical users of online symptom checkers in primary health clinics are supported by previous research in this area (77,344,370). For example, Verzantvoort et al. (77) reported most users were aged 19 to 45 years old. Although the socioeconomic status of patient groups has been theorised in previous research, and users tend to be of higher socioeconomic status (70,344,371), no studies have reported it based on actual experiences in general practice settings.

GPs from this present study reported overall low usage of symptom checkers in general practice settings, and even lower amongst older adults. These outcomes are similar to the findings of previous research revealing uptake and adoption of online symptom checkers is limited in national health settings (58). Although there are a few studies claiming a much higher usage amongst older adults, they were predominantly concerned with potential usage rather than actual usage, and not necessarily in public health settings as is the case in this study. For example, a UK-based study that engaged 1071 patients found that 51% aged between 55 and 69 years would use an online symptom checker (354). Many respondents showed an interest in using an trusted online symptom checker before (39%) or both before and after seeing a physician (37.2%) (354).

Usage during Covid-19 lockdowns

As a national response plan to the coronavirus pandemic, the UK government encouraged and accelerated the introduction of online symptom checkers into general practice to provide some form of access to treatment whilst reducing social mixing and spread of the virus. Therefore, the usage data may have been skewed by the lack of choices during the Covid lockdowns. For example, Mansab et al. (359) reported higher usage of symptom checkers during Covid, something like 44% of healthcare contact was made through online symptom checkers. Similarly, in this study, GPs also reported higher usage during Covid, but a key difference is that GPs mentioned there was a sharp fall in usage when the surgeries had re-opened their doors again and offered face-to-face consultations.

6.5.2 Advantages and Disadvantages

Advantages

In this research study, GPs perceived convenience for patients as one of the main advantages of introducing online symptom checkers in general practice. This is consistent with previous research in this area (70,372). For example, Aboueid et al. (70), exploring user perspectives on the use of symptom checkers using a qualitative approach, reported convenience as one of the main 'enablers' to increase user uptake and adoption. GPs perceive the convenience of being able to seek medical advice to self-triage at any time and from anywhere using an internet connected device is particularly helpful for older adults and those with age-related medical conditions such as mobility issues. Related to convenience and being able to seek medical advice remotely, GPs in this study agreed that online symptom checkers will help to reduce travel time to health care provider, in line with the finding of previous research (219,319).

Disadvantages

Patient won't always know which symptoms to enter or how to articulate them?

Research shows a significant portion of older adults in the UK have low health literacy (373) and as a result struggle with understanding medical terminology in both verbal and written communication. This affects older adults accessing public health services and taking medications correctly. Similarly, in this study most GPs in this study expressed concerns that older adults with varying degrees of health literacy and other challenges including complex

health conditions may struggle to articulate their symptoms into the online symptom checker. In addition, they felt online symptom checkers required the use of complex phrases and medical jargon which will further put off older adults from using the service, and if they do, they may enter inaccurate health symptoms which may result to wrong triage decisions. A recent study by Kujala et al. (219) reported health care professionals expressed concerns patients may not understand all the questions or wordings on an online symptom checker.

Potential to miss red flags?

The majority of GPs expressed deep worry about the possibility of online symptom checkers missing red flag symptoms and the life-threatening consequences it may have on patients. They noted older adults generally have more health problems and may be at risk if the online symptom checker missed something important. GPs also emphasised they looked out for emotions, tones, and non-verbal cues (such as patient's breathing) to evaluate a patient's condition as part of their diagnostic strategies, but this is not possible with online symptom checkers without going through a long cumbersome process. The concerns about the dangers of missing red flag symptoms for all patient groups is consistent with the findings of previous research (219,344,374).

Personalised treatment?

GPs felt online symptom checkers provide generic treatment suggestions rather than personalised treatment which GPs can provide with access to patient's electronic health records and with their historic interpersonal relationship with the patient. GPs particularly emphasised the importance of personalised treatment for older adults and patients with complex health conditions. This data from actual experience contrasts with the hypothesised claims made in previous research and by technology developers that online symptom checkers can provide personalised health service (375).

Disclosure of health information?

GPs disagreed that patients are more likely to disclose more information to health chatbots such as online symptom checkers than to health care professionals as indicated in previous research (202,376,377). GPs stressed that doctor's rapport with the patient and the quality of the doctor

will be influencing factors on how comfortable and willing patients feel in disclosing their personal health information. Although previous research emphasised the benefits of anonymity provided by online symptom checkers particularly to disclose sensitive health information (378), GPs made no distinctions and were referring to disclosure of all sensitive health information including stigmatised health issues (e.g., sexual health).

Exclusion of vulnerable groups?

Most GPs expressed concerns about the potential exclusion of vulnerable groups as one of the main disadvantages of introducing online symptom checkers into general practice. One of the vulnerable groups they were most concerned about was older adults. Amongst other reasons, they were particularly concerned about how older adults may struggle to use online symptom checkers which may act as a further barrier to accessing GP services. Overall, there is very limited previous research in this area. However, to some extent, this finding aligns with the results of a recent study conducted by Kujala et al. (219), which revealed that health care professionals expressed concerns about certain patient groups, such as older adults, being both unwilling and incapable of using online symptom checkers. Nevertheless, the key difference between this study and that of (219) was this was a qualitative study conducted in the UK health settings exploring GPs views in relation to the type of symptom checkers deployed in the UK, whereas (219) was quantitative study with a cross-sectional survey conducted in Finnish health settings exploring health care professionals' views (including nurses and physiotherapists, not necessarily only GPs) with the type of symptom checkers launched in Finland. However, Kujala et al. (219) did call for more in-depth future studies such as this study to explore health equity and support the wider adoption of symptom checkers in primary care settings.

May increase health inequalities for older adults?

In the current study with actual experience from general practice settings, GPs felt that in general the use of online symptom checkers is likely to exacerbate health inequalities for older adults citing reasons from older adults' difficulty in adapting to change to usability challenges due to age-related health issues. Although previous research predicted online symptom checkers risked worsening the 'digital divide' and further exacerbating existing health inequalities (38,39,115), there is limited research exploring the effect of online symptom

checkers on health inequalities from real world experiences. For instance, a systematic review reported the popularity of online symptom checkers with younger people has implications for health equity and recommended that future studies are needed to investigate the effect of online symptom checkers on health equity (344). One key difference from previous research is that some GPs noted some older adults could benefit from the use of the service particularly those who have mobility issues but are proficient with technology. Therefore, for some group of older adult patients, it has the potential to reduce health inequalities.

6.5.3 Impact on doctor-patient relationship

GPs interviewed reported that, due to their low usage, they do not believe online symptom checkers are currently have a significant impact on the doctor-patient relationship. However, the majority of interviewed GPs expressed concerns that the use of online symptom checkers could adversely impact the doctor-patient relationship. GPs anticipate a potential decrease in face-to-face consultations, and the resulting reduced communication and interaction may pose challenges in establishing interpersonal relationships, especially with older adult patients. Additionally, most GPs reported that essential components of the doctor-patient relationship, as well as power dynamics, are likely to be adversely affected.

The findings from this study concerning the impact on the doctor-patient relationship align with previous studies in this area, which have highlighted how online symptom checkers can negatively influence the traditional doctor-patient relationship by potentially reducing the frequency of in-person visits to the GP's office and affecting communication between doctors and patients (32,175,176,379). The emphasis on the human element expressed by GPs in this study is consistent with prior studies (32,379).

Some GPs believe that online symptom checkers have the potential to increase access to GP services, empower patients with more medical knowledge, and enable GPs to dedicate more time to listening to patients and developing relationships with them. This is also consistent with prior studies (109,180).

6.5.4 Broader impacts in general practice

Effect on existing services?

In this research, GPs reported no tangible effects on existing services which is in contrasts with theorised expectations in previous research. However, this is due to low usage amongst patients and relatively short time the symptom checker has been deployed. Nevertheless, in line with previous limited research (201,219), GPs have reported online symptom checkers have the potential to aid and complement existing services in general practice. For example, GPs highlighted that if the tool can help to reduce the burden of treating some of the minor ailments, then GPs maybe able to spend more time with older patients with complex health care needs. GPs are also equally apprehensive about the possibility of online symptom checkers overburdening GP services and wider health system with inappropriate appointments, which is again in line previous limited research in this area (33,380).

GP crisis?

The present study found that GPs have mixed opinions on the role of online symptom checkers in tackling some of the crisis in general practice. GPs expressed concerns how the NHS is facing real terms cut in funding and how it is unlikely, in their opinion, there will ever be enough GPs to serve the growing population.

In line with previous research (344), whilst some thought the use of online symptom checkers may exacerbate the crisis in general practice, some GPs felt innovative digital technologies with refinements and improvements could help to reduce some of the burden in general practice and to a certain extent indirectly compensate for the shortage of GPs. However, this study differs from previous research (319,374,381) as it reveals that while GPs did not consider online symptom checkers equivalent to qualified GPs, some believed these AI tools possessed more medical knowledge than certain non-clinical staff, such as receptionists. Improved patient triage by non-clinical staff, like receptionists, could help ease the workload on GPs.

6.5.5 Strength and limitations

Strengths

There are several strengths of this study. Firstly, to the best of our knowledge, this is the first study to explore the perceptions of GPs with some prior experience on the use of online

symptom checkers in general practice settings, and the potential impact on the doctor-patient relationship with older adults. Secondly, this study used a semi-structured interview method, a qualitative data collection strategy, to generate rich data about the topic as GP participants were able to freely express their views and experiences without being restricted to pre-made options, and the interviewer was able to ask follow-up questions and probes to delve deeply into the issues raised. Thirdly, this study used both inductive and deductive thematic analysis for analysing the study data, which offered the best of both top-down and bottom-up methods as well as the flexibility to answer the specific research question. Fourthly, several measures were taken to enhance the overall quality and credibility of the studies undertaken. For example, a sample of approximately 20% of interview transcript was coded by a second independent coder with an intercoder agreement of $\kappa = 0.90$. Additionally, this study was assessed by the standards defined as appropriate for evaluating qualitative research (253,382–384) and the summary of the assessment is presented in the Appendix 12.

6.5.6 Limitations

There were also several weaknesses to the design and implementation of this study. By the very nature of employing qualitative research methods for data collection, the generalisability of the findings with this study population (GPs) to the whole population of GPs is limited. Although data saturation was achieved, the number of participating GPs was relatively low.

Whilst there was a gender balance, and GPs from all backgrounds, experiences and age participated in this study, the use of snowballing sampling technique to recruit GPs means the GP sample was comprised only of those from the professional network of each participating GP. As the interview was conducted online over Google Meet, a video conferencing platform, it means GPs were familiar with smartphones and had certain level of technology proficiency which may not be representative of the entire GP population. Although mixed views were expressed, GPs' willingness to participate in the research could mean they held views which perhaps were more favourable towards the use of online symptom checkers in general practice which may make the findings less generalisable to the general population of GPs. A further limitation is that GPs had prior experiences with various online symptom checkers rather than just one specific brand. While most online symptom checkers were similar in terms of operational functionalities, differences such as graphic interface could have influenced their perception and experience.

6.6 Conclusion

This study showed that GP participants were slightly apprehensive towards the use of online symptom checkers in general practice. GPs were concerned about the potential negative effect it may have on vulnerable patient groups such as older adults and how the tool may act as a further barrier for them to access GP services. Whilst acknowledging and highlighting the potential benefits for the general population, GPs felt online symptom checkers could exacerbate existing health inequalities for older adults. In the following study, two ideation workshops are conducted to validate the findings from interviews with older people and general practitioners in relation to improving the use of online symptom checkers in general practice, thereby addressing RQ4.

Chapter 7 Validating and exploring user experience improvements and strategies to increase older adults' usage of online symptom checkers in general practice

In this chapter, two UX ideation workshops were conducted to explore, validate, and prioritise the design suggestions and uptake strategies that emerged from interviews with older adults and GPs. Both older adult and GP participants (see Chapter 5 and Chapter 6) have highlighted the low usage of online symptom checkers among older patients in general practice. This study investigates how the usage of online symptom checkers can be improved in general practice among older patients, thereby addressing RQ4.

The first part of this chapter provides an overview of the study's design, the methodology employed for data collection, and the ethical considerations taken into account. The subsequent section presents the outcomes resulting from thematic analysis, accompanied by relevant quotes extracted from interview transcripts. These quotes effectively capture the diverse perspectives shared by the participants. Following this, the findings are discussed in relation to existing literature and earlier research, leading to a conclusion that summarises the key points.

7.1 Introduction

The goal of the proposed UX ideation workshops was to facilitate two collaborative sessions involving the target group of users, which in this case is older adults, along with a GP and an IT expert (domain expert). The main objective of these sessions was to further explore, validate, and prioritise strategies for enhancing the usage of online symptom checkers among older adults in general practice. This involves examining the usability and user experience barriers and identifying potential solutions based on real-world insights that emerged from interviews and think-aloud protocols with older adults (see Chapter 5), as well as interviews with GPs (see Chapter 6).

The primary expected outcome of this research was to address R4 and develop broad design suggestions that specifically address the unique needs of older adults. Furthermore, the study

aims to provide additional strategies, including marketing and training, that can be implemented to improve the uptake of and engagement with online symptom checkers within the general practice setting.

(R4) - How can the use of online symptom checkers in general practice be improved for older adults, considering the perspectives of both older adults and GPs?

7.2 Study Design and Method

Two ideation workshops were primarily conducted to validate and gain additional insights into the specific barriers and facilitators influencing the use of online symptom checkers by older adults in general practice. These insights were derived from the thematic analysis of interviews conducted with older people and GPs. The objective was to summarise design suggestions and strategies to enhance the use of online symptom checkers among older patients.

The first workshop involved a round table discussion to explore design suggestions for improving usability and user experience specifically for older adults. The workshop facilitator, who is also the researcher, began by summarising emerging themes from previous studies related to user experience barriers and potential solutions suggested by older adults and GP participants. This was followed by a group discussion where older adults and GPs confirmed if the summary accurately reflected their interviews and think-aloud protocols, and if they had any additional insights to share. They were also invited to propose new suggestions and reach a consensus on the most valued features of online symptom checkers. After discussing each specific design issue, the expertise of an IT specialist was sought to assess the feasibility of implementing the suggested solutions using the available technology. The participants were then asked to prioritise the suggestions, sometimes leading to further discussions. The researcher summarised the discussions and confirmed the accuracy of the summary before moving on to the next issue.

The second workshop followed a similar process but focused on exploring strategies to improve implementation of online symptom checkers in GP settings, including training, support, and awareness raising. The first workshop focused on two substantive design and uptake strategies

(see Table 15), while the second workshop focused on four relatively smaller design and uptake strategy subthemes.

7.2.1 Participants

Population

The population of interest consisted of older people aged over 60 years old who are users of GP services., NHS GPs, and IT experts. The data collection took place in May 2023. This research was conducted in Sheffield, England.

Setting

This study involved working with older adults who were considered vulnerable participants. As with previous studies, established guidelines for working with older adults in research studies were adhered to, including the recommendations of the ethics committee and Sheffield University research guidelines.

Due to their vulnerability and specific needs, the choice of setting was more focused on accommodating older adults than other participants. For example, the workshops were deliberately held in a community centre that was fully accessible for people with disabilities and conveniently located to minimise travel distance for older adult participants. It was also ensured that there were toilets located near the workshop room to accommodate requests from older adults.

The workshop room also provided good WiFi access, windows with a pleasant greenery view outside, and was spacious enough for participants to feel relaxed and comfortable. There was also a nearby car park facility with disabled parking bays.

Sampling

As participants were recruited from a limited pool of individuals who had previously participated in studies, a convenience sampling technique was employed. This involved

selecting individuals who were conveniently accessible and expressed interest in participating. It should be noted that this approach also extended to recruiting an IT expert since it was challenging to find an expert specialising in chatbots and graphic user interfaces.

Eligibility Criteria

The selection criteria for older adults and GPs were identical to those used in Study 2 and Study 3, with the additional condition that participants must be capable and willing to travel to a nearby community centre for an in-person workshop. For choosing an IT expert, the criteria involved finding someone with expertise in improving the user-friendliness and overall user experience of applications and interactive web tools. This encompassed individuals who possessed extensive experience working with front-end graphical user interfaces at an industrial level, along with an understanding of chatbot technology and back-end implementation.

7.2.2 Participant Recruitment

Participants were chosen from a previously selected group of participants who had already been recruited for Study 2 and Study 3. The IT expert was recruited based on personal connections and met the specified eligibility criteria. The same process of initial discussions and opportunities for questions and clarifications occurred before the study. Before these discussions, the participants received an email containing the participant information sheet and consent form. A small WhatsApp group was created with the participants' permission to coordinate convenient workshops. This was considered the best way to keep everyone informed and allowed participants to interact with each other prior to the workshops.

It's important to note that participation in the study was entirely voluntary, and participants were not offered any monetary rewards except for reimbursement of travel expenses.

Number of Participants

The recommended minimum number of participants was recruited to ensure that everyone could express themselves in-depth (385). For the two UX ideation workshops in this study, this entailed including at least 3 older adults, 1 GP, and 1 IT expert. This approach allowed for diversity while maintaining a manageable group size for one facilitator. Additional participants

were approached as backups in case of last-minute cancellations, which were anticipated due to the busy schedules of general practitioners and the varying health conditions of older adults.

7.2.3 Challenges of conducting UX workshops with older adults

In addition to the recommendations from Study 2, the following measures were undertaken to enhance the likelihood of older adults' participation in the workshops:

- Keeping workshop activities simple: The activities in the workshops were designed to be straightforward and easy to understand, considering the age-related factors that can make it difficult for older adults to engage in group participation.

- Limiting the number of participants: The number of participants in the workshops was kept as low as possible to ensure that everyone had a chance to express themselves. This also increased the likelihood of older adults attending both workshops.

- Simplifying written and spoken language: Any form of written or spoken language used in the workshops was simplified to make it more accessible for older adults. This involved using plain language and avoiding complex jargon or medical terms.

- Starting with an icebreaker activity: The workshops began with an icebreaker activity where participants were asked to talk about their first job. This activity helped create a relaxed and inclusive atmosphere, encouraging older adults to participate and share their experiences.

- Encouraging equal participation: The facilitator made efforts to encourage and facilitate equal participation among all participants, paying special attention to older adults who may have felt less confident expressing themselves in front of a GP and IT expert.

- Structuring discussions: The workshops were conducted with a discussion structure that allowed the IT person to have the final say on a UX suggestion, particularly in terms of its implementation feasibility. This ensured that all participants' ideas were considered, while also leveraging the expertise of the IT professional.

- Ensuring accessible meeting centre location: The meeting centre location was chosen to be suitable for older adult participants including accommodations of accessibility needs.

7.3 Data Collection Procedure

A careful, step-by-step itinerary (see Appendix 16) was followed to ensure that the workshops were conducted in a manner that fostered rich discussions and generated valuable data, especially by taking into consideration the needs of older adult participants.

The workshops began with a customary introduction and the provision of health and safety information about the venue. This was followed by a few short icebreaker activities to help participants get to know each other and to create a relaxed atmosphere, particularly for older adults. Subsequently, a carefully planned workshop ideation discussion on each of the main themes that emerged from the interviews took place, focusing on design suggestions and uptake strategies in GP settings. The agenda included comfort breaks and time allocated for toilet breaks.

7.3.1 Transcription

The workshops were digitally recorded and later transcribed verbatim. The same transcription method as in previous studies was followed, but extra efforts were made to ensure capturing multiple participants talking at the same time, which posed a challenge.

7.3.2 Quality Criteria (validity of research)

To contribute to the establishment of credibility and enhance the rigour of the workshop findings, the researcher, acting as the facilitator, engaged in 'persistent observation,' which involved a thorough scrutiny of discussion topics (382,386). Additionally, the researcher made extra efforts to foster engagement through collaborative discussions and constructive feedback among the participants, helping not only to make them feel valued and heard but also to establish credibility in the workshop findings.

7.3.3 The role of the researcher

The researcher, acting as the facilitator, played a role very similar to that of the researcher mentioned in GP and older people interview studies. However, a key difference is the researcher's requirement in the workshops to engage in persistent observation with enthusiasm, build rapport, and foster engagement between participants.

7.4 Data Analysis

The data analysis technique employed for the qualitative workshops was identical to that used in the study involving interviews with older people and GPs. The reasons for its suitability and the rationale behind its selection can be found in Chapter 5.

The themes that emerged from the interviews with older people and GPs, regarding design suggestions and uptake strategies, were incorporated as inputs for the workshops. The outputs from these interviews were subsequently validated, prioritised, and expanded upon during the workshops, with consideration given to potential new data.

Ethical issues

This study has gained ethical approval for the workshops from the SCHARR Research Ethics Committee.

7.5 Results

Participant Characteristics

In total, 5 participants (3 older adults, 1 GP, and 1 IT expert) and one facilitator (the researcher) participated in the workshops. The same participants took part in both workshops. Two of the three older adult participants were in their 70s, and one was in their late 60s. Two out of three older adult participants were white British males, and one south asian female participant. All had some prior experience using Doctorlink. The GP participant was a female NHS GP in her

30s with some experience working in a GP surgery that made use of Doctorlink. The IT expert was a male in his 20s.

The resulting design suggestions and uptake strategies are organised into six themes, as emerged from the interviews in Study 2 and 3, and as illustrated in Table 15. The summary findings that emerged from the interviews and think-aloud protocols conducted in previous studies regarding design suggestions and uptake strategies will be abbreviated to '*Interviews*', and likewise, the findings from the workshops will be abbreviated as '*Workshops*'.

Strategy	Description
1	Incorporating age-friendly design and reducing effort expectancy
2	Improving usability and user experience for older adults
3	Enhancing implementation in GP settings
4	Improving training and support
5	Enhancing awareness and marketing
6	Co-creation with older adults

Table 15: Strategies to increase engagement and uptake.

7.5.1 Strategy 1 – Incorporating age-friendly design and reducing effort expectancy

Interviews

Most older adults found the online symptom checker challenging to use and poorly designed. Both older adults and GP participants emphasised the need to consider age-related needs in the design process to make it more user-friendly and accessible for older adults. For example, it is important to take into account older adults' visual needs, such as using bigger fonts, their hearing needs, by incorporating audio read-out loud features, and addressing memory loss issues, such as creating an easier login process without requiring them to remember passwords. These considerations would help increase usage among older adults.

'For older adults eyesight is an issue. Memory is an issue. You know, remembering how to get into it, for example.' [P10]

While older adults generally expressed the need for more user-friendly online symptom checkers, GPs specifically emphasised the importance of reducing the effort required for older adults to use the application by simplifying its functionality.

'To begin with, they need to be made more simple.' [GP6]

Workshops

During the workshops, both GPs and older adults reaffirmed and validated the findings of older people and GP interview studies, which stated that online symptom checkers should not only be made simpler to use but also incorporate age-friendly designs that take into consideration age-related needs as mentioned above. The IT expert also expressed similar views to those of the GPs and older adults, emphasising that online symptom checkers are inherently difficult to use and should be developed with reduced effort expectancy.

'When it comes to someone using it that wants to try and get an outcome, there's just quite an uphill kind of struggle.' [IT expert]

While participants from the workshops emphasised the need for age-friendly design, they prioritised reducing the general user effort expectancy (i.e., making it simpler to use for all ages) over incorporating specific age-related needs of older adults. The age-friendly design improvements that emerged from the workshops, suggested by older adults and GPs, are summarised in Table 16.

Age-friendly design		**Older adults Comments**	**GPs Comments**
Age-related needs	Design for older adults by accommodating a range of physical and cognitive abilities.	'So obviously, there's two types of accessibility, for example, dealing	'They might have a visual impairment or cognitive impairment that

		with visual impairment and so on' [P7]	stops them from accessing these online tools' [GP1]
Reduce effort expectancy – make it simple to use	Make online symptom checkers easy to use with a simple layout, simple graphics, and easy navigation	'More user friendly' [P4] 'Although I find my doctors online stuff practically impenetrable. It's not customer friendly' [P9]	'And simple layout, simple graphics. intuitive, easy to navigate' [GP9]
Tackling bias in AI	Make the AI algorithm more transparent and reduce inherent prejudices from historical data, including ageism.	'The problem with that is bias built in society, which is then transferred wholesale to into apps or services where they claim to use AI, that's a real big concern of mine. I'll be reluctant to endorse something which I don't	

		understand the algorithm. We don't have this openly declared. There needs to be transparency' [P7]	

Table 16: Age-friendly design

7.5.2 Strategy 2 – Improving usability and user experience for older adults

Interviews

Visual aid

Both GPs and older adults expressed a desire for increased graphic content and reduced text in order to enhance user engagement and assist older adults in using online symptom checkers. Both groups of participants emphasised the importance of incorporating visual aids such as an interactive body diagram to facilitate comprehension and enable rapid identification of areas of concern. In addition, older adults specifically requested a progress bar to track their progress during the consultation and determine how close they were to reaching a triage outcome. GPs, on the other hand, discussed the implementation of a digital human avatar that could personalise and imitate patients' interactions with their doctor. GPs mentioned that the online symptom checkers design should incorporate ample white spaces to ensure accessibility for patients with impaired vision, such as presbyopia.

'Use a more graphics, less words and use more pictures.' [P4]

Language

Most participants emphasised the importance of simplifying, using empathetic language, and avoiding jargon in online symptom checkers. The current language was found by older adults

to include complex medical terms (e.g., erythema nodosum) that were difficult to comprehend and discouraging. Older adult participants also expressed a desire for describing and inputting their symptoms in simple and easy-to-understand language. GPs highly recommended incorporating empathetic language, such as saying "I'm sorry to hear..." to replicate a consultation with a human doctor, thus making it more interactive and personalised. GPs also expressed the need for online symptom checkers to provide multiple language options to accommodate patients whose first language is not English.

