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THE INFLUENCE OF DIGITAL SELF-CARE INTERVENTIONS ON HEALTH INEQUITY IN HIGH BURDEN CHRONIC HEALTH CONDITIONS

Sophie Turnbull

A dissertation submitted to the University of Bristol in accordance with the requirements for award of the degree of Doctor of Philosophy (PhD) in Bristol Medical School.

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Abstract

Chronic conditions are a considerable burden for patients and health services and have been shown to have social patterning in severity and incidence. Digital interventions have the potential to reduce pressure on health services and reduce health inequities by increasing access to healthcare that can be tailored to the needs of the users. However, there is limited evidence available about the influence of these interventions on health equity. This thesis aimed to explore differences in the use and effectiveness of web-based interventions between groups with different social characteristics in a mixed methods study.

Two systematic reviews were conducted to explore the differences in i) use, and; ii) effectiveness of web-based self-care interventions for high burden chronic conditions between people with different social characteristics. Four physical health conditions were included: asthma, chronic obstructive pulmonary disease, diabetes and osteoarthritis. The reviews indicated that people with lower socioeconomic status may be less likely to use these interventions. For those who did use the interventions, men, minority ethnic groups and those with higher levels of health literacy benefitted more from them. However, there were several major limitations with the methodology and reporting in reviewed studies, which limited the strength of the evidence.

A qualitative interview study was undertaken to establish: how and why people with Type 2 Diabetes (T2D) use web-based self-care technology and how their experiences vary. The study indicated that the internal (knowledge, digital skills) and external (social, financial, status) resources available to people with T2D influenced whether they heard about, could access and use digital interventions. The technology people with T2D had access to and used was influenced by and interacted with their diabetic identity. For those who used these technologies, the interventions supported self-care and influenced the way the person with T2D was viewed by others.

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Author's Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

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Abbreviations

AA	African American
AI/AN	American Indian/Alaska Native
BAME	Black, Asian And Minority Ethnic Groups
BCT	Behavioural Change Technique
BGM	Blood Glucose Monitors
CC	Caucasian
CF	Cystic Fibrosis
CI	Confidence Interval
CINAHL	Cumulative Index To Nursing And Allied Health Literature
CONSORT	Consolidated Standards Of Reporting Trials
COPD	Chronic Obstructive Pulmonary Disease
DTA	Digital Technology Access Model
GP	General Practitioner
GPS	Global Positioning System
HCP	Health Care Practitioners
HIV	Human Immunodeficiency Virus
iBD	Inflammatory Bowel Disease
ICT	Information Computer Technology
IMD	Indices Of Multiple Deprivation
IQR	Interquartile Range
IT	Information Technology
LTC	Long Term Conditions
MESH	Medical Subject Headings
NA	Not Applicable
NHS	National Health System
NICE	National Institute For Health And Care Excellence
OECD	Organisation For Economic Co-Operation And Development
OR	Odds Ratio
PABAK	Prevalence-Adjusted And Bias-Adjusted Kappa
PIS	Participant Information Sheet
PP	Progress Plus
PRISMA	Preferred Reporting Items For Systematic Reviews And Meta-Analysis
QoL	Quality Of Life
RCGP	Royal College Of General Practitioners
RCTs	Randomised Controlled Trials
ROBINS-I	Risk Of Bias In Non-Randomized Studies - Of Interventions
SD	Standard Deviation
SDH	Social Determinants Of Health
SE	Socio-Economic
SES	Socio-Economic Status
SMS	Short Message System
SR	Systematic Review
T1D	Type 1 Diabetes
T2D	Type 2 Diabetes
TPB	Theory Of Planned Behaviour
UK	United Kingdom
USA	United States Of America
WHO	World Health Organisation
YLD	Lost To Disability

CHAPTER 1: INTRODUCTION

1.1. Management of chronic conditions in primary care

The proportion of people living with chronic or Long-Term Conditions(LTCs) is rising in high income countries due to increases in “lifestyle” diseases, an aging population and people living longer with LTCs.(van Oostrom, Gijsen et al. 2016) Around 15 million people in England are living with at least one LTC, with the most common being hypertension, depression, asthma and diabetes.(Department of Health 2012) They place a huge burden on the individual and their family, causing disability and premature death.(Alonso, Ferrer et al. 2004) By their nature, LTCs cause illness over long periods and their management is complex and costly.(Department of Health 2012) Treatment often involves a collaboration between the patient, their families, and associated healthcare services. In the 1990s it was recognised that LTCs were contributing to a growing proportion of costly inpatient care.(Billings, Dixon et al. 2006) Policy makers sought new strategies to improve health outcomes and reduce healthcare expenditure for this group.(Billings, Dixon et al. 2006) Evidence indicated that active management of LTCs resulted in the condition remaining relatively stable and reduced inpatient stays.(Coulter 1995, Billings, Dixon et al. 2006, Coulter, Roberts et al. 2013) This informed subsequent policy which orientated away from episodic management of chronic conditions in secondary care, to active management of LTCs in primary care.(Goodwin, Curry et al. 2010) However, demand on the primary care service increased and the service is struggling to cope with the growing number of people with LTCs.(Epping-Jordan, Pruitt et al. 2004, Østbye, Yarnall et al. 2005, BMA 2016, Iacobucci 2018) This coupled with nearly a decade of underinvestment by governments, has resulted in a crisis in primary care.(BMA 2016)