'Use normal (everyday) language, most people don't know clinical language.' [P1]

Questions – simpler, briefer, more relevant, and with audio alternative

In addition to shorter and simpler questions, many older adult participants expressed a desire for an improved flow of questions. Currently, in their view, the questions are too long, and the sequence of questions appears to be arbitrary and not always related. Furthermore, older adults indicated a preference for an audio feature that would enable them to have the questions read aloud to them.

Touch screen sensitivity

Older adult participants who used touch screen devices (e.g., smartphones and tablets) for online symptom checkers expressed a desire for adjustable and reduced touch screen sensitivity. They feel that the current sensitivity was too high, leading to accidental touches, especially for individuals with age-related trembling and shaky hands.

Button and text sizes

Older adults and GPs expressed a desire for the incorporation of bigger text size. The suggested recommendations for enhancing the usability of mHealth applications among older adults involve employing larger fonts, especially for important information, to accommodate those with poor or worsening eyesight. Additionally, less crowded screens should be used to reduce errors when selecting buttons

Colours

The older adults and GPs involved in the study expressed a desire for an age-appropriate colour scheme. When it comes to choosing colours, many participants suggested to have bright, distinguishable colours with strong contrast and boldness, rather than pale ones, considering age-related decline in visual abilities. Additionally, use a colour scheme to distinguish various options in multiple-choice answers (387).

Questions

Both older adults and GPs emphasised the importance of keeping the questions simple, avoiding excessive text or choices that could potentially confuse older users and lead to incorrect usage or abandonment.

Data entry

Older adults have highlighted the need for flexible data input options, citing the current methods as too rigid and limited. This encompasses voice input and a better understanding of variations in language and speech, such as local accents.

Help Guide

Older adults have emphasised the importance of having an easily accessible help guide with step-by-step instructions on how to use online symptom checkers.

Privacy

Concerns about privacy and confidentiality was emphasised by older adults. They also recommend the implementation of protective measures to reduce the chances of users sharing inappropriate personal messages.

Chatbot interfaces

Many participants stated that they wanted the online symptom checkers to be more interactive and responsive. While older adult participants did not mention any specific important

measures, some GPs talked about including chatbot interfaces to emulate conversations with a GP.

Navigation

Both the older adult participants and the GP participants expressed frustration with navigating the application. While several participants expressed dissatisfaction or encountered difficulties with navigation, only one older adult participant provided detailed suggestions for improvement. They believed that online symptom checkers should have an intuitive and user-friendly navigation system. Specifically, the older adult participant recommended placing a clear back button at the top of the interface to facilitate moving between screens. Currently, on Doctorlink, the back button is hidden in the top left-hand corner, making it challenging to locate, and clicking it takes the user out of the app.

Multiple ways to input data

Both general practitioners and older adult participants expressed the desire for multiple methods of data input, such as voice recognition, in the online symptom checker. Currently, users are limited to entering symptoms in a specific manner. Furthermore, older adults suggested the option to select multiple relevant symptoms simultaneously, instead of choosing them one at a time.

Login security

Older adults also complained about the difficulty of remembering the passcodes to log in to both the device (e.g., smartphone) and the online symptom checker application. Considering that older adults are more prone to experiencing memory loss as they age, some of them suggested the adoption of facial recognition or touch identification methods to unlock devices and ensure the security of applications or websites.

'So that it feels like a more interactive process for them' [GP2]

Workshops

Both GP and older adults who took part in the study confirmed the results from Study 2 and Study 3 regarding recommendations to enhance the usability and user experience of online symptom checkers for older adults. Additionally, an IT expert expressed the opinion that the design and usability of online symptom checkers were not suitable for older adults and could be greatly enhanced.

'I think there's just a lot going on. They've tried to fit a lot of functionality into an app.' [IT expert]

Graphics

The IT expert proposed enhancing the graphics in the workshop by enlarging the tap area on the screen. For instance, they recommended increasing the size of the buttons to facilitate easier tapping.

'The app also could make the options like the tap areas bigger and making them buttons easier.' [IT expert]

Interactive body map

The participants believed that the body map would help them identify problem areas of their body more quickly. Additionally, one participant noted that the body map would not only improve their knowledge of body anatomy and the positioning of organs but also supply valuable insights for assessing the urgency of the problem and making decisions about subsequent actions. On the whole, the participants expressed a belief that the interactive body map would bring various advantages.

'Might have a picture of a leg and you can touch the part of the leg, where you got the problem.' [P2]

'If you talk about your back you know, it could be anything, might not even, but you know, I didn't realise that the kidneys were so far around as what my doctor told me. So you're getting this pain, and you're thinking it's something else. It's actually your kidneys. So if you

can just point on that bit. The computer says, yeah that's a kidney problem, or that's something else.' [P2]

Avatar

All participants believed that the inclusion of avatars would be helpful in simulating a real GP consultation with physical contact. The IT expert mentioned that the latest avatars are capable of emulating human interactions to some extent, and the advanced facial detection technology can interpret the user's emotions, which is highly valuable for medical consultations. However, one participant expressed scepticism, stating that the use of avatars would still be limited to computer-based interactions, and the technology has a long way to go before it can truly mimic a genuine GP-patient interaction.

'They rate it really high up to be able to have that eye contact, to be able to feel like they've built a rapport with who they're speaking to.' [GP2]

'There is facial detection, the technology is there where it can read your emotions and things.' [IT expert]

'But it's still a computer thing.' [P1]

Language

The consensus among all the participants in the workshop was that the language used in online symptom checkers should be improved to better cater to older adults. This improvement entails simplifying the language to make it easier for them to understand, avoiding the use of medical acronyms, ambiguous words, or words with multiple meanings, and incorporating empathetic and conversational language that mimics natural conversations with doctors.

The participants, particularly the older adults, reiterated their preference for inputting data in various ways, such as through audio, and emphasised the importance of having additional language options, including regional accents. These preferences confirm the findings of Study 2 and Study 3. Furthermore, the IT expert suggested that the technology is available for this,

including approximate string-matching function to handle typos, misspellings, or slight variations in the text, as well as AI technology to recognise language variations including accents.

'I think they should use normal language, like not clinical language, because most people don't know clinical language, and make it more easy and simple.' [P1]

'Because some of the questions are quite vague. You could say no, but it's not actually.' [P2]

'I think it's getting there. The regional accents, I think has always been an issue that they've been trying to try to solve. I think, with the new application of AI and the new technologies that are coming through over the last six months, year or so I think that the detection and the understanding of what voice inputs are given is going to massively increase. I think that would help with understanding regional accents and variation of speeches.' [IT expert]

'It feels quite insensitive.' [GP2]

Navigation

Although all workshop participants confirmed the need to improve the app navigation, they provided only a few suggestions on how to do this. The navigation should be simplified so that older adult users feel supported throughout their journey, as if someone were guiding them step by step. One suggestion, made by an older adult participant, was to include a progress bar and use prominent arrows at the top. The IT expert acknowledged the feasibility of this suggestion.

'There's just quite an uphill kind of struggle to be to go into the right places, tapping the right places. Very busy, isn't it?' [IT expert]

'The back arrow was more better than a cross because you know people pressed the cross, and then, you've already spent half an hour trying to get through this and then click, oh no that's gone.' [P2]

Interactive / Chatbot

During the workshop, all attendees expressed their desire for increased interactivity when using the online symptom checker. This involves implementing a more advanced chatbot interface, an interactive body map, and potentially incorporating 3D avatars, as mentioned in the interviews with older adults and GPs. One of the older adult participants in the workshop emphasised the importance of adopting a proactive approach, rather than a reactive one, to address the challenges faced by older adults. They suggested that offering instant feedback during the question process would be beneficial, as the current experience feels overly procedural and lacks immediacy in delivering results.

'Just sort of trying to think out loud, is it possible that when you enter something, that a wee smiley face comes, ah that was reasonable answer to that, or that's okay, or oooh you've done something wrong there? So, it's like instant feedback on what you're doing.' [P9]

'The whole thing I think about new technology, is that it's got the ability to be proactive rather than reactive.' [P9]

Initial set up

Both older adults and GP participant validated the previous findings regarding the need for more assistance during the initial setup process, which is particularly challenging for older adults. This includes ensuring easy access, from downloading to installing the app.

The participants also discussed in-depth how the registration process for new patients is excessively time-consuming and overly complicated, leaving some users frustrated and confused. The IT expert suggested that the app could be pre-populated with user data, similar to the registration process of the NHS app. Additionally, participants discussed how the use of facial recognition could benefit older adults in terms of login security. The IT expert also recommended adjusting the phone screen sensitivity to prevent users, especially those with dexterity issues, from inadvertently pressing incorrect buttons.

'It wasn't kind of a smooth experience [the registration process]' [IT expert]

'It makes me feel frustrated.'[P9]

Personalised

During the workshop, all participants emphasised the need for online symptom checkers to be tailored to each user. This involves implementing a personal user profile that considers individual requirements and enables the application to adapt accordingly. The participants also discussed the idea of granting online symptom checkers access to users' electronic health records. This would allow for more customised questions based on the patient's specific needs and medical history.

'So, if you say you've got an eye sight problem there may be the font grows a bit. If you don't, then it stays where it is. Got hearing problems, it shouts very loud. So, its that kind of personalisation of it.' [P9]

'Maybe adding questions in about you know, like small talk kind of questions like 'how's your day' or 'how has your day been?'. Whilst it may not contribute anything to the application, it might add a kind of human touch to it.' [IT expert]

User guide

Both older adults and GP have re-emphasised the necessity for simplified user guide instructions with step-by-step guidance. This guide should be available in various formats, including video. During the workshops, they expressed a preference for these resources to be readily available through their GP service, as they are more likely to read and follow instructions when sourced from the GP surgery.

'Literature and simplified video instructions on how to use online symptom checkers provided by the GP surgery would be very useful.' [P1]

In terms of prioritising the suggested ideas to enhance user experience and usability, improvements should be made to the language, navigation, and graphics of the online symptom checker, as discussed previously. Usability design improvements mentioned by older adults and GPs are summarised in Table 17.

Usability:		Older adults Comments	GPs Comments
Graphics and visualisations	Use more visual aids (such as pictures, video clips, etc.) to engage users and enhance their understanding of the content. However, avoid using distracting images and animations.	'I think if there was some more, if there was an early visual, which was talking about the parts of the body, that you were concerned about that would help' [P5]	'They could try to incorporate more visual aids to help older patients' [GP6]
Chatbot / Interactive • Mimic human interaction • Improve interpersonal communication • Improve interactiveness	Integrate interactive chatbots that simulate human interaction to enhance user engagement. Presently, it seems too mechanical.	'Trust is built on the fact that they're getting a response. If there isn't a response for just a cold calculator' [P7]	'It's like talking to a chatbot, but it's like talking to a person, you know, you'd have something you send it and then he talks back to you he interacts with you. It feels like it almost human interaction' [GP9]
3D Avatar	Avatar designed to resemble a doctor and		'So if there was something that the

	replicate the atmosphere of a GP surgery. The primary objective is to create a sense of being present in a medical setting and to foster greater interaction.		patient could see online, like a visual, like a person, maybe speaking back to them, rather than just text, or audio, like they can actually physically see someone that possibly resembles a doctor or speaks back to them?' [GP1]
Interactive body map	An interactive body map allowing users to quickly pinpoint specific regions of the body.		'Symptom checkers incorporates a body map where patients can pinpoint where they're having an issue and then it can help to go down the process of finding an outcome' [GP6]
Alternative input methods	Provide additional methods for inputting symptoms and answering the questions.	'Just it didn't have the sort of straightforward route through that I'm used to, for example, where it says, enter your date of birth. You can't put a slash in there' [P6]	'So that could be simply more input from all the people in the creation of the software' [GP6]

		‘Use normal (everyday) language, most of most people don't know clinical language’ [P1]	
Login security	Provide a secure, yet convenient way to access the application without the need to remember passcodes. For instance, by implementing facial recognition technology. Additionally, allow family members to log in and use the application on behalf of the user.	‘I don't remember passcode. I mean, I've got quite a lot of passcodes. I don't remember that. And especially if I wasn't feeling well. I'm much more likely to forget. So that would make it more difficult to use.’ [P10] ‘What's going to happen, for example, if I've given lasting power of attorney to my daughter, and you know, I've got to a stage	

		where I can't do it. Would she be able to use this on my behalf? ‘ [P10]	
Colours scheme	Simple colours that are suitable for older adults and provide sufficient contrast to distinguish between colours used in and around text, icons, buttons, etc.	‘If it was pretty colours or something like that.’ [P10]	‘The Babylon one is a white app. No fancy colours, no lots of buttons’ [GP9]
Large fonts	Large fonts to ensure readability for older adults with minor visual impairments.	‘It could use a larger font?’ [P2]	‘Big size font so that if anyone has any visual impairment, they can see it easily’ [GP1]
Notifications	Alerts to remind users of their GP appointments and when to take medications, among other things.	From researcher’s notes and observations.	
Navigation	Seamless navigation.	‘Just back to previous question, or something navigating through the interface is one of the challenges. If you click back, it	‘And simple layout, simple graphics. intuitive, easy to navigate’ [GP9]

		takes you out of the app' [P6]	
Progress bar	Progress bar to visualise and inform the user about their distance from reaching a decision	'And the idea of giving some sort of feedback partway through rather than having to go through a very long list? [P10]	
Touchscreen sensitivity	Adjust the touchscreen sensitivity to reduce the chances of accidentally touching the wrong button.	From researcher's notes and observations.	
Audio	Audio option that reads out loud the question and options.	'But if the questions are read out, then it's not difficult, isn't it? There's no writing involved in that.' [P10]	
Fix app freezing and crashing	Fix the software code bugs that frequently cause the app to freeze and crash. These issues discourage users and undermine their confidence.	'And also, sometimes when you there, and it freezes some time. And when it's not working, and you are in the middle of the process. So you don't know what to	

		do then? You are very anxious then, it can be stressful for you' [P1]	
App size (needs moving)	App size reduction would enable its usage on a wider range of devices.	'You'd need a certain level of technology to access.' [P3]	
Easier ways to access app	Make the process of downloading, installing, and setting up the application easier and simpler.		
Personalised	Enhance its personalisation by incorporating not just design elements, but also providing access to the patient's medical history. This will create an experience similar to in-person consultations.	**'**Now it's about input and output. I think what you put in what you get out. How about saying hello, how are you today? Yeah, more dedicated for me' [P8]	'I think that these symptom checkers seem quite generic…there's no way that they can personalise it. Not yet at least' [GP2*]*
Language	Employ uncomplicated language that is easily understood by individuals	'Yeah, because that's like in Latin kind of thing or	'Look at the language they use. So we need to look at all the very

	with no specialised knowledge in the field. Additionally, offer language options in multiple languages can cater to diverse linguistic needs.	whatever medical term that you know, 'erythema nodosum' doesn't mean anything to me' [P2] 'Make it more easier for us. You know, small words' [P7]	different barriers' [GP2] 'Patients will, you know, need time to understand the questions' [GP6]
Emotion and empathy	Enhance the personal and empathetic nature of the interaction, consider incorporating phrases such as "I'm sorry to hear..." to convey emotions and empathy.	'I want to speak to someone because I want reassurance' [P3] 'And the other side of health, in my opinion is you want to talk to somebody that needs to be somebody that actually empathise' [P7]	

		.	
Questions	Revise the questions to be more focused and relevant. Currently, the questions are overly general and lack a specific connection. The sequence of questions should be more coherent and purposeful, rather than being random and arbitrary. Additionally, it would be beneficial to decrease the number of choices in multiple choice questions.	‘Right, this is one of the reasons I found that difficult to use, because I was being asked questions that I didn't have answers for’ [P10] From researcher’s notes and observations. ‘I'm not sure if some of the questions could perhaps have been slightly simpler, simpler and easier’ [P13] ‘I think some people might be put off when some	

		of the things I've got about eight different answers to go through' [P13]	

Table 17: Improving usability

7.5.3 Strategy 3 – Improving implementation in GP settings

Interviews

Based on the findings of the interviews, both older adult and GP participants expressed concerns regarding the protection of privacy and confidentiality. Many older adult participants expressed concerns about third-party ownership of online symptom checkers and would like assurance regarding their compliance with data protection and privacy regulations. GPs recommended implementing stringent software security measures to safeguard their patients' health information. GPs also aim to minimise system manipulation, which benefits those who know how to exploit the system to receive quicker attention. Older adults, who often have lower technological proficiency, are particularly disadvantaged.

Workshop

All participants reaffirmed the findings of the older people and GP studies that online symptom checkers, currently operating in isolation, should be integrated with their GP IT systems and wider health networks. Older adults and IT experts have emphasised several benefits if the results of the online symptom checker are shared with the GP surgery. This includes potentially giving GPs more time to engage with patients and offering personalised services with access to their electronic health records. However, the GP participant emphasised that they still had to perform their own triage rather than solely relying on the outcome of the online symptom checker. The IT expert recommended that online symptom checkers should not only be integrated with GP IT systems but also with other health gadgets such as Apple health watches to consolidate all health-related data for the benefit of the user.

'I've seen cases where people have their Apple Watches report they've got atrial fibrillation or whatnot going on, and they've gone into the doctors, well you're about to have a heart attack in the next two days or whatever. So it's good they've come in. So the technology is there, whether it's fully reliable.' [IT expert]

Among all the suggestions on how to improve the implementation of online symptom checkers in general practice, participants categorised integrating with GP systems as their top priority, while addressing privacy and confidentiality issues was considered the least concerning out of all the suggested ideas.

'I think if it would be better implemented in conjunction with GP systems. So this is the first step, you can go through the symptom checker. Yeah, as long as those details then end up with your GP, or with the person that you are going to see face to face in the end, whether that be in the hospital, the walk in centre, your GP wherever you get your appointment out of hours clinics, that could save that one or two minutes. Conversation when you're in the appointment, allows the GP to see more people, maybe spend less time writing notes, because that initial triage has been done. So, if the systems are linked together, I think that vastly improves the usability.' [IT expert]

'We go through the process and at the end that information doesn't go anywhere.' [P9]

The older adult participants reiterated their concern about data security when using online symptom checkers. The GP participant specifically expressed worries about the potential exploitation of patient data and the privacy of vulnerable patients. The older adults stated that they do not trust online symptom checkers as much as they trust their GP when it comes to data security.

'I'm just concerned about the data security and the safety.' [P1]

'Just concerned about data safety.' [P1]

'I think confidentiality is really important. Doctors are hardwired to be confidential.' [P9]

Furthermore, the GP participant re-emphasised safety features in online symptom checkers to protect patients from unintended harm. They suggested that these platforms should have built-in safety options to directly call their GP surgery and emergency services for immediate assistance.

'Doctors feel anxious about it from patients safety and medical legal point of view.' [GP2]

'You have to be very careful about vulnerable adults and their safety.' [GP2]

All participants stressed the importance of equal access to GP services for all patients, including older adults. However, many participants felt that online symptom checkers tend to favour younger patients, putting older adults at a disadvantage.

'It gave younger people who are able to access to service the capacity to send multiple messages about small things, which then clog up the triage list of things that you'd have to go through and then it means that patients, you know, older patients don't get seen.' [GP2]

Suggestions for improving the implementation of online symptom checkers in GP settings, as suggested by older adults and GPs, are summarised in Table 18.

Implementation in GP settings		**Older adults Comments**	**GPs Comments**
Integrate with GP surgery IT system and other telemedicine tools	Facilitate communication between online symptom checkers and GP surgery IT systems.	'Right now, if I thought that what I was doing was providing information that went on to the doctor so that when I went to the doctor, I didn't have to repeat all my	

		symptoms. Then that would be more useful' [P10]	
Option to book GP appointment through the app	Provide users with options to book GP appointments through the online symptom checker.	'If they knew which GP I was registered with, and if the outcome was that I need to go and see my GP, that if it allowed me to book an appointment with my GP through the symptom checker' [P3]	
Access to medical records	Access to electronic health records would help personalise treatment and address complex health conditions.	'Because I have a history of illnesses. That history always linked to my current conditions. And that wouldn't be you know, the process, the symptom checker won't be able to take that into account' [P3]	'Like I mentioned before, to things like their history, their medicines that they take, you know, their family history, all of these things. There's no way that they can personalise it. Not yet at least' [GP2]
Improve diagnostic accuracy	Improve the diagnostic and triage accuracy of online symptom checkers. The potential to miss red flag		'They might overburden general practice with sort of inappropriate appointments as well as

	symptoms may have life-threatening consequences.		directing patients inappropriately to A&E or other health care services' [GP2]
More health conditions covered by SC	Increase the number of health conditions covered by online symptom checkers. They are currently very restrictive.	'If there was a bigger range of symptoms, that would be helpful' [P5]	GPs have unequivocally agreed SC cannot effectively care to the full extent of the patients' needs. In fact, every single GPs interviewed either agreed or strongly agreed with this statement.
Ensure equal access to GP services	Ensure that the user has the option to access GP services using traditional methods.	'I still want somebody at the other end to respond. Already I'm prepared to accept. But when no choice can speak to a receptionist' [P7] 'But same time, you should have an option. If you're not satisfied, you need to go to the doctor and get an advice from doctor as well' [P1]	'So that could be another help. But also, this shouldn't reduce the opportunity of actually meeting a GP in person' [GP6]

Feedback from surgery	Provide users with the option to send communications to the surgery through online symptom checkers.	'You get an acknowledgement when you do something. And they send you saying we've got your request. It's like any communication with communities' [P9] 'Right now, if I thought that what I was doing was providing information that went on to that went to the doctor so that when I went to the doctor, I didn't have to repeat all my symptoms. Then that would be more useful' [GP10]	
Privacy (dignity breach worry) and confidentiality	Ensure that privacy and confidentiality are not compromised.	'And I might resist on the basis of privacy' [P7] 'Not least, it's certainly you don't want anybody else to know your health information. And by can you get to that	'[..] concerns have been laid to rest by the strict guidance from GDPR, from NHS digital, and all the various different, encrypted, secure compliances that these services have to adhere to when providing patient care' [GP9]

		sort of age, probably very fast' [P7]	
Third party proprietary software application	Assurance regarding third-party proprietary software applications – transparency regarding algorithms and profits.	'Ownership. Right. I don't want a third party owning anything' [P7]	
Safety considerations	Incorporate robust safety measures into the system to gain their trust and confidence.		*'Now I feel like it is something with the right technology and the right safety measures could be really, really useful to general practice' [GP2]*
Minimise system manipulation	Minimise the opportunities for 'gaming the system' in order to secure a fast-tracked appointment.		'Elderly patients who can't potentially manipulate that system, and they'll be left out' [GP2]
Emergency response plan	Provide the user with the option to call 999 in a medical emergency.	'There's got to be a feedback loop which could be on action. Literally. When the app says hang on this guy is having a heart attack. Somebody should be there to pick up the phone?' [P7]	

Table 18: Implementation in GP settings

7.5.4 Strategy 4 – Improving training and support

Interviews

Access to technology

Some older adult participants mentioned that they do not have access to the internet or the necessary technology to use online symptom checkers. They also mentioned that they cannot afford the cost, especially given the current cost-of-living crisis, and it's not their top priority. Most participants recommended aiding older adults, such as financial support, to help them access the necessary technology. Additionally, certain regions continue to experience problems with internet connectivity.

'Yes, though, one of the barriers is that, you know, the all those devices are very expensive. Phones and computers, new technology, everything. And that's what most people can't afford. So that's the barrier. Poverty.' [P1]

'And the other one is actually physically having access to broadband, for example' [P7]

Instructions and training

Older adult participants wanted beginner-level digital skills classes aimed at teaching them how to use smartphones, the internet, laptops, and online symptom checkers. They expressed a desire for both in-person training sessions and training videos to enhance their self-efficacy and build trust. They also emphasised the importance of receiving clear and straightforward instructions tailored to older adults, including guidance on downloading and installing applications. Additionally, they expressed the need for clear guidelines on when and when not to use these digital tools, as well as information on who should use them and who should not. Lastly, older adults expressed a desire for training support for their caregivers or dependent family members.

'I'm old fashioned. And it's hard for me to use phones. So it's hard to get used to the new apps' [P4]

Customer support

Older adults want a support service that includes the option to use online symptom checkers and also provides the ability to call and talk to someone on the other end.

Workshop

During the workshops, all the attendees validated the findings of Studies 2 and 3. They highlighted the significance of customer support, especially when dealing with issues related to the application. They also identified it as a crucial factor in promoting the adoption of online symptom checkers. The participants requested the support button, which enables them to seek assistance through virtual chat or phone call, to be easily accessible on the online symptom checker.

'Yeah. I think its an option every person should have. There should be a button there. Like it's an emergency call.' [P1]

Furthermore, older participants expressed that having access to smart devices and internet connectivity would motivate them to utilise online symptom checkers.

'I hope that you can get logged on. Because if you're on Virgin Media, and it rains, you ain't got no access to it.' [P2]

GP discussed how the involvement of family members could be advantageous for certain older individuals who may encounter difficulties while using the tool independently.

'I think this is where you need to get people that care for them, or family members to have access to online symptom checkers.' [GP2]

Older adults and GP participants reiterated their call to provide older adults with more training in using smart devices and utilising the online symptom checker tool. Improving training and supporting GP settings suggested by older adults and GPs are summarised in Table 19.

'Barclays say it's good to train people to use new technology, they advertise it all the time, to make more people do mobile banking, they must think it's worthwhile training people. Why can't the NHS do the same?' [P9]

Training and support:		**Older adults Comments**	**GPs Comments**
Accessible training materials	Provide simplified instructions on how to use them, whether through online resources, video tutorials, or printed leaflets.	'No, none that I'm aware of. It was just a case of somehow download it and then being rushed into the app and answering questions' [P3]	
Training for both older adults and GPs	Training using smart devices, the internet, and online symptom checkers.	'If there was any way, there could be some kind of help for somebody using it for the first time.' [P5]	'Training for older adults, support workers or family members doctors' [GP6] 'And of course, for them [GPs], they will also need training, just like our older population need training on how to use these before you can expect them to really be very openly accepting to use it.' [GP2]

Social support / Helping family members	Training for family members and support workers of older adults.	'Maybe carer support, or a family if there's somebody being cared for in a family?' [P5]	
Customer Support and troubleshooting	Troubleshooting support includes the ability to call and speak to someone on the other end.	'So, where to go? Who to ask for help? This is my question and concern. This is bad. This is a barrier I think' [P1]	
Access to internet and IT device			
Internet connection	Provide financial assistance for internet expenses.	'There might be issues with using it in areas which have poor internet connectivity' [P3] 'Definitely you need the free Wi Fi because what's happening on the wallet too expensive' [P4]	'A lot of them don't have money, maybe they, a lot of them don't have internet connections, and would not really know how to use new technologies' [GP2]

Access to smart device	Provide older adults with access to the necessary technology to utilise online symptom checkers, including financial assistance.	'So they would need the money to do that sort of, you know, to buy phones and get the technology so there's the money barrier' [P3]	'A lot of them don't have money, maybe they, a lot of them don't have internet connections, and would not really know how to use new technologies' [G2]

Table 19: Improving training and support

7.5.5 Strategy 5 – Improving awareness and marketing

Interviews

Both GPs and older adult participants expressed a desire for a wide range of marketing strategies to raise awareness. The strategies, summarised in Table 20, encompassed targeted ads, paid promotions on various platforms, newsletters, the GP website, the GP surgery, GP endorsements, and the patient participation group (PPG).

'I'd never heard of this before. So not from my GP or any posters in the in surgery or any my friends of our family' [P3]

'I don't think there really, a lot of them even know that you can access your doctors in that way' [GP2]

Workshop

In addition to confirming the findings of previous studies, the workshops participants emphasised the need for better marketing and awareness campaigns regarding the availability of online symptom checkers in general practice. Older adults expressed that they were unaware of this service and the benefits it offers, which led to low usage. Therefore, they called for targeted marketing efforts specifically aimed at older adults. Some suggestions included displaying posters in GP surgeries and advertising on media platforms that have a large audience of older adults, such as viewers, listeners, and readers. GP mentioned that the administrative staff could potentially train older adults, but they acknowledged that the staff is already overburdened with work.

An IT expert proposed that older adults are more likely to engage with and use online symptom checkers if they receive recommendations from trusted sources, such as their GP or well-known brands like the NHS. The IT expert further suggested that instead of having standalone applications, online symptom checkers should undergo evaluation and be integrated into the NHS app, creating a centralised platform for all digital health tools. This integration would enhance their credibility and increase the likelihood of user adoption.

'I mean, having it sign posted by the organisations that you're already trusted, that you already trust, for example by the GP, you're more likely to access it and try and use it in my opinion.' [IT expert]

'I think, like P9 has been saying, he already uses the NHS app. It's already there. Making use of that. The NHS brand that same brand awareness. Adding that into that as a function of the NHS app. Everyone's already got that already. So why wouldn't you make use of that make it a one stop shop for all your health needs?' [IT expert]

Awareness and Marketing:	**Older adults Comments**	**GPs Comments**

Increase awareness	A broad range of targeted marketing options.	'I wasn't really much aware of this app. It's not much marketing, no good. So, you need to put more, you know, more awareness' [P1]	'The outreach process can try to incorporate, you know, a wider variety of media, so radio, television, especially ones, you know, the BBC and so on news time, just anything that will widen the variety, you know, the number of audience particularly older adults.' [GP6]
Why use online symptom checkers?	Highlight the benefits of employing online symptom checkers and foster confidence.	'You better well, people want fundamental lack of trust with technology. Because of what's gone before' [P7]	'I guess you'd have to sell it for them' [GP8]
Worry of privatisation	Many people are worried that this could be a backdoor route to privatising the NHS. Provide reassurance that it is not, or alternatively, develop the app internally.	'Well, I'm just wondering things like who owns the app, is it owned by the health service, is it private, then that's part again of the privatisation of healthcare.' [P8]	

		‘It’s purpose for how to extract profit. And, you know, there are people coming out the other end are billionaires. I don’t want a third party owning anything’ [P7]	

Table 20: Improving awareness and marketing

7.5.6 Strategy 6 – Co-creation with older adults

Interviews

Most participants recommended the active involvement of older adults in the design and development process to co-create online symptom checkers with end-users. Additionally, they suggested conducting more usability testing with older adults to identify any pain points associated with using the app.

‘Developing online symptom checkers. I think really listening to patients listening to the individual’s realising, you know, these individuals who are frustrated who there’s an element of anxiety, you know, you don’t go in on this app’ [GP9]

Workshop

In the workshops, all participants reaffirmed the need to involve older adults in the design and development process to ensure that the specific age-related needs of older adults are incorporated into the online symptom checker and are made user-friendly for them. They also called for more user testing with older adults, which would enable the identification of software errors and user pain points. Co-creation ideas suggested by older adults and GPs are summarised in Table 21.

User-driven development process		Older adults Comments	GPs Comments
Involve older adults in the development process.	Work with older adults, listen to their needs, co-create, and co-design in order to align with the user needs and preferences of older adults.	'I think to do more research on this app, call elderly participants, talk to them, see the views, how to help everybody that you need to, you know, feedbacks from everyone' [P4]	'I think first and foremost, they probably need to involve older people in development. I think they need to look at what kind of problems older people are having' [GP2] 'So if you're looking to aim something, at older patients, they need to be aware of their concerns and the limitations that they have in terms of getting to grips with the technology and incorporate that into the development process' [GP6]
More user testing.	More testing to identify the user pain points and software bugs.		'Through every stage of the development, test the system [with users]' [GP2]

Table 21: Co-creation with older adults

7.6 Discussion

Strategy 1 – Incorporating age-friendly design and reducing effort expectancy

Most older adults and GPs found online symptom checkers poorly designed and challenging to use for older patients, aligning with previous findings that these tools do not support diverse user groups (388).

Although the consideration of older adults' physical, cognitive, and sensory limitations was highlighted by both older adults and GP participants, aligning with previous findings (389–393) (see Chapter 2), in this research, there was an extra emphasis on older adults' visual impairments, a type of sensory limitation, and how that negatively affects older adults' use of online symptom checkers. While many of the suggested improvements voiced by both older adults and GPs align with the usability guidelines put forth by Nielsen (394) and Nielsen and Molich (395), there was a specific emphasis on simplifying the login processes, something older adults currently found challenging and off-putting, which is not prominently highlighted in previous research.

Previous research has emphasised the importance of incorporating age-appropriate design elements to avoid stigmatisation or a diminished sense of self-worth resulting from older adults' perceived inability to use the technology (389). Both GPs and older adults mentioned that the online symptom checkers should be simpler, more intuitive, and age friendly. The IT expert also supported these views, stating that the online symptom checkers should be easily comprehensible and developed with reduced effort expectancy. This aligns with previous research on mHealth technology (389–393), emphasising the significance of considering user expectations and needs when designing healthcare technologies (396).

Strategy 2 – Improving usability and user experience for older adults

Both older adults and GPs participating in the study concur with previous findings (45,77,388), suggesting that online symptom checkers need improvement in terms of usability and user experience. The IT expert also echoed this sentiment, emphasising that current designs are inadequate and require significant enhancement.

Both older adults and GPs made several suggestions to enhance the user experience and engagement for older patients. For example, more graphic content, less text, and an interactive body diagram for improved comprehension and swift identification of health concerns. This aligns with previous research calling for readable fonts, as well as vivid colours (26) and the use of visual summaries (45).

In previous studies in this area, both older adults and GP participants desired online symptom checkers to be more personalised, taking into consideration not only their age-related impairments but also their design preferences, to make them more useful and relevant. For example, GPs mentioned the potential of using digital human avatars for personalised patient interactions. Older adults in prior studies have also emphasised the need for more personalisation in mHealth technology, not only to increase usefulness as observed in this study but also to enhance attractiveness and hedonic appeal, as seen in (71,389) (see section 2.5.1).

Navigation issues were a common frustration among both older adult and GP participants. Simplifying the navigation process would create a more supportive and user-friendly environment for older adults during their user journey. Older adults specifically desired for a progress bar to track their consultation progress and determine their proximity to a triage outcome. These findings align with previous studies and established guidelines for mobile user interfaces targeted at older adults (156,397,398), where there was a particular emphasis on a simple and user-friendly navigation structure. For example, it is recommended to use navigation aids (45), such as easily accessible return buttons to the home screen (156), and to keep basic navigation buttons visible at all times (398) (see section 2.5).

A difference from previous findings is that older adults and GPs put more emphasis on pragmatic attributes and less on hedonic attributes to enhance usability and user experience (see section 2.5.1). In fact, there was no mention of hedonic attributes. Another difference from previous findings is that this study revealed the time it takes to use online symptom checkers and get an outcome decision causes great frustration for older adults and impacts their user experience and engagement.

Strategy 3 – Improving implementation in GP settings

Both older adults and GPs worry about privacy and confidentiality issues related to using online symptom checkers. Data security concerns are particularly significant for GPs, who fear the exploitation of patient data and the privacy of vulnerable patients. GPs recommend implementing strong cyber security measures to safeguard patients' health information and prevent system manipulation. Older adults trust their GPs more than online symptom checkers when it comes to privacy. This finding is consistent with the results of previous studies (71,393,399).

The study highlights concern of both older adults and GPs regarding third-party ownership of online platforms and the need for data protection compliance. In addition to ensuring the security of data transmission, the information source or authority could have a positive impact on users' trust (388,400,401). Participants in the study expressed that they would trust online symptom checkers more if they were developed by the NHS rather than third-party proprietors, which aligns with the findings of a previous study (391).

Similar to the findings from this study, older adults in previous studies have expressed the need to develop dependable and reliable mHealth technology (352). This includes improving diagnostic accuracy (391,393,399,402), which could otherwise lead to the abandonment of the service, as observed in this study. Users were inclined to lose trust in online symptom checkers if recommendations were inaccurate (403,404).

As this study was one of the first to explore the use of online symptom checkers in general practice from the perspectives of older adults, several findings emerged that were either novel or received renewed emphasis. For instance, older adults expressed a desire for online symptom checkers to be integrated with GP software systems, providing access to electronic health records to enhance perceived usefulness and user experience. Currently, older adults find it frustrating and discouraging to input symptoms into the tool and then repeat them to their GP or other healthcare professionals.

Furthermore, older adults emphasised the need for online symptom checkers to seamlessly integrate with other digital health tools, such as video conferencing and consultation tools. They also highlighted that they would be more inclined to use online symptom checkers if the

platform allowed them to make appointments via the tool, included a broader range of health conditions, including age-related conditions—something not mentioned in previous studies from older adults' perspectives. However, consistent with prior research, there were mentions of providing functions that are similar to those in in-person medical visits (388).

Strategy 4 – Improving training and support

Older adults and GP participants expressed a desire for additional training in using smart devices and online symptom checkers. They recommend beginner-level classes to learn how to use online symptom checkers and navigate smartphones, laptops, and the internet. Older adults expressed a preference for both in-person sessions and training videos to enhance their confidence and trust in using these technologies. Clear and tailored instructions are needed, including guidance on downloading applications. Additionally, they seek guidelines on when and who should use these tools.

Previous studies have indicated that older adults stressed their desire to receive training, as they did not want to be perceived as a burden (392,393), aligning with the findings of this study. The few older adult participants who had faith in their abilities were more proactive in using online symptom checkers and more likely to adopt the technology compared to those who were apprehensive.

Additionally, they emphasised the need for training support for their caregivers or dependent family members - something not emphasised enough in previous studies.

Strategy 5 – Improving awareness and marketing

The study found that older adults exhibited low uptake of online symptom checkers due to a lack of awareness about the existence of online symptom checkers and their benefits in general practice. Although this is similar to the findings of a qualitative study by Aboueid et al. (80), where over half of the young adult participants were initially unaware of online symptom checkers, and this lack of awareness significantly impeded their utilisation of such tools, the lack of awareness was more prevalent among older adults, which is a new insight.

To address this, several targeted marketing efforts were recommended by older adults and GPs, specifically aimed at older patients. This includes placing posters in GP surgeries and advertising on platforms with a significant older adult audience. To build trust, endorsements from GPs and well-known brands were suggested, while also acknowledging the workload constraints of administrative staff in providing training. Although endorsement of established authorities is suggested in literature (405), these suggestions pertinent to older adults within the context of general practice are not found in previous studies, and implementing them may effectively increase the use of online symptom checkers among older patients.

In addition to GPs, the closer involvement of older adults' family members will play a crucial role in raising awareness and encourage the usage of online symptom checkers among this demographic. A study conducted by Spann et al. (352), which explored usability barriers of mHealth for older adults, revealed that many participants agreed to use mHealth tools solely due to encouragement and pressure from their relatives or healthcare providers.

Strategy 6 – Co-creation with older adults

The consensus among participants is to involve older adults in the design and development process to co-create user-friendly online symptom checkers, taking into consideration the user requirements of older adults and general practice context. Although both GPs and older adults express a desire for greater involvement of older adults, they do not specify the level of involvement, such as whether it should be co-design (406,407) or participatory design (408,409). Additionally, they recommend conducting extensive usability testing to identify any potential challenges faced by older adults based on actual users' experiences and that haven risen in situ (410). This aligns with the findings of prior studies in which older adult participants expressed a desire to be included in the design and development process to voice their suggestions on how to improve the usefulness and usability of mHealth technologies (390,399).

Strengths and limitation

Strengths

The ideation workshops, involving older adults, GPs, and an IT expert, were, to the best of our knowledge, the first of their kind, bringing diverse perspectives with real-world user

experiences and insights to validate the feasibility and viability of design suggestions and uptake strategies in a dynamic and collaborative setting. The workshop facilitator played an important role not only in motivating participants to actively engage in discussions but also in ensuring that everyone had an opportunity to express their thoughts, including older adult participants.

Thematic analysis was employed to examine qualitative data from two workshops, offering a structured and collaborative approach to analyse multifaceted content during real-time discussions. While the advantages of thematic analysis mirrored those discussed in older people and GP interview studies, this approach proved particularly effective in handling data from diverse participants engaged in dynamic discussions.

The interviews from both Study 2 and Study 3 were analysed and subsequently validated through workshops, thereby enhancing the robustness of the findings. The study's design and methodology facilitated the collection of detailed qualitative data, providing valuable insights into older adults' user needs and barriers to uptake and engagement. Overall, these findings may contribute to the development of online symptom checkers that better align with older adults' user expectations and preferences, as well as improve uptake and engagement in general practice.

Limitations

Similar to the older people and GP interview studies, the generalisability of the qualitative findings to the entire population may be considered limited. Although the workshops deliberately recruited only five participants to improve the quality and depth of the data, some could still argue that more participants could have contributed to more diverse perspectives, thereby not only improving the richness of the data but also enhancing generalisability.

While the workshop facilitator made concerted efforts to encourage equal participation, there is always a risk that some participants, especially older adults, did not feel as confident as others in speaking out during group discussions with a GP and IT expert. Moreover, generation gaps, along with challenges in understanding technological and health terms, may have limited the scope of ideation.

7.6.1 Conceptual framework: older adults' user engagement with online symptom checkers in general practice

An adapted conceptual framework from Acker et al. (128) (see Appendix 10) is presented in Figure 7, relating to the user engagement of older adults with online symptom checkers in general practice. This results from the findings of the studies. This framework serves as an additional contribution to the state of the art.

This study revealed low usage of online symptom checkers among older patients in general practice. "Usage" includes both initial acceptance (uptake) and ongoing interaction (engagement) (411). Successful mHealth solutions require high uptake and sustained engagement, but this study highlighted low levels in both aspects among older adults. User engagement is a subset of user experience that incorporates a qualitative dimension, taking into account the quality and depth of interaction (412). On the other hand, user experience encompasses all aspects of the user's interaction with a product, including satisfaction and emotions (222). User experiences contribute to enhanced uptake and increased user engagement (413). Sustained user engagement is crucial for the long-term success of mHealth interventions (414). User engagement plays a pivotal role in driving behaviour change and adherence to health recommendations (128). When users are actively engaged, they are more likely to follow through with the prescribed interventions (e.g., triage outcome or self-treatment advice), improving adherence to treatment plans and leading to better health outcomes.

However, to date, low uptake and poor engagement are commonly observed with digital interventions, as found in this study with online symptom checkers, which are often insufficient to sustain behaviour change (411,415). User engagement in mHealth interventions can help bridge gaps in healthcare access and reduce disparities faced by older adults. Users who find value in the application are more likely to persist in its usage over time, thereby maximising its potential benefit and impact on their health (416). However, poor engagement can have the opposite effect, increasing the health disparities that older adults already face (see Chapter 2).

Perski et al. (417) developed a conceptual model through a systematic review synthesising evidence on user engagement in mHealth interventions within healthcare. Their model integrates behavioural dimensions (e.g., amount, frequency) and subjective experiences (e.g.,

attention, interest). Descriptive themes are categorised into contextual factors (population and setting characteristics) and mHealth intervention characteristics (delivery and content factors). Acker et al. (128) expanded this model by incorporating new contextual factors (e.g., multimorbidity, sensorimotor problems, social support) and mHealth characteristics (e.g., gamification), based on evidence from qualitative and mixed-methods studies on older adults' engagement with mHealth interventions.

The main phases for developing a framework outlined in (418) were followed. For example, research question (RQ4) and objectives were considered, and a multidisciplinary literature review was conducted to grasp the current state of knowledge. During this process, the Acker conceptual user engagement framework was chosen as the base framework to be adapted, which is currently the only one of its kind in the literature and emerged as the most relevant and recent. However, the validation phase for extending the conceptual framework was not conducted, a step recommended for future research.

The Acker conceptual user engagement framework underwent refinement in accordance with specific characteristics and findings from this research project, ensuring alignment with objectives and capturing the complexities of the investigated phenomenon. For instance, the mHealth intervention was online symptom checkers, the target population was defined as older adults, and the context was specified as general practice. However, the contextual factors and mHealth characteristics that were included in the Acker model but did not emerge from S2-S4 have been removed (e.g., mental health in Perski and gamification from Acker). New factors that emerged from actual users' experiences, which may influence older adults' engagement with online symptom checkers in general practice, have been included in the revised framework and are italicised in Figure 7. This includes reliability, privacy, and security factors in the delivery of online symptom checkers, integration in GP settings, including content individualised to patients' health records, and targeted marketing and training for older adults. The findings from this research also suggest that older adults' perceptions of impact on the doctor-patient relationship may influence their usage of online symptom checkers.

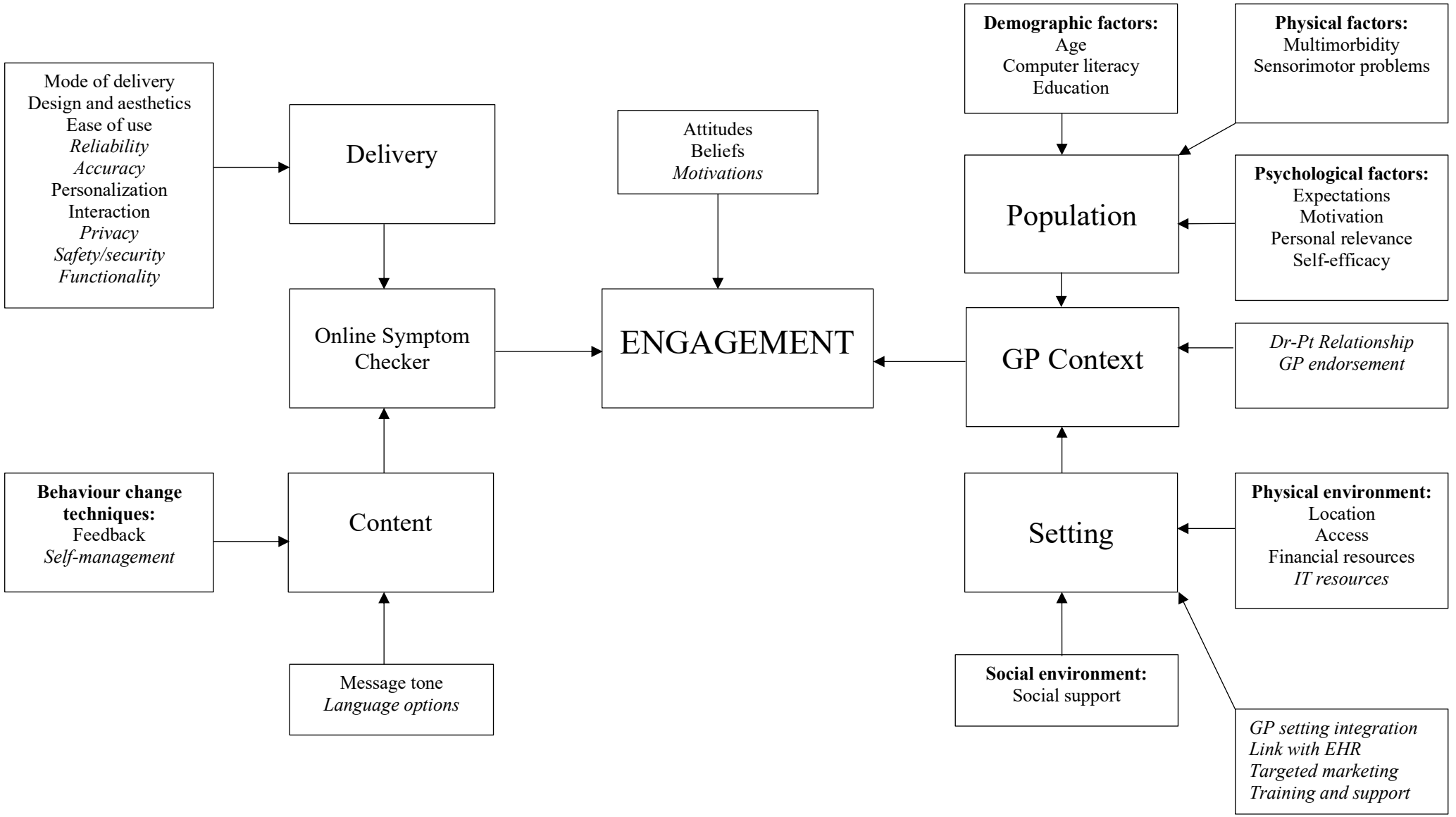

Figure 7: Conceptual Framework for User Engagement of Older Adults with Online Symptom Checkers in General Practice

Table 22 succinctly presents the additional factors included in the adapted conceptual framework, which emerged from interviews with participants in the research. These new factors, which are likely to enhance older adults' uptake and user engagement with online symptom checkers (SC), have been derived from design suggestions and strategies discussed in section 7.5. These factors range from enhancing user experience to improving implementation in GP settings, ultimately increasing the likelihood of older adults taking up and engaging with online symptom checkers.

Delivery	
Reliability	Older adults have reported that SC sometimes crashes or momentarily freezes. SC should function reliably as expected, without crashes or disruptions, and consistently perform on all platforms, including both the app-based and web-based versions.
Accuracy	Older adults have concerns about SC's low specificity and are unsure of how accurate the recommendations are. Improving diagnostic accuracy and specificity will result in more confidence and usage
Privacy and security	Older adults have voiced strong concerns about user privacy and the security of data transmission and storage, particularly from non-NHS developers. SC should put measures in place to improve privacy and security.
Safety	Older adults lack confidence in the current safety measures, especially in emergency situations. SC should implement measures to enhance safety for users, for example, by providing options to call 999.

Functionality	SC predominantly addresses low-risk common illnesses and has limited functionality. SC should enhance its functionalities and expand the number of health conditions covered, with a particular focus on addressing more age-related complex health issues.
Context	
Dr-Pt relationship	Many older adults have expressed concerns that the current SCs may negatively impact their doctor-patient relationship, discouraging them from using it. Make it as an additional option for seeking medical help, not as a replacement for in-person GP visits.
GP endorsements	Older adults have a high level of trust in their GPs. The recommendations and endorsements from their GPs will increase the likelihood of their uptake and engagement.
Setting	
IT resources	Lending or providing financial assistance to purchase internet-connected IT devices will help increase older adults' usage. Additionally, having IT devices in the GP surgery to use would be beneficial for older adults.
GP setting integration	SCs are disconnected from the existing practices. SC should be integrated as an additional pathway for seeking medical assistance in general practice.

Link with EHR	SC linked with patients' electronic health records to enhance the experience, making it more personalised and effective.
Targeting marketing	Older adults had a low awareness on the use of online symptom checkers. They expressed the need for more targeted marketing efforts aimed at their age group.
Training and support	Older adults expressed a need for more training and support for them and their family members or caregiver to use SC.
User	
Motivations	Older adults lack awareness when to use SC. Exploring the motivations of older adults will enhance their uptake and engagement.

Table 22: New factors for adapted conceptual framework

The adapted conceptual framework will be beneficial for developers of online symptom checkers, enabling them to make design improvements for older users. Additionally, it will assist NHS policymakers in developing the optimal ways to implement these improvements in general practice settings, ultimately increasing uptake and user engagement among older patients. Consequently, such efforts will help alleviate digital exclusion and address health disparities experienced by older adults.

7.7 Conclusion

The findings from older people and GP interviews were affirmed by the two workshops in relation to the user barriers and strategies for enhancing the use of online symptom checkers in general practice. Additionally, the workshops provided additional insights into some of the challenges regarding user experiences and design suggestions. The participants discussed and developed new recommendations to enhance the user experience, with the expectation that this would lead to increased uptake and user engagement of online symptom checkers among older patients. Moreover, the participants identified key UX themes that would greatly benefit IT

companies in developing the next version of the tool. These themes can serve as a focal point for their efforts and resource allocation.

The importance of further UX research and user testing in this field was emphasised by the participants, including the IT expert. They particularly stressed the involvement of older adults in the design process to address age-related needs and overcome barriers to using online symptom checkers and accessing GP services. The findings also supported previous research on other mHealth applications for older people, which strengthens the credibility of the findings. The adapted conceptual framework for user engagement will help technology providers and policymakers optimise implementation strategies to improve uptake and engagement among older patients in general practice settings.

Chapter 8 General Discussion

This chapter presents a summary of the thesis, which includes personal reflections, main findings, and a critical evaluation of strengths, weaknesses, and methodology. It discusses suggestions to improve the usability and user experience of online symptom checkers for older adults and increase their use in general practice. Additionally, it explores the implications for future research and concludes by highlighting the key insights derived from the thesis.

8.1 Overview

The aim of this research was to investigate and gain insight into the experiences and perspectives of older adults and GPs regarding the use of online symptom checkers in general practice. Additionally, the study aimed to understand the perceived impact of online symptom checkers on the doctor-patient relationship and the broader implications of their use in general practice from the perspectives of both older adults and GPs.

Online symptom checkers have the potential to assist with self-triage, empower patients, and alleviate pressures in general practice. However, despite the increasing availability and accelerated deployment of online symptom checkers in response to Covid-19, there is a lack of evidence in the literature regarding the viewpoints and experiences of older adults, who already face barriers to accessing primary care. This research aimed to address this gap.

To build upon the existing evidence base and improve the usability and user experience of mHealth tools, the research began with a systematic review of the literature. This review explored the existing literature on user perceptions and experiences of online symptom checkers in a primary care context, as well as their potential impact on the doctor-patient relationship. The findings of this review indicate that user perceptions and experiences were slightly more positive than negative, but the studies themselves were of poor quality, conducted in non-healthcare settings, and lacked the perspectives of older adults.

Through interviews with older adults, it was discovered that while they were willing to try online symptom checkers, they had reservations regarding their usability and the use of such

tools as a primary point of contact in general practice. Concerns were raised about the potential negative impact on the doctor-patient relationship. Interviews with GPs revealed a slightly more positive attitude towards online symptom checkers compared to older adults. However, GPs were uncertain about the safety and suitability of these tools for all older adults, as well as their potential to exacerbate health disparities among vulnerable patients.

Both older adults and GPs provided suggestions for design improvements and strategies to increase the adoption of online symptom checkers in general practice. These suggestions were further validated, refined, and prioritised through collaborative ideation workshops.

8.2 Main Findings

The main findings of each study are as follows:

Study 1: The Systematic Review

A systematic review was conducted to explore user perceptions, experiences, and challenges with online symptom checkers in primary care.

User perceptions are crucial as they can determine the acceptability and feasibility of online symptom checkers in healthcare systems (118,121–123) (see Chapter 3). While overall user attitudes in the eligible studies were broadly positive, caution was necessary when interpreting the findings due to the low quality of eligible studies. The lack of qualitative studies addressing user perceptions is a widely acknowledged issue in the literature on similar health technologies (118–120). Further research is recommended to identify user groups less likely to engage with online symptom checkers and face barriers in accessing primary care. This includes exploring patient perceptions, attitudes, willingness to engage, and adoption of online symptom checkers as a first point of contact.

The review also found that designing a patient-centric application was crucial for increasing user uptake. However, there was limited evidence of patient-centric design approaches in the eligible studies. Additional research on users' lived experiences was recommended to understand their needs and design preferences, identify barriers, impediments, and risks for vulnerable groups when using online symptom checkers.

Descriptive studies have raised concerns that automated triage tools, such as online symptom checkers, could potentially challenge doctors' authority and negatively impact the doctor-patient relationship by reducing in-person visits. Due to limited research in this area, further research was recommended to explore the effects of online symptom checkers on the doctor-patient relationship from both doctors' and users' perspectives.

In conclusion, while the review revealed generally positive user perceptions of symptom checkers, more research, particularly qualitative studies in primary care settings, is necessary to fully understand the perspectives and experiences of vulnerable groups such as older adults, and their impact on doctor-patient relationships.

Study 2: Older adults' perspectives on the use of online symptom checkers in general practice

This qualitative study investigated older adults' perspectives and experiences with online symptom checkers in general practice, including exploring their impact on the doctor-patient relationship. The study utilised moderated think-aloud usability testing in which older adults used online symptom checkers while expressing their thoughts. Semi-structured interviews were also conducted, using open-ended questions and probes to explore the advantages and disadvantages of online symptom checkers in general practice.

While older adults were increasingly positive about health technology, they remained unsure about its advantages in the general practice setting. Mobile health applications had not yet become integrated into their daily lives. After gaining actual experience with online symptom checkers in general practice, particularly during the Covid-19 pandemic, older adults, while acknowledging some potential advantages, predominantly developed negative attitudes toward using these applications. Consequently, once GP surgeries reopened after lockdown restrictions, most older adults reverted to their preferred methods of accessing healthcare, such as directly contacting or visiting their GP. This aligns with existing literature indicating older adults' reluctance to adopt new technologies and their preference for traditional GP services (138,293).

All interviewed older adults emphasised the significance of the doctor-patient relationship. However, many believed that online symptom checkers in general practice could create

additional barriers to accessing GP services, potentially negatively affecting the doctor-patient relationship.

Older adults expressed concerns about usability and user experience, suggesting improvements to make online symptom checkers more user-friendly for older adults and enhance their uptake in general practice. These concerns and potential for improvements were further explored in-depth in Study 4.

Study 3: GP perspectives on the use of online symptom checkers in general practice

GPs had a slightly negative attitude towards the use of online symptom checkers in general practice but had not yet observed significant real-life effects due to low usage by their patients. They believed it was too early to determine the full impact. GPs recognised the convenience for patients (70,372) but felt that online symptom checkers offered generic treatment suggestions, lacking the personalised approach GPs provide based on patients' records and relationships.

Concerns were raised about older adults with varying health literacy struggling to articulate symptoms accurately, potentially leading to inaccurate reporting and triage decisions. The potential exclusion of vulnerable groups, especially older adults, was a major drawback identified by GPs. They worried about barriers to accessing GP services and exacerbating health inequalities. Most GPs believed that online symptom checkers would negatively impact the doctor-patient relationship by reducing face-to-face consultations, which they considered crucial for continuity of care and building connections.

Opinions on the role of online symptom checkers in addressing the general practice crisis were mixed. Some believed they could worsen the crisis, while others thought innovative digital technologies, with refinements, could help alleviate the burden and compensate for the shortage of GPs (344).

GPs suggested improvements to make online symptom checkers more user-friendly for older adults and enhance their adoption in general practice. These concerns were further explored in-depth in Study 4.

Study 4: UX Workshops

The two UX ideation workshops utilised the analysis of older adults and GP interviews from previous studies to explore, validate, and prioritise the findings in relation to user experience improvements and strategies for increasing the use of online symptom checkers among older adults in general practice.

Both older adults and GPs expressed dissatisfaction with the current impenetrable and poorly designed online symptom checkers. They affirmed the importance of considering age-related needs in the design process to create a user-friendly and accessible experience for older adults. The participants also highlighted the significance of mHealth technologies that accommodate physical, cognitive, and sensory limitations specific to older adults (389–393).

To avoid stigmatisation and preserve self-worth, incorporating age-appropriate design elements was deemed essential. An IT expert supported these perspectives, emphasising the inherent difficulty of using the currently available online symptom checkers and the importance of reducing effort expectancy in their development.

Key UX challenges were identified, and strategies were proposed to improve the adoption of online symptom checkers among older adults in general practice. The involvement of older adults in the design process was seen as crucial to addressing age-related needs and overcoming barriers to using online symptom checkers and accessing GP services.

8.3 Reflection on the main findings

This research aimed to understand the perspectives of older adults and general practitioners regarding the use of online symptom checkers in general practice. This included exploring user experience barriers for older adults, examining the impact on the doctor-patient relationship, and investigating the broader implications of integrating online symptom checkers into general practice.

The following section reflects on the main findings of this research project and how they answered the research questions (RQ1-4) as stated in section 2.8.

A systematic review (Study 1) was conducted to explore the evidence base in the academic literature regarding user perception and experience of online symptom checkers, and their impact on the doctor-patient relationship, thus answering RQ1.

Older adult and GP perceptions

Studies 2 and 3 explored older adults' and GPs' perceptions of using online symptom checkers in general practice, addressing key aspects of RQ2 and RQ3.

The perceptions of older adults play a crucial role in the acceptance, adoption, and use of online symptom checkers in general practice (219,343). However, this research has notably uncovered that, despite older adults being generally open to trying new technologies, they developed negative attitudes towards the current deployed versions of online symptom checkers after actual experience of using them in the context of general practice. This finding was somewhat surprising because user perception within the general population has been generally reported as positive, with a high level of user satisfaction (77,196).

The findings of this study emphasised the importance of considering actual contextual user experience when exploring the acceptance and adoption of online symptom checkers by older adults in general practice. This contrasts with previous studies that fail to take into consideration factors such as lived experience, experimentation, and exploration of online symptom checkers by users—important factors to verify the usefulness and ease of learning of the technology, as stated by the Senior Technology Acceptance Model (STAM). A notable distinction between STAM and other technology acceptance models, such as the Unified Theory of Acceptance and Use of Technology (UTAUT) (419) is the incorporation of hands-on user experience through experimentation and exploration, linking these dynamic factors with their intention to use and actual use (see Appendix 10).

This discrepancy in user perception can also be attributed, in part, to previous studies primarily focusing on young adults and not adequately representing the broader population. For example, among the nine eligible studies included in the systematic review, only one study (79) explored the perspectives of older adults (aged 50 and over). Additionally, the studies in the literature mainly relied on quantitative surveys rather than qualitative methods like one-to-one interviews to capture in-depth insights (65). However, what is often overlooked is that the inconsistent

and varied definition of "user perceptions and attitude" makes meaningful comparisons challenging.

While GPs generally held slightly negative views on the use of online symptom checkers in general practice, their perspectives were not as strongly negative as those of older adults. Interestingly, GPs' perception of these tools decreased with experience, mirroring the trend seen in older adults. Despite some reservations, GPs were less concerned about the impact of online symptom checkers in general practice compared to older adults. This was attributed to low patient usage, a limited range of covered health conditions, and being busy with an ever-increasing number of patients post-Covid lockdown. Understanding GPs' attitudes is crucial for proactively addressing negative perceptions and potentially increasing user acceptance in clinical settings (219,319), especially among older patients who value GPs' views and recommendations (219,343).

Many older adults interviewed struggled with accessing relevant technology, lacked confidence in using online symptom checkers, and had concerns about their reliability and potential risks. These findings of this research align with previous studies (294,295) that highlight these challenges and reservations among older adults. However, some participants, particularly those in their 60s, recognised the potential benefits of self-triaging, as it allows them to make prompt health decisions and manage minor health concerns without scheduling appointments. The literature also reflects varying opinions about technology among different age groups of older adults (420). For example, smartphone ownership is relatively high among 60 - to 70-year-olds but significantly drops for those in their 70s and 80s (421), mirroring the variation in technology use and attitudes. Nonetheless, smartphone ownership among older adults in the UK is steadily rising, indicating that the attitudes and perceptions of older adults towards online symptom checkers may improve over time.

Although GPs recognised the convenience for patients through the use of online symptom checkers (70,372), they also nonetheless expressed concerns about the potential exclusion of vulnerable patient groups, such as older patients, as a major drawback. They worried about barriers to using online symptom checkers (e.g., accessing internet-connecting devices), which may further limit vulnerable patients' access to GP services and increase health inequalities.

User experience

Studies 2-4 explored adults' experiences with online symptom checkers in general practice from the perspectives of both older adults and GPs, addressing key aspects of RQ2-RQ4.

Both older adults and GPs expressed concerns about the usability and user experience of current online symptom checkers within the GP setting. Participants identified user needs and barriers of current online symptom checkers that should be addressed in future iterations to improve the user experience and uptake of the tool among older patients. For instance, both older adults and GPs highlighted the necessity for personalisation in online symptom checkers and linking with patient's electronic health records to enhance their utility. Previous studies in this field have also underscored the need for more personalisation in mobile mHealth technology, not only to increase utility, as mentioned in this study, but also to enhance attractiveness and hedonic appeal, as seen in (71,389).

Surprisingly, there was very little mention of enhancing hedonic appeal by participants in this study. The participants prioritised utilitarian factors (e.g., functionalities, usefulness, effectiveness, etc.) of the application over hedonic factors (e.g., enjoyment). Then again, given that it involves health, and the tool served as one of the first points of contact to access medical help, as well as potentially being used when the user is ill and distressed (or even in an emergency situation, although it was not advised), it is perhaps understandable why utilitarian factors may be perceived as more important for older adults than hedonic factors at the beginning. Predictably, the importance of further user experience research and user testing in this field was emphasised, with a focus on involving older adults in the collaborative design process to better understand and address age-related needs and user barriers (20,407,422).

Older adults and GPs views on the impact on doctor-patient relationship

Studies 2-4 explored adults' experiences with online symptom checkers in general practice from the perspectives of both older adults and GPs, addressing key aspects of RQ2 - RQ3.

The conceptual framework of the doctor-patient relationship comprises four essential elements: mutual knowledge, trust, loyalty, and regard (279). These aspects hold significant value for

older adults and greatly influence their satisfaction with general practice, as highlighted by both older adults and GPs in this research project and in past studies (32,174–176). One of the challenges identified in this study revolves around establishing trust in digital health technology among older adults. Older adults do not yet fully trust online symptom checkers as they have expressed several concerns regarding privacy, security, and reliability of the application, which aligns with previous studies (279). Another major concern raised by both older adults and GPs were the lack of empathy and compassion in online symptom checkers, which are considered important in patient care and an integral part of the doctor-patient relationship (58,142,158,202).

GPs have also expressed concerns regarding the potential negative consequences of online symptom checkers on in-person visits and communication with patients (32,134,151,423). They fear that excessive reliance on these tools might lead to impersonal interactions and undermine patient care (32,151,423,424). Striking a balance between integrating technology in healthcare and preserving the essential human qualities necessary for fostering a strong doctor-patient relationship is crucial.

While several concerns were expressed, both GPs and older adults also highlighted the benefits of using these tools alongside doctors' expertise. Interestingly, some older adults in their sixties viewed online symptom checkers to enhance their relationship with doctors. They believed that these tools could improve access to GP services, empower patients with medical knowledge, and enable doctors to allocate more time for active listening and relationship building. This perspective challenges previous findings and suggests a potential shift in older adults' attitudes towards incorporating technology into healthcare.

The older adults in this study recognised their limited health literacy compared to doctors and acknowledged the importance of GP training and experience. GPs, although open to the use of online symptom checkers and digital health interventions in the GP setting, expressed a preference for face-to-face consultations. They believe that in-person interactions not only make the consultation more personable but also enable them to capture all verbal and non-verbal information, facilitating a more accurate diagnosis. Additionally, face-to-face consultations allow them to explain treatment plans to patients using an appropriate level of language and understanding. These considerations are particularly important when dealing with older patients.

Both older adults and GPs firmly believed that GPs should remain at the centre of medical care in general practice, with online symptom checkers serving as complementary tools. Unlike some automated conversational chatbots that assist in managing mental health (142), none of the older adults and GPs participants reported developing or envisioning a "digital relationship" with the chatbot.

In summary, this research emphasises the importance of addressing trust-related issues and ensuring that online symptom checkers in general practice complement rather than replace doctors in order to maintain a patient-centered and mutually satisfactory healthcare experience. By understanding the perspectives of both older adults and GPs, healthcare providers can navigate the complexities of using online symptom checkers to enhance the doctor-patient relationship while upholding the core values of patient care.

Theoretical frameworks

While existing UX frameworks generally do not address the specific needs of older people (425), literature provides guidelines for improving user interface, accessibility, and usability for this demographic (426–428). This research has identified a knowledge gap and produced an outline of broad UX recommendations to enhance the user experience of online symptom checkers. These recommendations can serve as the foundation for a customised UX framework for older adults.

The participants, including the IT expert, stressed the significance of participatory UX research and user testing in this field with older adults to address age-related needs and overcome barriers associated with using online symptom checkers and accessing GP services. These findings align with previous studies, underlining the importance of considering the perspectives and requirements of older adults during the design and development stages (408,409,429).

TAM and UX models yield valuable insights into technology adoption. Their close association is evident as the core determinants of each model can be loosely encapsulated by the other (see Appendix 10). In addition to the two key constructs of TAM (perceived usefulness and perceived ease of use), an important supporting construct is perceived enjoyment (430,431), which is closely aligned with elements of user experience and the hedonic aspects forming the

basis of UX models (208). However, both older adults and GPs who participated in this research project made very little mention of including hedonic attributes. Instead, they focused on operational functions and user frustrations.

User experiences contribute to enhanced uptake and increased user engagement (413). User engagement is a subset of user experience that incorporates a qualitative dimension, taking into account the quality and depth of interaction (412). Sustained user engagement is crucial for the long-term success of mHealth interventions (414). This research has highlighted the low levels of user engagement among older adults. However, it's important to note that user engagement plays a pivotal role in driving behavioural change and adherence to health recommendations.

The Acker conceptual framework (128) for the user engagement of older adults has been extended by incorporating the outcomes of the findings from this research project in the context of general practice. In comparison to UX and TAM frameworks, the Acker framework takes into consideration the context and setting as important constructs in user engagement, in addition to content and delivery of mHealth intervention. This closely aligns with the objectives of this research, which explores the use of online symptom checkers in general practice. The Acker framework is similar to the prevailing model for technology provision and use in the world of assistive technology, where the main model components are person, technology, and milieu (context, or environment). In contrast, the Acker and Perski model brings together person and milieu within the 'context'. The adapted conceptual framework in section 7.6 constitutes as an additional contribution to knowledge.

Methodical considerations

The study-specific strengths and limitations concerning the systematic review (Chapter 3), older adult interviews (Chapter 4), GP interviews (Chapter 5), and UX ideation workshops have been duly considered at the conclusion of each chapter. This section encompasses an evaluation of the strengths, challenges, and limitations of the overall PhD research. It is important to note that the findings within this PhD should be interpreted in light of the methodological considerations that have been discussed.

8.4 Strengths, challenges, and limitations

This research has several strengths. Firstly, a major strength is that it employed qualitative research methods, such as semi-structured interviews, think-aloud protocol, and workshops, to gain a deeper understanding of the research topic, which focused on older adults' and GPs' perspectives and experiences with online symptom checkers in general practice. These methods allowed for a diverse range of viewpoints to be captured, enabling a comprehensive exploration of individual user experiences in their own words. The participant-centric approach of qualitative methods also facilitated flexibility and adaptability in capturing the nuances of perspectives and experiences.

Additionally, the research considered the views of both older adults and GPs, who are crucial stakeholders in general practice. By including these perspectives, the study aimed to provide unique insights into how online symptom checkers could serve as a point of first contact in general practice and their impact on older adult patients, including the effect on the doctor-patient relationship. Notably, this research is the first to explore older adults' lived user experience of online symptom checkers, as well as identifying usability barriers through the think-aloud protocol. As a result, the study contributes to the development of broad UX guidelines and strategies to enhance older adults' adoption of online symptom checkers in general practice. Overall, this research makes significant contributions to both the technology development and research aspects of the field.

In addition to a thorough literature review, a systematic review was conducted with a rigorous and transparent methodology. This review aimed to provide a comprehensive and unbiased summary of the available evidence, synthesising it to offer a clearer understanding of the overall evidence base. This information was then used to identify gaps in existing research and develop the research questions.

The selection criteria for older adults and GPs were well-defined. This ensured that both groups had lived user experience, enabling them to provide in-depth experiences and perceptions based on actual experiences. This aspect was lacking in previous studies and helped reduce potential biases in the selection process. For instance, the inclusion criteria focused on individuals with chronic health conditions to ensure that older adults frequently made use of GP services, making them more likely to have substantial user experience with online symptom checkers.

Another strength of the study was the use of think-aloud protocols, a form of usability testing, to capture participants' cognitive processes and enhance understanding of older adults' user experience with online symptom checkers in general practice. By vocalising their thought processes while using simplified but pre-validated vignettes from previous studies, the researcher was able to collect rich qualitative data from engaged and reflective participants. These data may not have been captured through other data collection methods and contributed to a deeper understanding of the research topic.

Although Covid-19 lockdown periods presented unprecedented challenges in accessing older participants, mainly due to their vulnerability and the restrictions imposed by university research guidelines, the post-Covid-19 era also provided an opportunity to conduct research with older adult participants who had actual user experience in the context of general practice. This was facilitated by the introduction of online symptom checkers in general practice to minimise the spread of the virus.

Finally, this study was guided by the theoretical foundations of technology acceptance models (369), UX models (432), UX guidelines (159), and Doctor-Patient conceptual framework (279) to justify both the research process and findings. In order to enhance the rigor of the research findings, the qualitative studies were evaluated using appropriate standards for qualitative research assessment (253,382–384).

The findings of this research contribute to the limited yet expanding body of knowledge and offer valuable insights for future researchers and developers seeking a deeper understanding of older adults' actual user experience and usability preferences when using online symptom checkers. Additionally, the strategies identified to enhance the usage of online symptom checkers can assist health policymakers in implementing these tools within the context of general practice.

Limitations

In this project, qualitative methods were employed to explore the perspectives of older adult patients and GPs regarding the use of online symptom checkers in general practice and their potential impact on the doctor-patient relationship. However, qualitative research is criticised

for its subjective nature, perceived lack of reliability, and challenges in replicability. Moreover, in qualitative studies, researchers actively participate in data collection, analysis, and interpretation, creating the possibility for personal biases to influence the research process. In this study, the researcher acknowledged their biases but engaged in self-reflection and maintained transparency to minimise their impact on the findings. Although data saturation was achieved, caution is warranted when generalising these findings to the entire population of older adults and GPs.

Recruiting and interviewing participants for the three studies posed several challenges, especially during and after the Covid-19 pandemic. Some older adults declined participation due to mobility issues, health concerns, or personal preferences. GPs' limited availability due to their busy schedules made it difficult to secure their participation. Additionally, there was a scarcity of IT specialists with the necessary expertise, and their work commitments and financial constraints further complicated the recruitment process. Moreover, since this was a self-funded PhD project, there was no budget for compensating participants, which could potentially introduce bias. To address these issues, the researcher employed a variety of recruitment strategies, both traditional and digital, and collaborated with local organisations to ensure a broader representation of participants.

Both GPs and older adults are considered hard-to-reach populations, so snowball sampling referrals were utilised to expand the participant pool. However, this approach may introduce self-selection bias, as individuals who were more motivated or interested in online symptom checkers were more likely to volunteer and engage with the study. Nevertheless, the increasing ownership of smartphones among older adults in the UK suggests that this concern may decrease in future generations who are more accustomed to smartphone technology.

Although data saturation was achieved, the sample size of older adults and GPs was relatively small. The sample of older adults had a higher representation of males, participants from BAME backgrounds, and non-native English speakers compared to the national average. Consequently, this sample may not be entirely representative, which could perhaps shed some light on the observed high usability barriers and stronger negative views towards online symptom checkers. Existing literature suggests that women are more likely to use online symptom checkers (20,141), highlighting a potential discrepancy between the sample and the general population. However, it is important to note that the qualitative approach of this study

aimed to explore participants' lived experiences, with the intention of informing practical recommendations to improve user experience and increase older adults' adoption of online symptom checkers in general practice, rather than focusing on generalisability.

During the interviews, some older adults may have provided socially desirable responses due to concerns about being judged for their lack of technology knowledge. This may have influenced the accuracy and depth of the collected data. Similarly, in the think-aloud protocol, older adults were self-conscious about their thoughts being recorded and may have been influenced by the researcher's presence, leading to modified or artificial responses. These factors introduced social desirability bias, which may have affected the accuracy and validity of the protocol. As the think-aloud protocol has a number of drawbacks, including participants facing challenges in articulating nuanced thoughts and resulting in incomplete or oversimplified insights, think-aloud studies may not consistently reflect real-life scenarios. Additionally, the presence of GPs and facilitators during workshops may have influenced older adults' responses due to power dynamics and perceived expectations.

The research faced challenges due to time and resource limitations associated with a part-time PhD project. This research primarily explored and examined one brand of online symptom checkers (Doctorlink); a decision justified within the confines of a PhD project. Nevertheless, a potential limitation arises from the narrow scope in which respondents had access to only one online symptom checker, which reduces the generalisability of the results. However, the rapid development of online symptom checkers also posed a significant challenge, especially considering that these tools were relatively new when the project began. During the Covid-19 restrictions, online symptom checkers were swiftly implemented in general practice to help control the spread of the disease. However, many of these applications were later withdrawn and required further development due to their limited effectiveness and low patient uptake.

8.5 Recommendations for further research, development and practice

The recommendations for further research, developers and practice includes several areas of focus to enhance the understanding and effectiveness of online symptom checkers in general practice, particularly in relation to user experience and usability, as well as the specific needs of older adults.

Expanding on each point, here are some possible directions for further investigation:

Investigate older adults' interaction with chatbot interfaces

Symptom checkers, featuring a chatbot interface that engages users in human-like conversations, are gaining popularity in the healthcare sector. As evidenced by the findings of this research project, they are expected to play a significant role in future developments (388,433). Chatbots can vary from simple, predefined designs to sophisticated models with powerful artificial intelligence engines (434). Despite this, there is a lack of research, especially concerning the impact of conversational design on older adults, particularly within the realm of primary care.

Research on older adults' interaction with chatbot interfaces is crucial for the effective use and acceptance of online symptom checkers. Future studies should aim to explore older adults' perceptions and engagement with chatbot interfaces in depth, focusing on interaction patterns, comfort levels, ease of use, comprehension of conversational prompts, and overall satisfaction. These insights would be invaluable for designing user-friendly interfaces that meet the unique needs of older adults and improve their experience with online symptom checkers. Conducting additional primary research can contribute to developing a deeper understanding of how older adults interact with chatbot user interfaces in general practice, as currently, there is not enough existing literature to conduct a meta-synthesis and generate new insights.

Refine UX recommendations and strategies to improve uptake and engagement

Conducting additional studies to refine the user experience recommendations developed in this research project – and incorporating older adults' physical, cognitive, and sensory needs and incorporating technology acceptance model principles for seniors - can help identify specific design elements which align with the user expectations of older adults and contribute to an optimal user experience with online symptom checkers. This should involve building prototypes based on the recommendations and user-testing them with the end users. Additionally, further research should also explore and evaluate strategies that can effectively promote and encourage the adoption of online symptom checkers among older adults. This could involve studying the impact of educational initiatives, tailored marketing campaigns, or

partnerships with healthcare providers to raise awareness and address any concerns or barriers that may hinder older adults from using these tools.

Longitudinal studies

While participants had some previous experience with online symptom checkers, this PhD research revealed that both older adults and GPs feel the need for a longer period of user experience to develop more conclusive opinions about the tool within the context of general practice. To address this, conducting larger longitudinal studies over an extended period is recommended. These studies would allow researchers to observe the evolution of participants' perceptions and experiences as they become more familiar with online symptom checkers. Such studies would provide a deeper understanding of the advantages, limitations, and potential areas for improvement of this emerging technology.

The eligibility criteria for this research project required participants to have some prior user experience with an online symptom checker in general practice, not necessarily limited to the same brand of online symptom checker. While exploring various online symptom checkers can provide comprehensive insights and is highly recommended, researchers may also benefit from focusing on a specific prominent online symptom checker, such as the NHS symptom checker. This approach allows for a more in-depth investigation of user interactions, decision-making processes, and functionalities that contribute to an overall positive user experience.

The participants in this research were primarily from Sheffield. However, to ensure a more diverse representation of demographics, it is recommended to conduct further research with a broader sample.

Recommendation for developers and researchers

Collaborative approach

The potential advantages of online symptom checkers can be enhanced by addressing the needs and expectations of older adults. To achieve this, developers should involve older patients and GPs in the development process. This ensures that the tool is tailored to meet the requirements of older users and provides the maximum benefits in self-triaging and self-treatment. A more

collaborative, patient-centered approach would lead to improved online symptom checkers capable of assisting older patients in managing their health.

It is also important for developers to continue their involvement even after the tool is released. By offering guidance on incorporating the tool into regular healthcare IT systems and processes, including technical support, the effectiveness of the tool can be further enhanced.

Usability testing

In order to gain deeper insights into user behaviour and improve the user interface (UI) of online symptom checkers, further usability research can be conducted utilising screen capture video and eye tracking software to understand participants' gaze patterns and their interactions with the chatbots. By employing screen capture video, researchers can record participants' interactions with the chatbots in real-time, providing a comprehensive understanding of their navigation, swiping, tapping, and typing actions within the chatbot interface. The recorded videos will allow for review and analysis of specific moments where users struggle or encounter difficulties while using the chatbots.

In addition to screen capture video, eye tracking software can be incorporated to gain insights into where participants focus their attention during their interaction with the chatbots. By tracking eye movement, researchers can identify the specific elements within the UI that attract users' attention or cause confusion. The combination of screen capture video and eye tracking data will enable researchers to pinpoint moments of user struggle and areas where the UI may require a redesign to enhance the overall user experience, making it more intuitive and user-friendly for older adults. Further research could also involve other user-research methods such as ‘Wizard of Oz’ testing where, under lab conditions, participants could converse with a ‘simulated’ automated agent. Future research and usability testing should also encompass a wide range of online symptom checkers available in the market and commonly used in general practice. This approach will enable a more comprehensive understanding of older adults' perceptions and experiences.

Collaboration between researchers and developers

The ideation workshops in this research demonstrate the feasibility of collaboration between researchers and developers in exploring the technological possibilities and challenges of such tools in healthcare settings. By working together, they also ensure the translation of research findings into practical applications with greater methodological rigor, validation, and transparency. In the case of this study, this collaboration has the potential to develop online symptom checkers that are more likely to be evidence-based, user-friendly, and effective for older patients in general practice.

This research has provided developers with broad design recommendations and strategies to increase uptake. If the issues identified in this research are addressed, online symptom checkers can be improved, although further evaluation is necessary to ensure their effectiveness. Additionally, other mHealth apps could benefit from this research by incorporating the research findings into their app modifications.

Rapid developments of online symptom checkers

Online symptom checking is a swiftly evolving field, as seen in the duration of this research project. With symptom checkers set to leverage increasingly advanced artificial intelligence, the progress is expected to accelerate further. However, there exists a time gap between research and the technological advancement of online symptom checkers available in markets and used in healthcare settings.

To keep up with the rapid development of online symptom checkers, there needs to be quicker and more agile research undertaken, along with closer collaboration between health researchers and developers in the development process.

Practice and Policy

Although there are many potential benefits of using online symptom checkers in general practice, this study has demonstrated the challenges of not only integrating them into the general setting and patient journey but also the challenges of getting patients, particularly older adults, to use them effectively, safely, and securely.

Considering the predominantly negative views of the current widely used online symptom checker in general practice, especially among older adults, and its low overall usage, caution is needed, particularly as it has the potential to increase health disparities and impact the doctor-patient relationship for older adults. Therefore, it may be prudent to either temporarily suspend online symptom checkers from general practice until substantial enhancements are implemented (as outlined in this thesis) or, if continued, present it as an additional option in general practice with clear communication of its benefits and risks, while actively working on further improvements.

Suggested practice and policy recommendations derived from the research findings concerning increasing older adults' uptake of online symptom checkers within the general practice context would require the following steps to take place: 1) conduct a longitudinal study and health technology assessment to gather both qualitative and quantitative evidence regarding the app's effectiveness and clinical safety; 2) collaborate with older adults and other relevant stakeholders to make any necessary usability and UX improvements to the app, including those identified in the current research; 3) consult with policy makers and domain experts to assess how this app could be safely integrated into the existing GP setting and IT infrastructure, such as linking with electronic health records; 4) develop a plan to facilitate the implementation in general practice, amending the patient journey and GP's workflow; 5) Provide required training and ongoing technical support to the users of the app (e.g., older adults) as well as GPs; 6) roll out the app as an additional option, not as a replacement, with targeted marketing for older adults and other vulnerable groups facing further digital exclusion.

Regulatory challenges

Numerous self-triaging applications are commercially available in app stores; however, there is currently no standardised method for evaluating their quality or disseminating this information to potential users. Although online symptom checkers are considered a medical device by the Medicines and Healthcare products Regulatory Agency (MHRA), they are only classified as Class 1, which is regarded as low risk (435). Given the serious concerns raised by older adults and GPs in this study regarding reliability, diagnostic accuracy (e.g., missing essential red flags), and safety, this classification seems inadequate.

This issue should be addressed with more regulation to control and assess digital health tools, such as online symptom checkers, with closer scrutiny aided by independent experts. Furthermore, stricter regulations should be imposed on digital health tools intended for deployment in the context of the NHS and general practice. In the case of online symptom checkers, the classification should be reconsidered so that devices better reflect the clinical function and associated risk. A higher classification would require greater post-market surveillance scrutiny and compliance than current requirements.

In addition to the availability of online symptom checkers (e.g., AI Symptom Checker (436)), designed for different countries and jurisdictions, both in the app stores and on the web, there are also some unregulated online symptom checkers (e.g., Mayo Clinic (437)). A carefully curated collection of specialised app libraries, approved by clinicians, could serve as a reliable alternative to unregulated app stores (438). One example was the NHS Apps Library, a trusted resource where patients could access safe and effective digital tools. Developers were required to address security enquiries before their apps received endorsement for use (439). However, the NHS Apps Library was decommissioned in December 2021, and the NHS now directs users to recommended apps through its website.

8.6 Conclusion

The research found that online symptom checkers can be valuable additional tools in general practice for non-emergency medical issues. However, older adults have encountered significant barriers in using and accessing these tools, leading to a predominantly negative perception. Many older adults felt that the current iterations of online symptom checkers did not take into account their physical, cognitive, and sensory limitations specific to older adults when designing the automated digital health tool, limiting their user experience and usability. Additionally, they perceived a lack of appropriate functionalities, a lack of technical customer help, and a lack of integration with NHS IT systems, which negatively impacted their acceptance and adoption of the tool. The older adults felt that the widespread implementation of current versions of online symptom checkers had the potential to create two tiers of GP services, exacerbating existing health inequalities faced by older adults.

Although GPs had slightly warmer views about the use of online symptom checkers in general practice compared to older adults, they also expressed reservations and concerns about the

negative impact on older patients. GPs believed that only select older adults would benefit from these tools and that they would not be appropriate for many older adults with age-related frailties.

The research explored the impact on the doctor-patient relationship, with both older adults and GPs expressing concerns about the potential negative impact on this important relationship, which is highly valued by older patients and plays a crucial role in the treatment process. The research demonstrates the complexity of this relationship and highlights how qualities like empathy, compassion, and regular face-to-face consultations are vital in maintaining and strengthening it. The use of online symptom checkers would negatively impact this relationship if doctor-patient encounters were reduced.

The research found that the usage of online symptom checkers amongst older adults in general practice is low but could be improved with enhancements in user experience and usability, along with the implementation of strategies to enhance uptake and engagement. However, if these suggestions for improvement are addressed, the future potential of online symptom checkers for use in general practice is enormous. This potential includes expanding older adults' access to GP services and reducing digital exclusion.

Word count:77,963

APPENDICES

Appendix 1: Systematic Review Search Strategies

MEDLINE via OVID

https://www.sheffield.ac.uk/library/cdfiles/biomedmedline

Search Results:

Database	Search Result (05.2.2019)	After Title Screening (05.2.2019)	After Abstract Screening (05.2.2019)
MEDLINE via Ovid	326	53	21

Search Terms:

Database: Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily <1946 to February 04, 2019>
Search Strategy:
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1 ("symptom? checker?" or "online diagnosis" or "self triage" or "web based triage" or "electronic triage" or etriage).tw. (94)
2 (chatbot? or chat-bot? or bot or bots or smartbot? or "conversational interface?" or "artificial intelligence").tw. (4889)
3 ("primary care" or "primary healthcare" or "gp" or "general practice" or "general practitioner" or "family doctor").tw. (178074)
4 (attitude? or acceptability or acceptance? or engagement or barrier?).tw. (504210)
5 (user? adj (perception? or perspective? or experience? or satisfaction?)).tw. (5022)
6 usability.tw. (10440)
7 (("doctor patient" or "physician patient" or therapeutic) adj relation*).tw. (8370)
8 "therapeutic alliance?".tw. (2199)
9 ("human computer interaction?" or hci or "user-centered").tw. (2697)
10 or/4-9 (527159)
11 7 or 8 (10387)
12 1 and 3 (12)
13 1 and 10 (17)
14 2 and 3 (34)
15 2 and 11 (5)
16 ("symptom? checker?" or "online diagnosis" or "self triage" or "web based triage" or "electronic triage" or etriage).tw. (94)
17 (chatbot? or chat-bot?).tw. (30)
18 16 or 17 (124)
19 (Askmd or DocResponse or EarlyDoc or Econsult or Esagil or FreeMD or "gp at hand" or healthdirect or Healthline or iTriage or MEDoctor or "NHS Symptom Checkers" or Steps2Care or Symcat or Symptify or Symptomate or webgp or WebMD).tw. (199)
20 ("mayo clinic" or "everyday health" or isabel or "family doctor").tw. (10025)
21 1 and 20 (0)
22 19 or 21 (199)
23 22 not 18 (194)
24 1 or 12 or 13 or 14 or 15 or 23 (326)

Appendix 2: Systematic Review Clinical Significance of Online Symptom Checkers

This section presents the clinical significance of online symptom checkers, extracted and synthesised from the eligible studies in the systematic review. It is included in the appendices rather than the main review because it was not one of the original topics of interest. However, it was deemed relevant and pertinent to the research, particularly in the context of a general practice setting.

Profile of users

Although symptom checkers in a primary care setting were used by patients of all ages including by parents for their children (77), the majority of users were aged 19 to 45 years old (77). Study (196) reported that women were generally more likely to use online self-diagnosis than men, which extended to adults over 65 as well.

Patient Access / Empowerment

Apart from potential to save travel time and costs (78,196,197) particularly for certain groups such as working people (78), there is insufficient evidence in the literature to determine whether symptom checkers improve overall access for frequent GP visitors. Study (197) reported that special attention should be paid to patients who can benefit from the use of symptom checkers (e.g. young people) as well as those who face the greatest chance of being excluded from the service e.g. older adults as cited in study (79).

Service demand

Out of 10, 3 studies (77,195,196) reported that symptom checkers offered defensive advice due to safety and medico-legal concerns which meant more recommendations to existing health services (e.g. A&E) as a precautionary measure. However, study (197) reported only 3% would not have approached a medical service if symptom checkers were not available, indicating this is yet to be a supply-led demand service. This is in contrast to study (26) which reported a significant 18% of patients claiming they no longer needed to book a GP appointment they had planned to due to symptom checkers. Though low uptake makes it difficult to generalise (31),

there is little evidence to suggest that the use of symptom checkers will increase service demand within the local health system (195).

Workload

Three studies (77,195,196) reported symptom checkers generally offered risk-averse defensive advice which could guide more patients to existing health services, and may therefore potentially increase workload for clinicians. For instance, study (77,196) reported symptom checker mostly recommended the user to contact a doctor (85% and 58% respectively) even for health issues which were identified as been treatable with self-care advice. In spite of this, study (26) reported that symptom checkers identified a proportion of patients with minor ailments that did not need a face-to-face consultation which has saved over 400 GP hours in appointments.

Common complaints submitted on symptom checkers were for cold symptom such as sore throat and cough (77,196) which were similar to complaints received in normal GP practices (196). However, there is inconsistent evidence in literature on whether symptom checkers reduces actual pressures on the existing primary care health services. If anything, according to study (78) the overall workload has not necessarily decreased but noticed a slight shift of responsibility from doctors to other practice staff particularly with administrative duties and carrying out mundane tasks.

Reduce costs

Although 2 studies (31,196) reported that symptom checkers have the potential to reduce costs through decreasing patient demands, both studies found symptom checkers were either not advanced enough for meaningful cost-beneficial analysis or did not appear to offer clear cost savings in its current form. It appears there is little evidence in literature to support technology providers' claim that symptom checkers will reduce primary care costs (31,196).

Existing System Effect

Two studies (31,78) reported concerns of GP practice staff about the challenges of integrating symptom checkers with pre-existing practice systems and the implications for adverse

interactions. For example, study (78) reported that webGP did not easily integrate with some of the existing IT systems. Furthermore, staff were concerned about patients gaming for appointments and telephone consultations by circumventing existing systems. To facilitate integration, study (31) reported that the presence of a human 'champion' in the practice might be beneficial to address arising technical issues as well as to promoting user engagement. However, study (196) reported that symptom checkers might be better combined with lifestyle interventions and online education rather than integrating with existing systems.

Uptake

The uptake of symptom checkers by users were an important indicator in determining whether symptom checkers gets adopted not only by users but also by the health authorities. 2 studies (31,78) reported that the overall uptake was slow within practices and less than anticipated by the practice staff. Study (197) reported on the possible reasons for non-use which included patients simply not being aware of the existence of the service or explicitly preferring to see a doctor. 4 studies (31,78,195,197) reported on how to promote and increase the usage of symptom checkers which included adopting a patient centred approach (197), tailored education to increase awareness (197), better instructions (197), presence of human champions (31), better communication and marketing (78) and 'IVR' in queue messaging in NHS111 supplemented by auto sms messaging (195).

The early indication is that overall uptake has been less than anticipated (31,78). Although potential factors affecting slow uptake have been explored, there is limited evidence of the effectiveness of some of the promotional strategies.

Limitations of Primary Care Context Studies

The majority of studies conducted in the primary care context primarily adopted a qualitative approach, focusing on cross-sectional designs with narrative analysis (26,32,35,77,195). These studies aimed to provide a detailed understanding of the subject matter by examining individual experiences and perspectives. However, it is important to note that the observational cross-sectional nature of these evaluations only captured a momentary snapshot of prevailing thoughts and opinions, confined to a specific time frame such as a week, month, or couple of

months (78). Consequently, this limited timeframe hinders the ability to draw broader conclusions or make generalisations based on the findings.

Among the reviewed studies, three out of ten (30%) (35,78,195) had relatively small sample sizes, resulting in reduced representativeness of the population under study. In particular, study (195) encountered variations in the underlying population and demographic characteristics across different pilot areas, thereby preventing meaningful comparisons between these sites.

In two separate studies (31,78), a direct interview with patients was not conducted, thus limiting the understanding of the patient perspective within these studies. Additionally, one of the studies (77), exhibited potential selection bias due to an imbalanced distribution of sex and education among the participants. Furthermore, another study (197) failed to encompass patients who lacked internet access.

Of the two studies (31,195), both had relatively short durations, which prevented an assessment of the long-term sustainability of symptom checkers.

Surveys emerged as the predominant methodological instrument employed across the studies. However, in one particular study (31), the survey questions were determined by a third-party company, potentially introducing an external influence on the research design. Furthermore, one study (196) encountered some incomplete responses, which may have impacted the accuracy and comprehensiveness of the findings

Appendix 3: Systematic Review Quality Assessment

NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies

*CD, cannot determine; NA, not applicable; NR, not reported; PC, primary care.

Author	Context	1. Was the research question or objective in this paper clearly stated?	2. Was the study population clearly specified and defined?	3. Was the participation rate of eligible persons at least 50%?	4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)?	5. Was a sample size justification, power description, or variance and effect estimates provided?	6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome	9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	10. Was the exposure(s) assessed more than once over time?	11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	12. Were the outcome assessors blinded to the exposure status of participants?	13. Was loss to follow-up after baseline 20% or less?	14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	Overall QR1	Overall QR2
Carter et al. 2018	PC	Y	Y	N	Y	N	NR	N	NA	NA	NA	Y	NA	NA	NA	FAIR	FAIR
Cowie 2018	PC	Y	Y	N	Y	N	N	N	N	NA	NA	Y	N	NA	Y	FAIR	FAIR
Nijland et al. 2009	PC	Y	Y	NR	Y	N	NA	N	NA	NA	NA	Y	N	NA	Y	FAIR	FAIR
Nijland et al. 2010	PC	Y	Y	N	Y	N	NA	Y	NA	NA	NA	Y	N	N	N	FAIR	FAIR
Macro-Ruiz et al. 2017	Non-PC	Y	N	Y	NR	N	NR	Y	N	NA	NA	NA	NA	NA	NR	POOR	POOR
Li 2017	Non-PC	Y	Y	NA	NR	N	NA	N	NA	Y	NA	Y	NA	NA	NA	FAIR	FAIR
Copeland 2018	Non-PC	Y	N	NA	NR	N	NR	N	NA	Y	NA	Y	NA	NA	N	POOR	POOR
Sola 2018	PC	Y	Y	N	Y	N	N	N	NA	Y	NA	Y	NA	NA	N	FAIR	FAIR
Verzantvoort 2018	PC	Y	Y	NA	Y	Y	N	N	NA	Y	NA	Y	NA	N	N	FAIR	FAIR
Luger 2014	Non-PC	Y	Y	NR	Y	N	N	Y	N	NA	NA	Y	NA	NA	NR	GOOD	GOOD

Table 23: Systematic review quality assessment

JBI Critical Appraisal Checklist for Text and Opinion Papers

*Y, Yes; N, No; UC, Unclear; NA, Not applicable.

Criteria / Author	1. Is the source of the opinion clearly identified?	2.Does the source of opinion have standing in the field of expertise?	3.Were the interests of the relevant population the central focus of the opinion?	4.Is the stated position the result of an analytical process, and is there logic in the opinion expressed?	5.Is there reference to the extant literature?	6.Is any incongruence with the literature/sources logically defended?	Overall appraisal
Karches et al. 2018	Y	Y	Y	Y	Y	Y	Include
Robertson et al. 2014	Y	Y	Y	Y	Y	Y	Include

Table 24: JBI Critical Appraisal Checklist for text and opinion papers

JBI Critical Appraisal Checklist for Qualitative Research

Criteria / Author	Is there congruity between the stated philosophical perspective and the research methodology?	Is there congruity between the research methodology and the research question or objectives?	Is there congruity between the research methodology and the methods used to collect data?	Is there congruity between the research methodology and the representation and analysis of data?	Is there congruity between the research methodology and the interpretation of results?	Is there a statement locating the researcher culturally or theoretically?	Is the influence of the researcher on the research, and vice-versa, addressed?	Were participants, and their voices, adequately represented?	Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	Do the conclusions drawn in the research reported flow from the analysis, or interpretation, of the data?	Overall
Jutel et al. 2015	Y	Y	Y	Y	Y	N	NA	NA	NA	Y	INCLUDED
Lupton et al. 2015	Y	Y	Y	Y	Y	N	UC	NA	NA	Y	INCLUDED

Table 25: JBI critical appraisal checklist for qualitative research

Appendix 4: Further study details and ethics

Pre-study meeting

Participants must clearly understand the safety disclaimer regarding using symptom checkers, and comprehend fully that the symptom checker used in this study will be no substitution for their GP service or any other health services such as A&E. Considering older adults over 65 are classified as a vulnerable group according to studies (440), a pre-study meeting will be exclusively held to conduct a risk assessment and meticulously explain these critical safety points as well as carefully go through the information sheets and consent forms individually. The information sheet will be distributed to the participant prior to the meeting in either print or electronic form, providing a brief background, context, and purpose of the study. It will also outline the main research activities during the sessions and what is expected of the participants. An FAQ brochure will be included to address common questions as well as contain useful contact details. Participants will be informed both verbally. and in writing of their ethical rights including anonymity and right to withdraw any time. They will also be given ample time and opportunity to ask questions throughout process, answers will be provided in simple jargon-free English. Participants, should they request it, will be permitted to invite a close family member or friend to be present at the pre-study meeting to provide moral support and help better understand the safety requirements.

Advertising methods

Potential recruitment source will be requested to:

- Allow recruitment poster and letter (see appendix 9) to be put up on their regular social venues' notice board. Fliers with study details will also be physically distributed, and any interested individuals will be signposted to the research website.
- Advertise the study details on their website (e.g., www.ageuk.org.uk/sheffield).
- Formally circulate the call to their membership mailing list and including the project in their newsletters.
- Allow attendance to some of the organisation's events and functions such as Coffee mornings, to give short presentations. This will enable direct promotion of the research study and give opportunity to reach out to potential participants, allowing for any questions to be directly answered face to face.

Setting

This is open to suggestion from the participant, with preference to the environment that they feel most comfortable (441) (e.g. home/work/church/university etc). However, the interview site must be suitable to conduct interviews (e.g., without noise or disturbance) and must have wireless internet connection (wired ethernet connection is not suitable for the use of symptom checker applications) and mains power supply for electrical devices including voice recorders. The site must also facilitate individual participant's personal needs (e.g., disability ramps) as well as satisfying standard safety requirements. It would also be desirable to have WC facilities nearby with accessible toilets given the long duration of each session.

In addition to following health and safety guidance for research undertaken in the community (442), the interview site will undergo a risk assessment check to identify potential hazards to both the researcher and participant (e.g. risk of physical threat or abuse). If the setting prerequisites are not met and if the participant declines to consider alternative (suitable) venues, then the participant will be disqualified from the study.

Irrespective of the interview location, in the room there will be the participant and the principal researcher (MIU) conducting the interview. Interview setting in terms of equipment layout would be as illustrated on Figure 8.

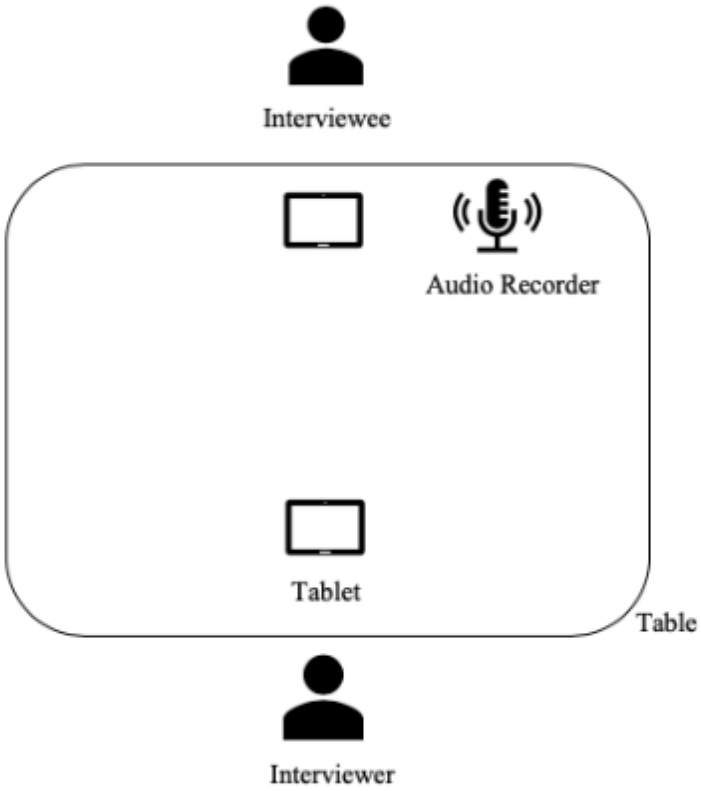


Figure 8: Interview setting adapted from (443)

UX ideation workshop

The UX ideation workshop will be carried out with stakeholders in University buildings during working hours. Several colleagues will be present at the workshop.

Materials

Cleaned and sanitised iPads will be loaned from the Sheffield University CATCH research group with the previous data on the devices being wiped. Tablets will be made available for the main interview sessions, think-aloud method and the two workshops. Backup tablets will be available when required.

Before the interview, the electronic devices and online symptom checker application will be checked to ensure they are fully functional and all previous personal data on the device have

been cleared. Encrypted digital voice recorder will be tested by conducting a short mock interview consisting of simple ice-breaker questions.

All data will be deleted from the devices after uploading (and checking) the data onto the University Filestore.

Material list:

- iPads (borrowed from CATCH)
- Extra chargers
- Download Babylon Health app.
- Wifi internet connection.
- Age appropriate questions and literature (simplified + print size): (i) info pack (ii) consent form
- Digital encrypted audio recorder to record the interview.

Consent

Fully informed and non-coercive written consent will be taken from the participant when the following key steps of the informed consent process has been achieved:

• Participant has fully read all the study literature including the consent form and information sheets.
• Participant fully understands the purpose of the study and benefits and risks of participation.
• Participant fully understands the risk factors and disclaimers of the symptom checker (e.g. not a replacement for doctors etc).
• Participant has had several opportunities to ask any questions (and seek clarifications) and received satisfactory answers in a way easy to understand for them. On the day, they will also have the opportunity to ask any questions.
• Participant fully understands what their role is and what is expected of them in the study.
• Participant knows the full details of the study activities including timeline and what tools and equipment will be used throughout the study (e.g. video camera).
• Participant knows their withdrawal rights at any time including rights to request to view or cancel their data.

In addition to obtaining written consent, questions will be asked in simple language to check the participant's understanding of the consent document. If a participant's family or advocate wishes to meet and discuss any questions or concerns, this will be openly facilitated. The signed consent forms will be collected and archived, and a copy provided to the participant in the format of their choice.

Payment

No financial incentive will be offered for participation other than travel reimbursement.

Safety assessment

This research involves engaging with the general public outside of the University premises in private settings (e.g., home visits). Furthermore, this research involves engaging with potentially vulnerable older adults who may have multiple chronic health conditions. Hence, necessary precaution will be taken to minimise risk to the health and safety of everyone involved as required by the University of Sheffield Research Ethics Committee (SUREM) guidelines and Management of Health and Safety at Work Regulations 1999.

Risk assessments specific to this project will be conducted before the research commences and appropriate procedures and control measures put in place to mitigate for this. Risk assessment forms will be adapted to the specific needs of this research and will be carefully archived for any future liability claims. The Chief Investigator (MIU) is responsible for all health and safety aspects of this research. The protocol will receive a scientific review from experienced researchers (at least PhD holders) from the CATCH research group at Sheffield University.

For semi-structured interviews, the choice of alternative to home visits will be provided (such as University building or local community centre etc.). To reduce risk, initial telephone contact will take place to assess safety prior to attendance. During home visits, interviews and interactions will take place in communal rooms such as living rooms (avoiding private rooms).

The researcher will carry and present identification: authenticated badges or UCard. To provide extra reassurance to vulnerable senior participants, researcher's DBS certificate will be shown. The option of a chaperone will be always offered to participants for the home visits.

Details of researcher's itinerary and appointments with be left with both of researcher's supervisors including mobile phone numbers, and they will receive notifications of changes or completion. The UX ideation workshop will be carried out with stakeholders in University buildings during working hours. Several colleagues will be present at the workshops.

Overall this is a relatively low risk study provided that the participants do not substitute the symptom checker for their regular doctor and other established medical health services, and do not rely on it for emergency health advice. Precautionary measures will be in place to minimise potential harm to participants e.g., regularly reminding participants throughout the study period to make sure they keep contact with their usual GP.

Potential adverse events

Adverse events maybe be classified as 'related' (a result of administration of any research procedures) or 'unexpected' occurrence (not listed in the research protocol). Adverse events will be documented using incident report forms and forwarded to pre-existing institutional audit sessions. This will begin with the research steering committee (comprising PGR student and supervisory team) who will decide whether the incident warrants forwarding to the pre-existing department audit sessions (e.g., ScHARR Research Ethics Committee) or can be resolved or mitigated without further escalation. If judged to be a serious adverse event (SAE), the matter will be escalated to the main university research ethics committee (SUREM) without delay. All reports of SAEs will be copied to the SUREM for information only and to the two research supervisors for their awareness and input.

If there is a safety concern relating to the symptom checker, the study will be temporarily suspended until the risk has been mitigated.

Potential harm to participants

Sheffield University's guidelines on 'participant and researcher safety and well-being' will be followed (444).

Potential harm to participants could result from:

- Participants viewing the symptom checker app as a replacement for their doctor – for instance, does not make doctor appointment as they routinely would have done for health concerns.
- Participants resorting to symptom checker app for self-help advice in genuine emergency situations (e.g., heart attack). The technology is still in its infancy and has known to misdiagnose and incorrectly triage certain health conditions.

In both scenarios, potential harm can be minimised by making sure participants fully understand from the onset that the symptom checker is not a replacement of their GP service or any other health service provider such as emergency services (A&E). This will be clearly stated on the information sheets and carefully explained in person. Moreover, regular reminders (e.g., phone calls) throughout the course of study will further reduce the risk factor.

Recruitment criteria has been devised so that it excludes high-risk participants (e.g., severe mental illness or dementia sufferers etc) who will find it difficult to operate the digital health device without compromising safety.

Interview site

A full health and safety check of the participant's preferred interview site will be completed prior to the interview - ensuring all the participant's special needs are addressed (e.g. disabled ramps, accessible toilets, diabetic friendly foods etc) as well as making sure the site is conducive to holding interviews (e.g. power supply) with adequate privacy (e.g. out of earshot from others).

Right to withdraw

Subject withdrawal or discontinuation rule:

Participants will be informed both in writing and verbally that they can discontinue participation in the study at any time without needing to give a reason, and without affecting their affiliation with the organisation that assisted with recruitment.

Quality assurance

Data processing and management

The research data will be collected, managed and stored securely, in line with good practice (e.g. Sheffield University Research Data Management guidelines and ScHARR's IG Policy) and according to national legislation (e.g. *Data* Protection *Act* 2018). Participant data will not be kept longer than is necessary for the purposes for which it is being collected, as required by Article 5 (e) of the GDPR, and will be destroyed promptly. Research data and related material will be retained not more than 10 years after the study has been completed. Data will be stored and encrypted on the University Networked Filestore with access restriction. The key data will be in an access restricted folder on the Filestore.

The principal researcher will undertake transcription and manage different access levels.

Managed data access:

- Researcher – all research data and information such as audio files, transcripts with identifiable data, key code/pseudonym file, anonymised transcripts and digitised diaries.
- PhD supervisors – all research data and information such as audio files, transcripts with identifiable data, key code/pseudonym file, anonymised transcripts and digitised diaries.
- Second coder – anonymised transcripts.

The data collected in the participant's interviews, think-aloud protocol and workshops will be kept strictly confidential.

Use of the university's managed devices and software made available by the university's IT Services department will significantly reduce data security risks.

Babylon health symptom checker is an online app which stores information online in secure data centres. Therefore, no participant data will get retained on the iPad. Once the application launcher of the symptom checker is uninstalled, everything gets deleted. A full wipe or factory resetting will not be required.

Confidentiality and anonymity

As participants become familiar with the researcher, they may become more relaxed and perhaps inadvertently speak about their personal medical conditions when describing their use of the symptom checker, thus amplifying issues of confidentiality (445).

To mitigate against this, participants will be reminded about general confidentiality guidelines at the beginning of each research activity. Participants will be asked not to share the conversations had within the workshop, outside of the workshop to respect the privacy of their fellow participants.

Qualitative data will be anonymised using best practices for anonymising text to remove both direct and indirect identifiers without distorting the data set or removing important contextual issues. UK Data Service recommends planning for anonymisation as early as possible in the data lifecycle to reduce anonymisation costs. Pseudonymisation, a type of data anonymisation technique, will be applied to this research.

Pseudonymisation strategy:

- A code/pseudonym for each participant will be created and stored securely on the university x drive with restricted data access. This will be stored separately from the pseudonymised data files and will be password protected.

- The code/pseudonym will be used for all data collected and throughout the project.

- When transcribing interviews identifiers of any nature such as all names and places will be removed and replaced with consistent pseudonyms and appropriate replacements. Redaction of statements will be considered where there is an increased risk of harm or disclosure.

- The pseudonymised transcripts and unedited version will be kept securely on the university x drive in an access restricted folder.

Expertise

This is an interdisciplinary study involving the marrying of knowledge from different areas of research particularly, Computer Science and Health. As well as drawing upon on the vast wealth of knowledge and expertise from the two cross-departmental PhD supervisors (MH: Health & VL: CS), consultation will be made with specialist research advisors from within the University, and beyond, to provide guidance and input in various stages of the study to optimise the overall research quality.

Qualitative Methods Opinion

This is qualitatively oriented research, therefore, consultation with qualitative study specialists in ScHARR and professional experts outside the department will be sought, for feedback on the research methods and the qualitative data analysis to improve quality and academic rigour.

The following qualitative methods experts have offered to help with this study:

- Dr Kate Fryer - Qualitative Research Associate at the Academic Unit of Primary Medical Care in Northern General Hospital.
- Dr Richard Cooper - co-ordinator of the Qualitative Research Design and Analysis module (HAR6531)

Project management

Although the Chief Investigator (MIU) will be primarily in charge of project management, monthly research steering committee meetings will be held (face to face or via video conference) to monitor the progress and resolve project management issues. The steering committee will consist of: Chief Investigator (MIU), research supervisors, and research consultants. Online project management tools such as Trello boards will be used to plan and track activities.

Participant vulnerability

Recruitment criteria has been devised to exclude vulnerable older adult participants (e.g. those with cognitive impairment) who may find it difficult to operate the digital health device without

compromising their own safety or those around them (e.g. symptom checking for young family members such as grandchildren).

The study participants will be fully informed (verbally and written communication) about the study purpose and processes. There will be several opportunities to ask questions from the initial point of contact to pre-study home visits, before giving fully informed consent. Participants will be made fully aware of their rights to withdraw from the study as voluntary participants at any time without needing to give a reason.

Service users

The target service users for this project are older adults aged over 65 from the general population, who are registered with an NHS GP practice, and although they may have different levels of IT proficiency, they must not have previously used symptom checkers for self-diagnosis purposes.

Dissemination

Dissemination of the findings will be via publication in scientific journals and presentations at relevant academic (e.g., Digital Public Health *Conference* ('DPH')), local clinical teams and industry conferences (e.g., Digital Health Summit) covering the realms of digital health.

Taking the work forward

In addition to gaining in-depth understanding of older adults' user perception and perceived usefulness, this study will provide the research community with detailed data on older adults' deep thought processes on key issues such as barriers of uptake, acceptability, and adoptability of symptom checkers. Furthermore, the findings can be used to devise measures that may help to change older adults' perceptions and increase uptake. Measures ranging from technological developments to promotion strategies may be the subject of further studies with bigger sample populations and longer study durations. This will be extremely valuable for technology providers, policy makers and health authorities.

This study explores whether older adults perceive symptom checkers yet another digital health intervention, the design of which disadvantages older adults (and by extension other vulnerable groups) and, therefore has the potential to widen health inequalities. It may though contribute to the opposite effect: work as an empowering tool, providing older adults with much needed access to GP services.

Intellectual property

IP generated by this research is owned by the University as per the terms of registration and governed by Regulations XXIII relating to Student Intellectual Property.

Project Timetable and Potential Impact of Coronavirus (Covid-19)

Although the provisional start date for recruitment of participants is October 2021, the schedule may be subject to change due to the ongoing Covid-19 pandemic. The researcher will follow Sheffield University's (and departmental) advice and guidance on this matter. In theory all the proposed research activities can be adapted to be carried out via video conferencing, but this route will be only pursued as a last resort - preference will always be given to face-to-face interactions if it's safe to do so for both the researcher and participants.

Appendix 5: Ethics approval for previous studies

Downloaded: 28/06/2021
Approved: 17/07/2020

Mohammed Ullah
Registration number: 180250622
School of Health and Related Research
Programme: PGR

Dear Mohammed

PROJECT TITLE: Investigating the use of online symptom checkers in general practice from the perspective of older adults.
APPLICATION: Reference Number 033676

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 17/07/2020 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 033676 (form submission date: 25/06/2020); (expected project end date: 01/10/2021).
- Participant information sheet 1077013 version 5 (25/06/2020).
- Participant consent form 1077014 version 4 (25/06/2020).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Jennifer Burr
Ethics Administrator
School of Health and Related Research

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: https://www.sheffield.ac.uk/rs/ethicsandintegrity/ethicspolicy/approval-procedure
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

Appendix 6: Interview guides

General qualitative interview guidelines and strategies in health care literature will be closely adhered to (e.g. (446–448)) when conducting interviews for each of the studies. This includes conducting the informed consent process before the interview begins, making the participant feel at ease and carefully explaining the purpose of the interview as well as their right to stop the interview at any moment without giving a reason. Probing questions will be asked, and participants will be allowed to express their views on their own terms. The interviews will conclude by debriefing the participant on what happens next and reassuring them that their participation will in no way affect the quality of their current general practice service.

Example of pre-interview briefing:

- Welcome participant and introduction of researcher.
- Explain the general purpose of the discussion and why the participant was chosen
- Discuss the purpose and process of interview.
- Explain the presence and purpose of recording equipment.
- Thoroughly discuss consent issues, reiterating that participant may withdraw from the interview at any time, and do not have to answer any questions they would prefer not to.
- Address confidentiality
- Inform the participant that the information discussed will be analysed as a whole and all identifiable data will be omitted.
- Read the protocol summary to the participant:

This study is intended to explore your perception and user experience of the use of symptom checkers.

Discussion Guidelines:

I would like the discussion to be informal. If you don't understand a question, please let me know. I am here to ask questions and listen.

I hope you'll feel free to speak openly and honestly.

As discussed, I will be tape recording the discussion, because I don't want to miss any of your comments. No one outside of this room will have access to these tapes and they will be destroyed after 10 years.

I will also be taking notes to help me.

Let's begin. Let's find out some more about each other. Tell me your first name, marital status, age, employment status and duration of your condition.

Interview guide for User Perception

Overview:

- To capture the participant's general attitude towards technology, adapted pre-validated questions on technology acceptance will be used (449) (Dr Lanfranchi's questionnaire).
- For the think-aloud protocol, standardised clinical vignettes (have been used in peer-reviewed studies) will be used. (179).
- To capture potential use and acceptance of symptom checkers, questions will be constructed around key STAM model concepts (280) particularly perceived usefulness (PU) and perceived ease of use (PEOU).
- Probing open-ended explorative questions will be used to identify new factors/determinants affecting older adults' use and acceptance of symptom checkers.

General use and attitude towards technology (see Vita's Questionnaire (449)**)**
Example questions:

- Are you willing to try new technologies?
- How often do you try new technologies?

Think-aloud interaction

Age-appropriate questions from standardised clinical vignettes used in previous peer-reviewed study (28) but will be put in lay language for this study:

Emergency care (e.g. go to A&E Visit)

Heart Attack[2]	Mr. Y is a 64 year old Chinese male who presents with chest pain for 24 hours. One day prior to presentation, the patient began to experience 8/10, non-radiating substernal chest pressure associated with diaphoresis and shortness of breath. The pain intially improved with Tylenol, however over the following 24 hours, his symptoms worsened. The patient went to his primary physician, where an EKG was performed which showed ST elevation in leads V2-V6.	64 y/o m, 1 day chest pain (8/10), non-radiating substernal chest pressure, sweating, shortness of breath, (*chest tightness*)

Non-emergency care (e.g. go to GP or Pharmacist)

Shingles[1]	A 77-year-old man reports a 5-day history of burning and aching pain on the right side of his chest. This is followed by the development of erythema and a maculopapular rash in this painful area, accompanied by headache and malaise. The rash progressed to develop clusters of clear vesicles for 3 to 5 days, evolving through stages of pustulation, ulceration, and crusting.	77 y/o m, 5 day burning and aching on right side of chest, erythema, maculopapular rash, headache, malaise, rash progressed to clear vesicles after 3-5 days

Self-treatment

Acute bronchitis[5]	Mrs. L is a 61 year-old woman who presents with 4 days of a cough productive of yellow sputum. Her symptoms started 4 days ago with rhinorrhea and productive cough. She initially had fevers as high as 101 for 2 days, but those have now resolved. In the office, she has normal vital signs and a normal physical examination. She is otherwise healthy except for high cholesterol for which she is being treated with atorvastatin. She has no drug allergies.	61 y/o f, 4 day cough, yellow sputum, rhinorrhea, fever (resolved)

Figure 9: Pre-validated clinical vignettes (179)

Participants will be asked to reflect on their user experience and user interface usability of the application.

Participants will be politely prompted whenever there is a prolonged period of silence (e.g. what are you thinking now?) (309) or if there is distraction.

P1 = User perception of symptom checkers

Questions regarding key topic/determinants adapted from (135):

Theoretical constructs	Example Questions (will be further simplified for the layman in the study)
Performance Expectancy:	In what ways might you benefit most from using symptom checkers in general practice?

Effort Expectancy:	What do you think - is it easy or not easy to use symptom checkers?
Social Influence:	Are you influenced by people that you trust (such as family and friends) regarding the use of symptom checkers? If so, how? How would they have to influence you so that you would use symptom checkers?
Facilitating Conditions:	What sort of things will you need in your environment to be able to use the full functionalities of the symptom checkers? (state examples to better explain these questions if necessary)
Hedonic Motivation:	What aspects do you consider as fun and pleasurable when using symptom checkers? (do you consider them as important for accepting this technology?)
Habit:	What would make you use symptom checkers on a regular basis? (societal factors, marketing?).

Table 26: User perception interview guide

In addition to perceived usefulness, participants will be asked about their views on potential barriers and opportunities of using symptom checkers as an assistive self-diagnostic tool in general practice.

Example of open-end explorative questions:

- What comes to your mind when thinking about symptom checkers?
- What do you think are the (i) benefits, (ii) challenges and (iii) risks of using symptom checkers in general practice?
- How does it compare to searching health information online?
- How do you feel about the use of symptom checkers in general practice, as potentially the first point of contact for your health concerns?
- Which characteristics of symptom checkers, in your opinion create and foster acceptance?
- What do you think are barriers to adoption of this technology, unique to older adults? Please give as many examples as possible and describe them.
- Which kind of action can technology developers take to increase symptom checker acceptance? Please rate the factors you named and the proposed ones from 0 (irrelevant) to 3 (essential)
- How do you think symptom checkers will reduce, or exacerbate health inequalities faced by older adults?
- How does using symptom checkers affect your outlook on conventional GP services?
- What emotions did you experience when using symptom checkers? What emotions did you associate to the application?
- What adjectives do you associate with the symptom checker application? What do you mean?
- How do you feel the use of symptom checkers gives you control of your health?
- What were your expectations of the application before use?
- Why would you use the application again?

Closed-ended questions adapted from (319)**:**

Do you think symptom checkers will help older adults to (strongly agree to strongly disagree)?

- Better manage their own health? If so, how? etc.
- Improve the quality of patient care?
- Help provide more personalised treatment?
- Reduce travel time to health care provider?

- Prevent unnecessary visits to health care providers?
- Disclose more information to symptom checker compared with health care providers?
- Increase patient privacy?
- Improve access and timeliness to care?

Rate the following (from strongly agree to strongly disagree) challenges of using symptom checkers:

- Patient data privacy and confidentiality concerns.
- Cannot understand or display human emotion.
- Lacks the intelligence or knowledge to accurately assess patients.
- Offers poor health-related advice.
- Cannot effectively care to the full extent of the patients' needs.
- Take too much time to use.
- Older adults will struggle to have access to the necessary technology for symptom checkers.
- May reduce health inequalities for older adults.
- May exacerbate health inequalities for older adults.

Debriefing / Closing:

- Do you have anything to add?
- Closing remarks
- Thank the participant

UX Structured-Interview Questions:

Questions about PU, PEOU and general UX:

- What was your overall user experience of symptom checkers? What was good about the application? What was bad? What do you like least/most about the symptom checker?
- Follow up with symptom checker functionalities and aspects of the user interface design: Reliability? Trust? Effectiveness?

- How did you feel using the symptom checker? Did you feel empowered? Did your feeling of empowerment change over the course of the study? How did it impact on your feelings of self-efficacy?
- Overall, how useful did you find the symptom checker? How useful did you find some of the specific functionalities?
- When did you use the symptom checker? Before or after seeing a doctor? When did you to use the symptom checker, but decide not to see your own GP?
- What were the main barriers to a positive experience for you? Elaborate.

Design

- What made the design easy or difficult to use?
- Do you believe you would use this type of app design? (e.g., Babylon Health Symptom Checker)
- Would you actually use this design?
- How much of the information on the symptom checker did you understand?
- How much of the information do you feel was relevant to you?
- How did you use the information?

Was the information easy to find? (accessibility)
Was the information clearly presented? (presentation)
Were you able to find what you were looking for? (content)
What other information should technology developers provide on the symptom checker?

Improvement suggestions

How could the information be made easier to understand?
What additional information do you want it to include?
Which feature of the symptom checkers are most important to you?
Which feature of the symptom checkers are least important to you?
What is the most important feature you think technology developers should add?
If you could change one thing about symptom checker what would it be and why?
Was there anything surprising or unexpected?
On a scale of 1–5, how likely or unlikely would you be to recommend this to a friend?

Final question

Is there anything more that you want to tell us in relation to the interview that I have missed to ask? Any comments, questions, or concerns?

English version

obstructive	o o o o o o o	supportive
complicated	o o o o o o o	easy
inefficient	o o o o o o o	efficient
confusing	o o o o o o o	clear
boring	o o o o o o o	exiting
not interesting	o o o o o o o	interesting
conventional	o o o o o o o	inventive
usual	o o o o o o o	leading edge

Figure 10: Short UEQ (450)

Interview guide for Doctor-Patient Relationship

Doctor-Patient Relationship Questions:

P1 Existing Perceived Value of Doctor-Patient Relationship

Typical baseline questions:

In your opinion:

What makes a good doctor-patient relationship?

How important is the doctor-patient relationship for you? Please elaborate.

How does the doctor-patient relationship affect your health outcomes (e.g. client/patient diagnoses), adherence to treatment etc.

How does the use of e-health technology in general practice impact your doctor-patient relationship?

After the think aloud protocol

How do you think the use of symptom checkers in general practice may affect your doctor-patient relationship? Please elaborate

- Will the use of symptom checkers enhance your Dr-PT relationship?
- Will the use of symptom checkers adversely impact your Dr-PT relationship?

How will the use of symptom checkers affect your X with your doctor?
X:

- Loyalty (patient's preference for seeing that particular doctor)
- Trust ('confidence', 'faith', 'security', and 'competence')
- Regard (comfort and liking)
- Interaction
- Communication
- Doctor-patient power dynamics

How will the relationship formed with symptom checkers technology impact your doctor-patient relationship?

How can symptom checkers be designed to improve / strengthen your relationship with healthcare providers?

How do you think this might impact your health outcomes, adherence to treatment etc.

Appendix 7: Participant information sheet

Research project title: Investigating the use of online symptom checkers in general practice from the perspective of older adults.

You are being invited to take part in this research study which will be conducted remotely using the secure video conferencing tool Google Meet. Before you volunteer, it is important that you understand why the research is being done and what it will involve. Please read the following information carefully and take your time in deciding if you still wish to take part. You are entitled to ask if there is anything that is unclear to you, or if you would like more information. Thank you for reading this.

What is the purpose of this study?

This study is led by Mohammed Ibrahim Ullah and forms part of a PhD qualification. The aim of this research project is to explore the use of symptom checkers in general practice from the perspectives of older adults. Online symptom checker apps are designed to help you understand quickly and conveniently what your medical symptoms could mean and help you to decide whether you should see your doctor or self-care. It does this through asking a series of questions about your symptoms and then works out an informal diagnosis based upon your responses. It is intended for information purposes only and is NOT a substitute for professional medical advice, diagnosis, or treatment.

The study particularly focuses on exploring the views of older adults regarding online symptom checkers, their 'user experiences' with these smart apps, and how it affects their doctor-patient relationship. Exploring this in-depth will provide a deeper understanding of the potential usefulness of this technology. The findings will also assist technology providers and health policy makers in understanding the motivation behind older adults' use, and non-use, of symptom checkers, particularly demonstrating how they engage and react to the application. This will help to design symptom checkers that are user-friendly for older adults as well as being useful in developing effective training strategies.

Why have I been chosen?

You have been approached and given information about this study because you may fulfil the inclusion criteria:

- The study needs individuals aged over 65 living with at least one chronic health condition.
- You must be fluent in English.
- You must have basic IT skills (e.g., able to send and receive emails, browse internet etc).
- You must have some prior experience in using online symptom checkers in general practice.

In total, there will be to approximately 12-16 older adults participating in Sheffield.

Do I have to take part?

No, participation is completely voluntary. It is completely up to you to decide whether to take part. If you decide to take part, you can keep a copy of this information sheet and will be asked to sign a consent form. However, you can withdraw from the study at any time, and you can do so without giving a reason. Refusing to take part or withdrawing from the study will NOT have any effect on the care that you receive from your GP or any other publicly funded health care service.

What will happen to me if take part? What do I have to do?

A pre-study online meeting will be arranged, at your convenience, to go over the details of the study activities including what is expected of you and your participation rights. You will be given every opportunity to ask questions or review any concerns you may have. The project consists of a two-phased approach lasting approximately 1 hour. In the first phase after a brief introduction, usability testing via think-aloud protocol will be conducted using age-appropriate vignettes (lasting 20 minutes). This will be followed by in-depth questioning relating to user

perceptions on the use of online symptom checkers in general practice, and how it may affect the doctor-patient relationship from your viewpoint (lasting 40 minutes).

You may also be contacted to take part in two UX ideation workshops (lasting 2 hours each) along with other people such as healthcare professionals and user experience (UX) designers, to attempt to find solutions to the user experience barriers identified from the interviews and the think-aloud protocol. Further information will be provided once you have expressed interest to participate in the UX ideation workshop.

All information collected during the research will be anonymised, and kept safe following strict data management protocols, as stipulated by Sheffield University ethics guidelines.

What are the possible benefits of taking part?

Online symptom checkers have the potential to empower older adults and improve access to healthcare services. Although there may be no direct benefit to you, it is hoped that studying user perceptions and user experiences will help technology providers to develop more user-friendly applications for older adults, who are often overlooked in the design process. This may, in the bigger picture, contribute to reducing health inequalities faced by older people.

What are the possible risks of taking part?

It is not anticipated that you will experience any disadvantages or harm by taking part in this study, as long as all instructions are followed. However, it is extremely important not to view the application as a replacement for your doctor or any other healthcare professionals or health service. You should always seek medical care as you would in normal circumstances.

The study is primarily interested in your perceptions and experiences of using the symptom checkers, not about your personal health or medical history. However, if some personal or sensitive information is revealed indirectly during the interview reflections, please be reassured your confidentiality will be fully respected.

If you have any questions or concerns at any stage of the study, please do not hesitate to contact Mohammed Ibrahim Ullah, his details are provided at the end of this form.

Will my taking part in this study be kept confidential?

All the information about your participation in this study will be kept confidential. Your name and personal details will be deleted from the information you provide and nobody other than the research team will be able to identify who you are. If you consent to taking part in this study, the interviews will be recorded on an encrypted audio device. This shall also apply if you consent to taking part in the ideation workshops. The researcher has no access to the data entered by participants on the symptom checker. Recordings will be promptly removed from the recording device once stored on secure university network in line with highest standards for data protection. Any paper-based notes will be shredded after being digitised and transferred onto the secure university network. Only the research team will have access to this folder. Any printed transcripts will be promptly shredded after use.

Any information you provide will be handled according to the General Data Protection Regulation. Your words may be quoted in publications, reports, webpages, and other research outputs but your name will not be used in these outputs. Where quotes are used, personal details will be changed to make sure you are not identifiable. Your personal details such as name, phone number, address and email address etc. will not be revealed to anyone. Research data and related material will be retained not more than 10 years after the study has been completed.

What is the legal basis for processing my personal data?

According to data protection legislation, the researcher is required to inform you, that the legal basis for processing your personal data is for 'processing necessary for the performance of a task carried out in the public interest' (Article 6(1)(e)). Further information can be found in the University's Privacy Notice https://www.sheffield.ac.uk/govern/data-protection/privacy/general.'

Some of the data that will be collected is defined in the legislation as more sensitive

(i.e. information about health), therefore, the following condition in law: that the use of your data is 'necessary for scientific or historical research purposes', is being applied by the researcher.

What will happen to the results of this study?

In addition to informing relevant stakeholders such as health policy makers about the perceptions of older adults regarding symptom checkers, this data will also be used to suggest design recommendations which are closely aligned with the needs of older adults and likely to improve key aspects of their user experience within the general practice context. You will be able to receive a summary of the results of the study if you wish. The results will be published in high quality journals and presented at digital health conferences.

Who is organising and funding the study?

The study is organised by Mohammed Ibrahim Ullah, a postgraduate research student from the University of Sheffield, and is supervised by Professor Mark Hawley and Dr Vita Lanfranchi from the University of Sheffield. The study is self-funded. The study has been reviewed and approved by the University of Sheffield's School of Health and Related Research Ethics Committee.

Who is the Data Controller?

The University of Sheffield will act as the Data Controller for this study. This means that the University will be responsible for your information and using it properly.

What if something goes wrong and I wish to complain about the research?

If you wish to complain please contact Professor Mark Hawley mark.hawley@sheffield.ac.uk. However, if you feel your complaint has not been handled to your satisfaction please contact the Dean of School of Health and Related Research (ScHARR), Professor John Brazier (j.e.brazier@sheffield.ac.uk), who will then escalate the complaint through the proper channels. If the complaint relates to how your personal data has been handled, please contact Anne Cutler, The University of Sheffield Data Protection Officer

dataprotection@sheffield.ac.uk. Further information about how to raise a complaint can be found in the University's Privacy Notice: https://www.sheffield.ac.uk/govern/data-protection/privacy/general. If you feel your complaint has not been handled to your satisfaction, please contact the Information Commissioner's Office.

Contact for further information

Mohammed Ibrahim Ullah	0781 6466761	ibby.ullah@sheffied.ac.uk
Professor Mark Hawley	0114 222 0682	mark.hawley@sheffield.ac.uk
Dr Vita Lanfranchi	0114 222 1865	v.lanfranchi@sheffield.ac.uk

Appendix 8: Participant consent form

Research project title: Investigating the use of online symptom checkers in general practice from the perspective of older adults.

Name of Researcher: Mohammed Ibrahim Ullah **Participation Identification Number:**

Please tick the appropriate boxes	**Yes**	**No**
Taking Part in the Project		
I have read and understood the project information sheet dated [15/04/2020] or the project has been fully explained to me. (If you answer No to this question, please do not proceed with this consent form until you are fully aware of what your participation in the project will mean)	☐	☐
I have been given the opportunity to ask questions about the project.	☐	☐
I agree to take part in the project. I understand that taking part in the project will include being remotely interviewed via the Google Meet video conferencing tool. I understand the two-phased interview will be recorded.	☐	☐
I understand that my taking part is voluntary and that I can withdraw from the study any time; I do not have to give any reasons for why I no longer want to take part and there will be no adverse consequences if I choose to withdraw.	☐	☐
How my information will be used during and after the project		
I understand my personal details such as name, phone number, address and email address etc. will not be revealed to people outside the project. I understand my identifiable details will be deleted when use is no longer required.	☐	☐
I understand and agree that small parts of what I say may be quoted anonymously in publications, reports, web pages, and other research outputs. I understand that I will not be named in these outputs.	☐	☐
I understand that the recording of the interview will be stored in an access restricted folder on secure university network in line with highest standards for data protection and retained for not more than 10 years after the study has been completed.	☐	☐
So that the information you provide can be used legally by the researchers		
I agree to assign the copyright I hold in any materials generated as part of this project to The University of Sheffield.	☐	☐
Optional future research		
I agree to be re-contacted about possible future participation in ideation workshops.	☐	☐

Name of Participant [printed]	Signature	Date
Name of Researcher [printed]	Signature	Date

To be signed and dated in presence of the participant.

Project contact details for further information:

Mohammed Ibrahim Ullah (Lead researcher) 07816466761
ibby.ullah@sheffied.ac.uk

School of Health & Related Research (ScHARR), University of Sheffield, Regent Court, 30 Regent St, Sheffield S1 4DA.

Prof. Professor Mark Hawley (Principle supervisor) 0114 222 0856
mark.hawley@sheffield.ac.uk

Dr. Vita Lanfranchi (Second supervisor) 0114 222 6530
v.lanfranchi@sheffield.ac.uk

Appendix 9: Example letter to be emailed to potential participants

The use of online symptom checkers in general practice from the perspective of older adults

Dear Sir or Madam,

My name is Mohammed Ibrahim Ullah and I am a researcher working at the University of Sheffield. I will soon be conducting a research study exploring the use of online symptom checkers in general practice from the perspective of older adults.

Symptom checkers are online applications that are designed to help you understand quickly and conveniently what your medical symptoms could mean and suggests possible next steps such as seeing your doctor or self-care. In addition to exploring older adults' perceptions, I would like to explore your experiences with this application, and how the use of it may affect your doctor-patient relationship.

The findings of this study are expected to assist technology providers and health policy makers to better understand your motivations, which should help to make it more user-friendly for older adults.

I am looking for motivated participants over the age of 65 with at least one chronic condition and have some prior experience of using online symptom checkers. You will need to have basic computer skills as well as be fluent in both written and spoken English.

This project will involve a two-phased online interview (lasting 1 hour). You will also have the option to participate in two ideation workshops (lasting 2 hours each), helping to suggest design recommendations which are closely aligned with the needs of older adults within the general practice context.

If you are interested in participating in this research project, please let a member of staff know so that they can inform me. I will arrange an appointment at your convenience to have a telephone conversation to discuss the study in more detail, as well as answer any questions you may have.

Please know:

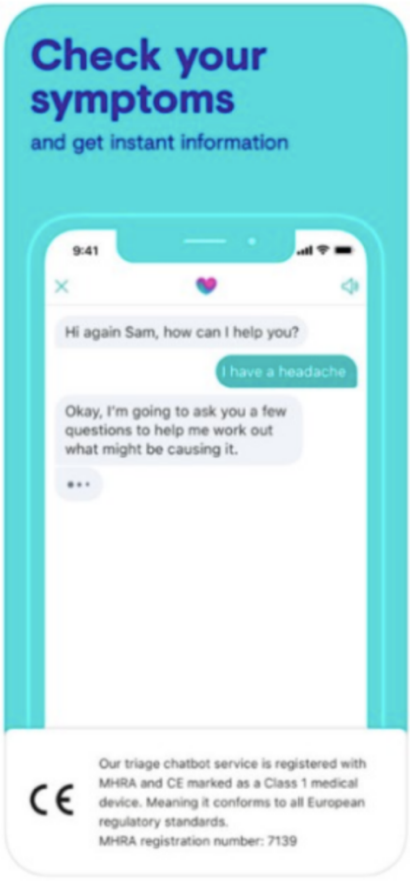
- Online symptom checkers are not a substitution for your doctor or any other health professionals or service.
- It is completely your decision whether you take part in the study.
- You can leave the study at any time for any reason.
- The information collected from you during the research will be kept confidential.

Thank you for taking the time to consider this research.

Poster for Noticeboards:

The University Of Sheffield.

Would you like to help us with some research on using an online symptom checker?



Source: Babylon Health

Please note online symptom checkers are not substitute for your regular doctor or any other health services. This study has been approved by ScHARR's ethics committee at the University of Sheffield.

Hi, I'm Ibby. I'm a researcher at the University of Sheffield.

I am looking for over 65's to test a leading online symptom checker and tell me about their perceptions, user experience and thoughts on how it may impact the doctor-patient relationship.

If you are over 65+ with a chronic condition, and would like to take part in our research, I'd love to hear from you. You need to be fluent in English and have some basic IT skills.

You can contact us by phone 0114 2220713 / 07816466761 or email ibby.ullah@sheffield.ac.uk and I'll get right back to you with more information about the study, so you can decide whether to take part.

CATCH
Centre for Assistive Technology and Connected Healthcare

powered by PIKTOCHART

Invitation email/letter for UX ideation workshop:

The use of online symptom checkers in general practice from the perspective of older adults.

Dear (participant's name),

Thank you for completing the interview phase of our research project. Your participation has been extremely helpful. Please know that your time and contribution has been greatly appreciated.

Going forward, I would like to invite you to the final phase of the research project. Two remote UX ideation workshops will be held involving older adults, doctors and UX expert suggest design recommendations which are closely aligned with the needs of older adults and likely to improve key aspects of their user experience within the general practice context. Your participation for the remote UX ideation workshops is completely optional. Please note, as only 3-5 older adult participants are required, I may randomly select 3-5 people should I receive more than 3-5 expressions of interest.

The terms of the original consent form and participants information sheet will be extended to the UX ideation workshop including your rights to withdraw from the study at any time without giving a reason.

I have attached a brief information sheet about our UX ideation workshop.

Please feel free to contact me (Mohammed) directly if you need any further information.

Best wishes,

Mohammed Ibrahim Ullah

Brief summary of the ideation workshop

What is an ideation workshop?

The purpose of an ideation design workshop is to engage real life users such as yourself and others like doctors and designers to generate new and diverse design ideas. It will help to give a collective direct understanding of symptom checker's user experience issues, which can be used to improve the design so that it closely matches the unique requirements of older adults.

Image source: ckpolice.com

Participants:

There will be two ideation workshops lasting approximately 2 hours each, and will involve 3-5 selected older adults, 2-4 GPs and 1-2 UX expert/s.

Venue:

The ideation workshops will be held remotely over the video conferencing platform Google Meet.

Activities on the day:

After introductions, I will also present the latest developments in literature in this area of research.

User experience storyboards will be used to visually demonstrate the process that you will go through and how you will interact with the symptom checker when using the application. Groups will be divided into subgroups (e.g., doctors, designers etc) and moved to breakout rooms in Google Meet to provide feedback on the initial user experience particularly relating to usability, user satisfaction and usefulness aspects, and ways in which they believe the application can be made more user-friendly for older adults.

Participants will be guided how to use Google Meet compliant virtual annotation tools (e.g., online whiteboard and sticky notes) to attempt to find solutions to the user experience barriers identified from the interviews and the think-aloud protocol. I will conclude with a virtual round table discussion to openly communicate ideas.

Outcome:

The findings from the ideation workshop will be used to produce design recommendations to improve older adults' user experience of symptom checkers.

Email when potential participant expresses an interest to participate in the study:

Dear (participant),

I'm delighted that you have expressed an interest to take part in my study. I've attached an information sheet which briefly explains the research.

Please feel free to contact me if you have any questions based on this.

Once you feel satisfied that you understand what is involved, and if you are happy to take part, please call or send me an email to arrange a convenient date and time for a quick initial telephone conversation or a video conferencing meeting on Google Meet (lasting approximately 10-15 minutes) to check if you meet our participation criteria. You will also be given opportunity to ask further questions or seek clarifications with regards to any aspects of the study.

Contact details:

Email: ibby.ullah@sheffield.ac.uk
Direct line: 07816466761.

Best wishes

Mohammed Ibrahim Ullah

Appendix 10: Theoretical Frameworks

This chapter will introduce and appraise relevant acceptance and adoption models to this research, starting with the original technology acceptance model (TAM) and conclude by considering Seniors' Technology Acceptance Model (STAM) and UX frameworks for older adults.

Technology Acceptance Model

Although there are varying definitions of technology acceptance, the following definition will be applied in this research: "the approval, favourable reception and ongoing use of newly introduced devices and systems" (451). Whilst various extensions of Technology Acceptance Models (see Figure 11) continue to be studied and expanded, the original model is still regarded as one of the most influential information system theories, providing reliable and valid measure to statistically predict and explain the end-user's acceptance (or non-acceptance), as well as use of new technology (452,453) .

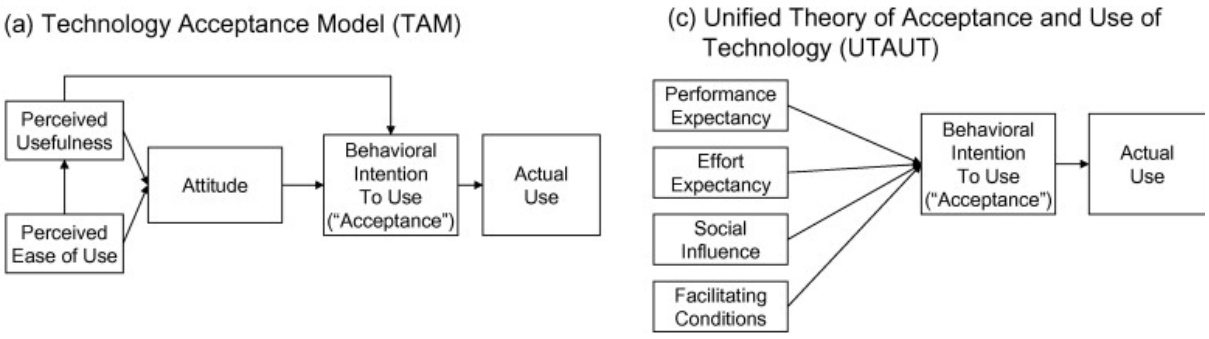


Figure 11: TAM and UTAUT Model (369)

TAM is comparatively a simple model, developed from Azen's theory of planned behaviour (TPB) and Fishbein's Theory of Reasoned Action (TRA) (419). It builds on the notion that a specific behaviour is influenced by user intention to carry out the task. This intention is determined by a number of factors including user attitude and perception, which may lead to (or not) behaviour execution or actual use in the information system context.

TAM has two primary influencing constructs:

Perceived Usefulness (PU) - defined by Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance" (454). In the model, PU is influenced by PEOU, and directly influences both attitude toward using the system, and the behavioural intention to use the system.

Perceived ease-of-use (PEOU) – defined by Davis as "the degree to which a person believes that using a particular system would be free from effort" (454). In the model, PEOU directly influences attitude towards using the system.

TAM is a robust and parsimonious model that has been successfully utilised in many empirical studies. It predicts user acceptance despite substantial variance in usage intentions and behaviours, across various disciplines including technologies associated to symptom checkers such as mobile phones, computer interfaces and e-government services (181,452). As well as identifying additional determinants (external variables influencing PU and PEOU) such as prior experience and attitude towards technology, numerous convergent evidences in these studies showed that the two primary constructs of TAM (PU and PEOU) were significant influencers in forecasting technology acceptance.

Limitation of TAM includes the assumption of rational users, and it may ignore important theoretical constructs as identified in the UTAUT model (see Figure 11). It also fails to reflect the variety of user task environments and constraints, including limited resources. It is argued that TAM is more appropriate for individual use and acceptance of technology, than in an institutional application that requires integration of information technology (455). If symptom checkers were to be deployed in general practice, it will need integrating with the existing GP IT systems and infrastructure, ideally with minimal costs and disturbance, alongside being acceptable by the users.

Unified Theory of Acceptance and Use of Technology

Vankatchet et. al (419) developed The United Theory of Acceptance and Use of Technology (UTAUT) to predict an individual's usage behaviour and behavioural intention (BI). This was achieved by extending the original TAM, and including constructs from several other existing

prominent theories and models (in total eight previous models of technology acceptance) such as the Motivational Model (MM) (456), Innovation Diffusion Theory (IDT) (457) and Social Cognitive Theory (SCT) (458).

Addressing a significant limitation of TAM, Vankatchet included social influence and facilitating conditions, two external influencing factors not directly related to system's perceived properties, enhancing the ability to examine external variables impact on usage behaviour and intentionality.

The four core determinants to UTAUT:

Performance expectancy (PE): "the degree to which an individual believes that using the system will help him or her to attain gains in job performance"

Effort expectancy (EE): "the degree of ease associated with the use of the system

Social influence (SI): "the degree to which an individual perceives that important others believe he or she should use the new system"

Facilitating conditions (FC): "the degree to which an individual believes that an organisational and technical infrastructure exists to support use of the system"

Venkatesh also included four mediating variables (gender, age, experience, and voluntariness of use) in the UTAUT model to moderate the extent to which the four core determinants impact on behavioural intention and use behaviour.

Several studies have attempted to use the UTAUT model and framework with varying degrees of success to determine older adults' acceptance of technologies including some healthcare-related systems that are closely related to symptom checkers, such as telehealth service (459).

Limitations:

UTAUT is an amalgamation of 8 different technology acceptance models, however according to Saliza and Kamil (2012), 'there is no universal UTAUT that can explain all

situations of acceptance" because 'a unified model is being accepted and integrated in many studies of various fields, their results revealed some inconsistencies when applied in different areas or situations'.

It has weak explanatory ability despite being more predictive and integrative. This is largely due to the fact 32 variables have been reduced to four moderators, producing too general predictions.

It may be unsuitable for sensitive and complex data collection studies.

UTAUT does not include cultural factors and more focused on individual's internal schema of beliefs, excluding general external factors.

Seniors' technology acceptance model (STAM)

Older adults remain late adopters of technology and it is still considered a major challenge to incorporate the appropriate use of new technologies into their lives (452) in comparison to their younger counterparts. Despite technology acceptance being a topic of active research, research on older people's technology usage and acceptance (and non-acceptance) is relatively underexplored, and in general, insufficient considerations are given to age-specific or age-related factors (140,170) when studying consumer technologies. As a result, there remains a limited explanation of technology acceptance amongst older adults in literature (171).

The majority of studies investigating the relationship between older people and technology acceptance have thus far predominantly attempted to adapt extant theoretical models of technology, rather than build new models specifically designed for older adults to predict their behaviours. The very few studies that do, are severely limited in their application due to a number of factors from inadequate sample size of older adults, to failing to measure intention to use a technology for longer-term use (i.e. adoption) mainly due to resource limitations and research time constraints (37).

However, an exception to this tendency is the senior technology acceptance model (STAM) proposed by Renaud and Biljon (280) (see Figure 12) and then developed further by Chen and Chan in a 12 months study of user behaviour (170) considering senior age-related aspects not

covered by previous TAMs. These included physical, psychological and social characteristics associated with influencing older adults' interactions and acceptance of gerontechnology.

STAM, initially constructed to explain older adults' mobile phone adoption, is in essence theoretically underpinned by theoretical notions and constructs from several technology acceptance model such as TAM and UTAUT.

In STAM, there are three procedural phases that the user is expected to go through to determine whether to accept or reject a new technology (280) :

Objectification phase – this is where the user forms an intention to use the system which is influenced by perceived usefulness (similar to PU in TAM and PE in UTAUT) and user context (e.g. personal factors such as age and ability as well as social influences).

Incorporation phase – this is where a user explores and experiments with the system to first form initial impressions of the ease of use (similar to PEOU in TAM and EE in UTAUT) of the system and then validates them through more experimentation and exploration.

Conversion – depending on the outcomes of previous phases, the user will progress to either accept or reject the technology.

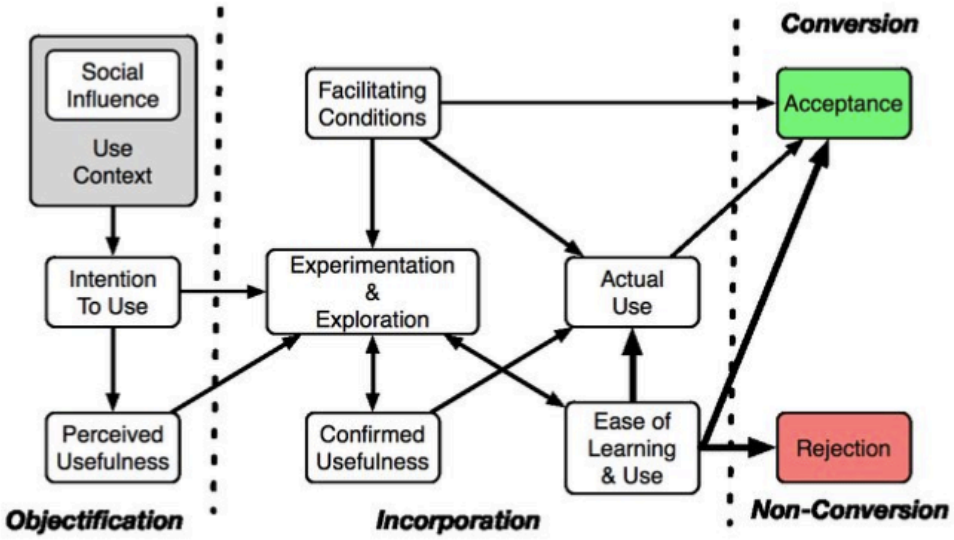


Figure 12: Senior Technology Acceptance Model (STAM) (134)

A significant difference between STAM and prior models is the incorporation phase, where a user acquires a hands-on experience of a technology via experimentation and exploration and links these dynamic factors with their 'intention to use' and 'actual use'.

From the study of three existing models of technology acceptance (TAM, UTAUT, and STAM), study conducted by Shore et. al (280) determined the important components that influence technology acceptance of people in general. They are listed on Table 27.

	ITEM	TAM	UTAUT	STAM
Phase	Intention to use	Yes	Yes	Yes
Phase	System experimentation	No	No	Yes
Phase	Actual use	Yes	Yes	Yes
Factor	Perceived ease of use	Yes	Yes	Yes
Factor	Perceived usefulness	No	Yes	Yes
Factor	Social influence	No	Yes	Yes
Factor	Facilitating conditions	No	Yes	Yes
Factor	User context	No	Yes	Yes

Table 27: TAM, UTAUT, and STAM Characteristics (452)

User Experience (UX) Models

Although there is no single dominant model of UX, there are a range of UX approaches (e.g., (135,460)) capturing a broad range of UX concepts through common attributes such as hedonic, emotional and pragmatic attributes. UX models can be expected to have a certain degree of complexity given user experience is highly subjective, context-dependent and dynamic over time (461). For example, Hassenzahl's UX Model postulates that interface quality comprises both hedonic and pragmatic aspects as illustrated on Figure 13 and assumes users create a subjectively meaningful experience by choosing and combining a specific product's features (462).

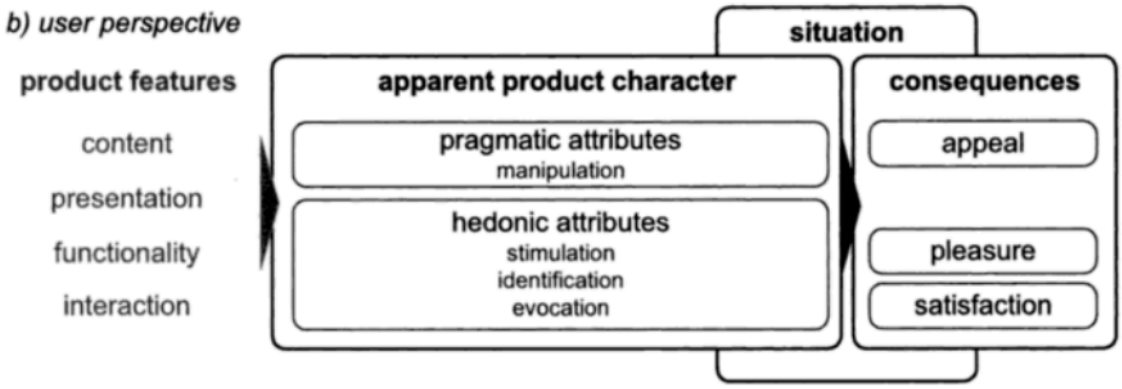


Figure 13: Hassenzahl's "Model of User Experience" (135)

Models such as UX mental models are based upon user's beliefs and perceptions of the world (270,394) which often of varies widely. However, user experience design frameworks such as BASIC UX (463) consists of shared but well-defined principles to evaluate the overall user experience as follows:

Beauty - Is it aesthetically pleasant?

Accessibility - Can 'everyone' use it?

Simplicity - Does it make life easier?

Intuitiveness - Is it easy to use?

Consistency - Does it match the system?

A good user interface (UI) is crucial to an overall positive UX, the following are some standards KPIs of the UI, forming the basis of user the experience model (464):

Utility: *What is the subjective value of the content and functions for the target group?*

Accessibility: *How good is accessibility and compatibility? How does the user feel about the performance and loading times? Is the product suitable for its terminal?*

Usability: *How effective and thus satisfying can users achieve their goal?*

Brand promise: *How well does the product meet the brand promise and therefore the user's expectations?*

UX and TAM

TAM and UX models provide rich insights on the uptake and use of technology. UX models seek to describe and understand the experiential and hedonic aspects of technology / interactive products, whereas TAM is concerned in individual adoption and use (465). In addition to the two key constructs of TAM (PU and PEOU), an important supporting construct is perceived enjoyment (430,431), which is closely aligned with elements of user experience and the hedonic aspects forming the basis of UX models (208).

Although UX models have lower priority on utilitarian aspects, the close association between TAM and UX models is highlighted by the fact that the core determinants of each model can be loosely encapsulated by each other (466). For example, perceived ease of use in TAM corresponds to usability in UX design, perceived usefulness corresponds in TAM to utility in UX design. Similarly, engagement in UX design can be the result of a multitude of TAM factors such as user attitude and behavioural intention.

Despite the seemingly close link between TAM and UX models through the all-important experiential component, research studies actually overlapping between these two models is limited even though there are many theoretical and practical benefits of doing so. For example, prediction of technology acceptance using TAM should inform design, and new constructs in UX models should solidify and support TAM prediction. Thus, a better understanding of experiential component provided in overlapping studies will not only simultaneously advance both strands of research but also blend the two research approaches (465).

User engagement conceptual model

User experiences boost uptake and engagement (413). User engagement, a subset of user experience, involves the quality and depth of interaction (412). Sustained engagement is essential for the long-term success of mHealth interventions (414). Given the presumed connection between user engagement and the effectiveness of the mHealth intervention, as suggested by Donkin et al. (467), a conceptual model was developed by Perski et al. (417)

following a systematic review aimed at synthesising the available evidence on user engagement with mHealth interventions in a healthcare context using principles from critical interpretive synthesis.

Perski et al. (417) integrated both behavioural dimensions of engagement (e.g., amount, frequency, duration) and subjective experiences (e.g., attention, interest, and affect). Descriptive themes were further categorised into contextual factors and characteristics of the mHealth intervention itself. Contextual factors encompassed population characteristics (e.g., age, computer literacy) and setting characteristics (e.g., location and social support). mHealth characteristics included factors related to delivery (e.g., mode of delivery and ease of use) and factors related to the content of the intervention (e.g., self-monitoring and feedback).

Acker et al. (128) synthesised available evidence from qualitative and mixed-methods studies on older adults' user engagement with mHealth interventions and expanded Perski et al. (417) conceptual model by identifying and adding new contextual factors (e.g., multimorbidity, sensorimotor problems, and social support), and mHealth characteristics (e.g., gamification).

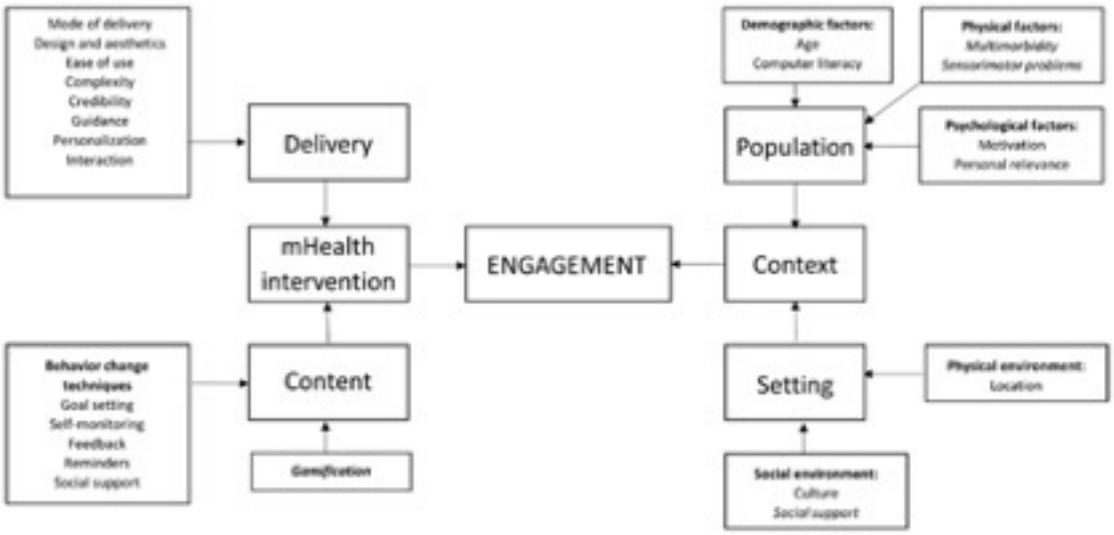


Figure 14: User engagement conceptual model extended by Acker (128)

UX Framework for older people

There are only few formal theoretical UX frameworks based around the needs of older people (425). However, there are several guidelines in literature such as (426–428) advising how to make user interface, accessibility and usability more friendly to older adults. These include making UI patterns memorable to aid cognitive difficulties, and using colour and contrast for optimal visibility (468).

Appendix 11: Data Management Plan

A Data Management Plan created using DMPonline

Creator: Mohammed Ullah

Affiliation: The University of Sheffield

Template: The University of Sheffield

Defining your data

- **Where does your data come from?**
- **How often do you get new data?**
- **How much data do you generate?**
- **What format(s) are your data in?**
- **If pre-existing datasets are being used, where will these come from? How will they be used? Who owns them?**

The research data are from:

- Semi-structured interviews (participants: older adults and GPs), think-aloud protocol (participants: older adults), and ideation workshops (participants: older adults, GPs and UX experts), capturing qualitative data. This will be recorded on Google Meet video conferencing platform which has end-to-end encryption for meetings.

In summary, data will be collected in video format. Data will be generated until the point of data saturation has been achieved. Expecting to generate no more than 20GB data which is well below the allocated quota in ORDA, the University's data repository.

Looking after your data

- **What different versions of each data file do you create?**
- **What additional information is required to understand each data file?**
- **Where do you store your data?**
- **How do you structure and name your folders/files?**

- **How is your data backed up?**
- **How will you test whether you can restore from your backups?**
- **What safeguards will you put into practice?**

Data will be processed using MS Word and NVivo (qualitative data analysis computer software package).

The data will include some personal data relating to human participants. However, personal data will be only used for admin purposes during the study such as identifying participants (same set of participants will be involved in multiple stages of data collection) but destroyed once data collection has been completed. Only anonymised data will be archived.
Records of datasets will be published in ORDA, the University of Sheffield's registry of research data produced at the University, which will issue DataCite DOIs for registered datasets and promote discovery.

The data do not require additional information except the collection process which is available in the thesis.

Data will be stored in the University Network Filestore (central institutional) which is secure with automated back-up procedure. Data will also store on a secured computer (most likely laptop) but the data will be encrypted, regularly backed up and transferred to the University Filestore.

Folders will be named according to source, stages of analysis and date designation: stage_subject_YYYY_mm_dd. A README file will be added to the repository to explain naming format, abbreviations and list all files etc.

Back up will be checked by file dates.

Data will be stored securely, and drive are not left unattended. The University's Information Security Policies will be abided by at all times.

Archiving your data

- **What should be archived beyond the end of the project?**
- **For how long should it be stored?**
- **When will files be moved into the archive?**
- **Where will the archive be stored?**
- **Who is responsible for moving data to the archive and maintaining it?**
- **Who should have access and under what conditions?**

Data will be archived in line with the University of Sheffield's Research Data Management Policy, which is a component of the University's Policy on Good R&I Practices (the 'GRIP' Policy).

Participant's personal data will be anonymised comply with Data Protection Act (1998) or equivalent legislation outside the UK. There are unlikely to be any embargo periods for political/commercial/patent reasons.

Data collected in paper form will be routinely digitised and the paper form disposed of.
Research data will be retained and securely stored for a minimum of ten years after publication or public release - this will match participant's consent form as well as information pack.

The file will be moved to ORDA (University of Sheffield's data repository) archive at the end of project.

The key investigator is responsible for moving data into the archive.
Anyone can access the data for the purpose of research only.

The data will be subject to Creative Commons Attribution NonCommercial (**CC-BY-NC**) license.

No business intension without the permission of the key investigator.

Sharing your data

- **Could any of your data be considered sensitive personal data under the GDPR?**
- **Does permission need to be obtained for future re-use and sharing?**
- **Have participants transferred copyright (if necessary)?**
- **Who else has a right to see or use this data?**
- **Who else should reasonably have access?**
- **What should/shouldn't be shared and why?**

This research collects data concerning older adults' and GPs' experiences and perceptions of an online symptom checker.

While it is not the intention, there is a chance participant may inadvertently reveal / record personal health (aka "Special Category") data in the audio/written recordings. Sensitive personal data will be anonymised and managed according to data protection principles e.g. General Data Protection Regulation (GDPR) and ScHARR's IG Policy.

Permission must be obtained for further reuse of the data.

No participant information will be published.

Only researchers can see and use the data. Data can be shared for the purpose of research.

The PI will have exclusive use of the data until the main research findings are published or patent applications have been filed.

Implementing your plan

- **Who is responsible for making sure this plan is followed?**
- **How often will this plan be reviewed and updated?**
- **What actions have you identified from the rest of this plan?**
- **What further information do you need to carry out these actions?**

The principal investigator is responsible for following this plan. However, in the unlikely event PI wins the lottery or get hit by a bus, the back-up plan is to share the responsibility with the project supervisors. This plan will be reviewed at the end of the PhD.

Extra data management plan from ethics application

1. Data Processing

Will you be processing (i.e. collecting, recording, storing, or otherwise using) personal data as part of this project? (Personal data is any information relating to an identified or identifiable living person).

Yes

Which organisation(s) will act as Data Controller?

University of Sheffield only

2. Legal basis for processing of personal data

The University considers that for the vast majority of research, 'a task in the public interest' (6(1)(e)) will be the most appropriate legal basis. If, following discussion with the UREC, you wish to use an alternative legal basis, please provide details of the legal basis, and the reasons for applying it, below:

As recommended above: 'a task in the public interest' (6(1)(e)) will be the most appropriate legal basis.

Will you be processing (i.e., collecting, recording, storing, or otherwise using) 'Special Category' personal data?

No

3. Data Confidentiality

What measures will be put in place to ensure confidentiality of personal data, where appropriate?

• Personal data will be managed according to data protection principles e.g. General Data Protection Regulation (GDPR) and Common Law Duty of Confidentiality.

• The extent to which a participant's data will remain confidential will be disclosed to the participant as part of the process of seeking informed consent.

• Manage data acquisition by collecting and storing minimum personal detail necessary for administrative purposes only to be used during the course of project e.g. name, phone number, address and email address etc.

• To control confidentiality, manage data access to ensure access is only authorised and granted to those who have a "need to know". Users will have their access authenticated with strong authentication. Furthermore, access list will be reviewed periodically and promptly revoke access when it is no longer necessary.

• Identifiable data will be deleted when use is no longer required and will not be revealed to people outside the project.

• Identifiable data will be pseudonymised or anonymised wherever possible.

4. Data Storage and Security

In general terms, who will have access to the data generated at each stage of the research, and in what form

Researcher - identifiable

PhD supervisors - pseudomymised

Transcription / double coder: anonymised

What steps will be taken to ensure the security of data processed during the project, including any identifiable personal data, other than those already described earlier in this form?

• Recording of the interview will be saved in an access restricted folder on the University of Sheffield's Shared Networked Filestore. Encrypt files particularly those with identifiable data.

• Devices and paper documents will be physically secured from misuse or theft by storing them in locked areas. Will never leave devices or sensitive documents unattented in public locations.

• Data, devices, and paper records will be securely and appropriately disposed when no longer required for research-related purposes. For example, paper documents containing identifiable data will be shredded rather than dumped into trash or recycling bins.

• Identifiable / sensitive data on devices will securely erased to ensure that their previous contents cannot be recovered and misused.

• Follow basic cybersecurity hygiene by using anti-virus software, whitelisting applications, using device passcodes, suspending inactive sessions, enabling firewalls, and using whole-disk encryption.

Will all identifiable personal data be destroyed once the project has ended?

Yes

Please outline when this will take place (this should take into account regulatory and funder requirements).

Identifiable personal data will be destroyed after successful doctoral defence.

Appendix 12: Evaluating Qualitative Research

This study was assessed by the standards defined as appropriate for evaluating qualitative research (253,382–384) and the summary of the assessment is presented in the following table:

Sensitivity to context/credibility *Does the researcher show extended engagement with the subject matter/sensitivity to context?*	A focused and comprehensive review of relevant studies was carried out, revealing a thorough comprehension of the research subject, particularly regarding the most common barriers encountered by elderly individuals when attempting to utilise GP services. The researcher adhered to recommended protocols for working with vulnerable participants, addressing and minimising potential sensitivities and risks associated with conducting usability tests and interviews with older adults, whether in person or online. Throughout the study, significant efforts were made to actively involve older adults, starting from the recruitment stage all the way to data collection. This involvement was achieved by communicating in simplified language, providing ample opportunities for questions, and demonstrating sensitivity towards age-related health concerns.
Credibility *Has the researcher reflected on their role in research?*	Great attention was devoted to ensuring that the research question, the philosophical viewpoint, and the approach were well-aligned. Alongside providing reasons for choosing the qualitative method, a thorough description of the research process was included in the methods section to enhance clarity and openness.
Transparency and Coherence/Dependability	Great attention was paid to guaranteeing a harmonious alignment among the research question,

Is there a fit between the research questions, the philosophical perspective and the method?	the philosophical viewpoint, and the chosen method. Alongside providing reasons for opting for the qualitative method, the methods section included a detailed research plan to enhance transparency.
Transparency and Coherence/Dependability *Is there an audit trail of the research process?*	An audit trail was present, providing a clear account of the research process from start to end. The methods section explicitly outlined various aspects, such as recruitment methods, data collection procedures, analysis techniques, and encountered difficulties. Additionally, the researcher maintained field notes while conducting think-aloud protocols and semi-structured interviews.
Credibility *Has triangulation been used?*	The study's findings were compared with previous research in the field and a comprehensive review of relevant literature to examine the research question from various angles. This comparative analysis is presented and discussed in the dedicated section of the study.
Credibility *Has the researcher tried to ascertain whether participants recognise the findings to be true to their experiences?*	The interview script was sent to participants chosen at random once their data had been transcribed. They were then requested to validate whether they believed the findings accurately represented their interview and personal experiences. Through an iterative process, participants had the chance to impact the evolution of the findings, which are elaborated upon in the methods and discussion section.
Credibility *Is the data collection and analysis complete?*	The process of gathering information concluded once enough data was obtained, which occurred after conducting 13 interviews with older adults. The methods section of the study outlines and clarifies

	the process of data collection and analysis, which involved a combination of thematic analysis techniques.
Transparency and coherence *Is there clarity of presentation of the analysis?*	The analysis was effectively demonstrated by clearly presenting themes and sub-themes through the use of thematic analysis, which aimed to promote transparency and improve the overall cohesiveness.
Dependability *Has the researcher shown attention to negative cases?*	In the findings section, the researcher went above and beyond to recognise and emphasise instances that deviate from the regular themes and have negative attributes.
Transferability *Does the analysis reach a level of abstraction?*	The findings section of the study employs thematic analysis that goes beyond mere description and instead proposes connections between different themes. As a result, this analysis may resemble the perceptions and experiences of older adults in general practice and could potentially be relevant in various clinical settings, including emergency departments.
Impact and importance *Does the research contribute to, and advance knowledge?*	This research made a valuable contribution to our understanding of how older adults view and navigate online symptom checkers when seeking healthcare in general practice. Additionally, by investigating the effects on the doctor-patient relationship, it shed light on a research area that has been largely neglected.
Impact and importance *Does the researcher make well founded and plausible claims about the significance of findings?*	In the discussion section, the researcher presented sound and credible assertions regarding the importance of the findings, drawing upon current literature and their own expertise in the field.

Table 28: Qualitative research qualitative assessment applied to this study

Appendix 13: Study 3 GP Interviews

Views and attitudes expressed

Positives	Negatives	Neutral
Convenience	Risky	Patient-dependent
The Future	Unreliable	No substitute for humans
Efficient	Limited	It has its place
Faster treatment	Ineffective	
Quick	Cumbersome	
Easy to use	Safety concerns	
Easily accessible	Robotic	
Useful	Slow	
Better than Googling	Not accurate	
Assurance	Infancy	
	Clunky	
	Automated	

Table 29: GP adjectives to describe SC

Perceived Advantages		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
T1	Better manage their own health?			**X**		
T2	Improve the quality of patient care?			**X**		
T3	Help provide more personalised treatment?		**X**			
T4	Reduce travel time to health care provider?				**X**	
T5	Prevent unnecessary visits to health care providers?			**X**		
T6	Disclose more information to symptom checker?		**X**			
T7	Increase patient privacy?			**X**		
T8	Improve access and timeliness to care?			**X**		
T9	May reduce health inequalities for older adults?		**X**			

Perceived Disadvantages		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
T10	Cannot understand or display human emotion?				**X**	
T11	Lacks the intelligence to accurately assess patients?				**X**	
T12	Offers poor health-related advice?			**X**		
T13	Cannot effectively care to the full extent of the patients' needs?				**X**	
T14	Take too much time to use?				**X**	
T15	Older adults will struggle to have the necessary technology?				**X**	
T16	May exacerbate health inequalities for older adults?				**X**	
T17	Concerns about patient data privacy and confidentiality?				**X**	

Table 30: Perceived advantages and disadvantages Likert scale average

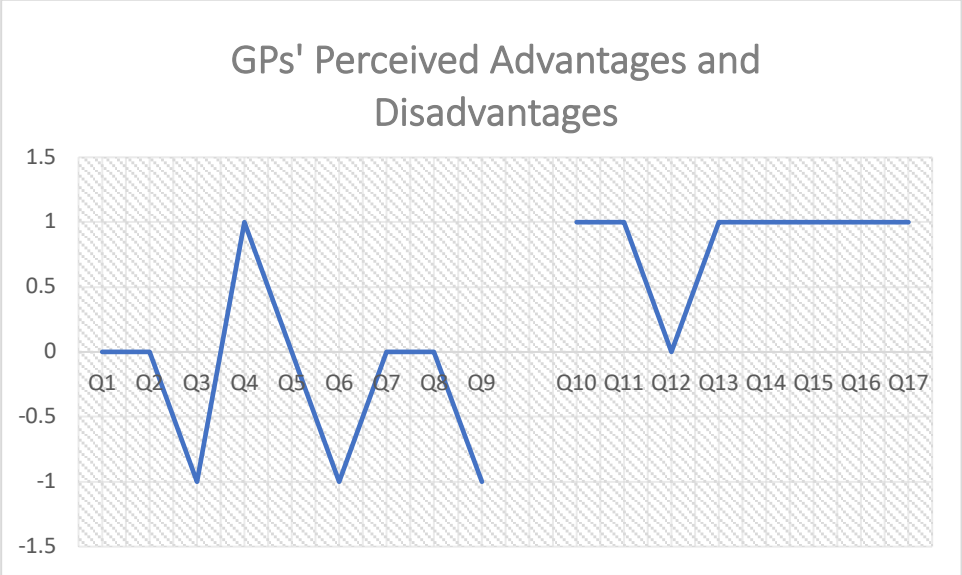


Figure 15: Perceived advantages and disadvantages

Appendix 14: GP Recruitment and Snowballing Technique

Recruiting GPs for study participation is usually considered to be very challenging, even more so shortly after the lifting of the pandemic restrictions whereby GPs were under extreme pressure to deal with the backlog. The first GP was recruited after introduction made by a personal contact. This GP then made referrals to their fellow GP colleagues from their professional network who they thought could satisfy the study eligibility criteria. This continued until number of participants were adequate to reach data saturation.

Thus, majority of the participants were in effect recruited using the snowball sampling technique. The benefit of this is that the researcher had some sort of connection with the participants which made the ice-breaking introductions little easier, but connection was so weak that it had no material impact on what was said in the interviews. Although the interviews were held online using Google Meet, the researcher had to be very flexible with his interview availability. Majority of the interviews were held in the evenings after GPs' work where the interviewees were more relaxed in contrast to those few interviews which were held during the GPs' time-constrained lunch breaks. Several interviews had to be rescheduled which was frustrating but understandable given the busy nature of GP jobs (medical emergencies, surgeries running late etc). Furthermore, many of the participating GPs were also working as locum GPs which involved taking on paid work at short notice which took precedence over unpaid study interviews.

The researcher very much enjoyed all the interview process and made all the interviewees feel at ease with a light-hearted pre-interview chat with emphasis that there were no right or wrong answers. Given the researcher's family member was also a GP, it was relatively easy to relate to the typical working day in the life of a GP and build a rapport.

The interview questions were semi-structured and open ended. Although majority of the interviewees waited for the interview to ask questions before answering, some participants dived into talking about their perceptions and experiences of using online symptom checkers. The researcher had to carefully directed the interview back to a semi-structured format without upsetting the interviewee whilst also taking note of what was being said and asking relevant follow-up questions.

In summary, a heterogenous group of GP participants were interviewed, both male and female, as well as varying age, years of experience and GP positions. Although every interview was in-depth and unique, a semi-structured interview format was followed to maximise the opportunity to understand the perceptions and experiences of this varied group on the use of online symptom checkers in general practice.

Appendix 15: Study 3 quality evaluation

This study was assessed by the standards defined as appropriate for evaluating qualitative research (253,382–384) and the summary of the assessment is presented in the following table:

Sensitivity to context/credibility *Does the researcher show extended engagement with the subject matter/sensitivity to context?*	The researcher conducted a thorough literature and systematic review which demonstrated an in-depth understanding of current research in this area of study. Furthermore, in the method and methodology section, the researcher meticulously considered all the nuances which may affect the quality of the data collection. These, along with other measures undertaken including detailed mitigation strategies, showed researcher's extended engagement with the subject matter and sensitivity to context.
Credibility *Has the researcher reflected on their role in research?*	The researcher, who is regarded as a human instrument of qualitative study and active respondent in the research process, undertook an exercise of reflexivity which explored the role of the researcher in this study and the potential influence on the findings. This was demonstrated both in the methods and discussion section.
Transparency and Coherence/Dependability *Is there a fit between the research questions, the philosophical perspective and the method?*	The researcher considered a range of research methodologies and selected that which met the needs of the research. Justification for this can be found in the methodology section.
Transparency and Coherence/Dependability	There was an audit trail of the research process from the beginning to the finish. For example, the recruitment strategies, data collection process and

Is there an audit trail of the research process?	analysis as well as challenges are explicitly set out in the methods section.
Credibility *Has triangulation been used?*	The results of the study have been compared with the existing findings in the literature to view the research question from a wide range of perspectives. This has been discussed in the discussion section.
Credibility *Has the researcher tried to ascertain whether participants recognise the findings to be true to their experiences?*	Randomly selected participants were forwarded the interview script after transcription of the data and were asked to ascertain whether they recognise the findings to be true from their interview and experiences. In an iterative way, they had an opportunity to influence the development of the findings which are discussed in the methods and discussion section.
Credibility *Is the data collection and analysis complete?*	Data collection was complete (saturation point was reached after 12th GP interview) and has been analysed according to the steps outlined in the methods chapter. Details of data collection and analysis are explained in the methods section.
Transparency and coherence *Is there clarity of presentation of the analysis?*	The results sections were clearly presented with identification of themes and sub-themes using thematic analysis.
Dependability *Has the researcher shown attention to negative cases?*	In the findings section, the researcher made concerted efforts to identify and highlight negative cases including those cases that do not fit typically within the themes.
Transferability *Does the analysis reach a level of abstraction?*	The thematic analysis presented in the findings section does reach a level of abstraction by going beyond description and suggesting relationships between themes, and therefore may be analogous to perceptions and experiences of other HCPs in primary care and

	may be applicable in other clinical settings such as the emergency departments.
Impact and importance *Does the research contribute to, and advance knowledge?*	The researcher demonstrated in the discussion section that this study contributed to the knowledge of GPs' perspectives on the use of online symptom checkers in general practice, and by exploring potential impact on doctor-patient relationship, contributed to an area of research which is vastly underexplored.
Impact and importance *Does the researcher make well founded and plausible claims about the significance of findings?*	In the discussion section, the researcher made well founded and plausible claims about the significance of findings, based upon on the latest literature and researcher's knowledge of the subject area.

Table 31: Qualitative research qualitative assessment applied to this study

Appendix 16: UX ideation workshops itinerary

Workshop 1 itinerary

1. Introduction inc. health and safety — 5 min

2. Icebreaker – 10 min
    - Introduction
    - First job chat

3. Workshop overview — 10 min
    - Aim and objectives - 5 min
    - Q&A – 5 min

4. User experience — 30 min
    - Present summary of findings – 5 min
    - Discussion – 15 min
    - Prioritisation – 5 min
    - Summary – 5 min

5. Break – 10 min

6. Usability 40 min
    - Present summary of findings – 5 min
    - Discussion – 20 min
    - Prioritisation – 10 min
    - Summary – 5 min

7. Wrap up — 5 min

1 hour 50 min total

Extra time will be provided for toilet breaks or request from participants

Workshop 2 itinerary

1. Introduction inc. health and safety — 5 min
2. Icebreaker – 5 min
3. Summary of workshop number 1 — 10 min
    - Summary of findings from W1 - 5 mins

- Discussion and verification – 5 mins

4. Improving implementation in GP Settings— 25 min
    - Present summary of findings – 5 min
    - Discussion – 10 min
    - Prioritisation – 5 min
    - Summary and feedback – 5 min

5. Break – 10 min

6. Improving training and support — 25 min
    - Present summary of findings – 5 min
    - Discussion – 10 min
    - Prioritisation – 5 min
    - Summary and feedback – 5 min

7. Improving awareness and marketing — 25 min
    - Present summary of findings – 5 min
    - Discussion – 10 min
    - Prioritisation – 5 min
    - Summary and feedback – 5 min

8. Wrap up — 5 min

1 hour 50 min total

Extra time will be provided for toilet breaks or request from participants.

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