In Britain, a neoliberal philosophy for healthcare dominates, which espouses individual responsibility.(Galvin 2002, George and Martin 2016, Ellis, Boger et al. 2017) The patient is characterised as autonomous, capable of making decisions and taking actions to support their care.(Galvin 2002) The principles of individualism, the need to find alternative ways to manage LTCs, alongside the healthcare crisis, has resulted in an increase in policy support for self-management by patients with LTCs.(Ellis, Boger et al. 2017) The concept of the self-management of chronic illness was adapted from Lorig’s work from the United States of America (USA), and has been assimilated into United Kingdom (UK) National Health System(NHS) policy.(Lorig, Ritter et al. 2001, Department of Health 2005) In the self-care model, the patient is their own health resource. They are encouraged to be actively involved in their care, with the Health-Care Professional(HCP) sharing ‘power and responsibility’ for the care of their condition.(Barlow, Wright et al. 2002, Coulter, Roberts et al. 2013, Foundation; 2014) It has been argued that self-care transfers responsibility of care for the ill provided by the state to the individual responsibility to stay healthy.(Ayo 2012) The appeal of self-care for healthcare services and policy makers is that it has the potential to slow disease progression without increasing demand on health services (this will be covered in detail in Chapter 2 section 2.2.2).(George and Martin 2016)

1.1.1. Self-care as the prominent medical paradigm

The term self-care has become popular for describing behavioural interventions and the performance of health behaviours, particularly in the context of chronic conditions.(Lorig and Holman 2003) The term self-care encompasses a range of other terms that are commonly used, including self-management and self-help. Self-care is a broad concept and there is currently no agreed upon definition. Barlow et al. (2002, pg. 178) defined self-care being an "individual's ability to manage the symptoms, treatment, physical and psychosocial consequences and lifestyle changes inherent in living with a chronic condition." They suggest that effective self-care is determined by "ability to monitor one's condition and to effect the cognitive, behavioural and emotional responses necessary to maintain a satisfactory quality of life".(Barlow, Wright et al. 2002)

This definition encapsulates the complexity of managing a chronic condition, and the multifaceted nature of self-care. For the person with a chronic condition and their family/carers, the changes to their lives demanded by self-care are widespread and pervasive. In this model, patient self-care is an essential and inevitable part of having a chronic condition.(Lorig and Holman 2003, Jones Martyn, MacGillivray et al. 2011) Self-care requires the patient to take a reflexive approach to their care, which involves self-monitoring of activities and symptoms and is dependent on bodily awareness and self-control.(Giddens 1991) Living with chronic illness involves a series of management activities, such as: self-medication, daily self-monitoring of symptoms and signs, and adaption to new diet and exercise regimes.(Newbould, Taylor et al. 2006, Kennedy, Rogers et al. 2007) Being diagnosed with a chronic illness can be experienced as a disruptive life event.(Bury 1982, Goldman and Maclean 1998)

1.1.2. The treatment of chronic health conditions in the UK

The current care pathway for chronic conditions in the NHS includes, identifying people at risk of developing a condition, managing those at risk to prevent the condition occurring and, manage chronic conditions once people have been diagnosed.(BPAC 2012) The central aim of the management of chronic conditions is to keep the symptoms stable and ensure no further complications occur.(England 2016) Policy guidelines recommend primary care practices provide people with chronic conditions with: routine reviews, medication, evidence-based self-care education and personalised action plans.(NICE 2016) The Department of Health describes three tiers of healthcare delivery for chronic conditions, with decreasing degrees of involvement from healthcare services.(Department of Health 2004, Kennedy, Rogers et al. 2007) The most intensive level is case management for people who have multiple complex conditions and patients have a key worker (usually a nurse) who actively manages and join up care for the individual, with the aim being to avoid hospital admissions.(Department of Health 2004, Department of Health 2005) The middle level is disease management for patients with some risk, where multidisciplinary teams manage care, following agreed primary-care based guidelines and pathways for managing specific diseases, which are often facilitated by financial incentives for the practice (such as Quality and Outcomes Framework).(Department of Health 2004) The third level is estimated to be for 70-80% of patients with chronic conditions and is self-care support for low risk patients.(Department of Health 2004, Kennedy, Rogers et al. 2007) The self-care support is usually delivered by HCP in primary care.

Sometimes group interventions are offered that are facilitated in the community by trained non-medical workers.(Department of Health 2004) The aim of these intervention is to improve skills and confidence of the management of the condition and reduce health service use.(Kennedy, Rogers et al. 2007) Benefits and limitations of community based self-care support will be discussed in Chapter 2 section 2.2.2.

1.2. Social inequalities in health and chronic health conditions

Even in high income countries, people living in constrained conditions and with lower Socio-Economic Status (SES) experience LTCs more commonly and with greater severity than average for the population.(Furler, Harris et al. 2011, Department of Health 2012) These inequalities in health have been attributed to Social Determinants of Health(SDH) and inequity in access to health care.(CSDH 2008) SDH are the complex interacting elements in the physical and social environment that contribute towards disparities in health status. Inequalities in the distribution of good quality healthcare mean that people do not have equal access to treatments that can improve health outcomes. Acting together, SDH mean disadvantaged groups suffer more illness and more severe illness, but are least likely to receive effective treatment which together result in disparities in health outcomes.(WHO 2016)

SDH are arguably responsible for the unfair and avoidable differences in health status found within and between countries.(Marmot, Smith et al. 1991, Pincus, Esther et al. 1998, Wilkinson and Marmot 2003, Woolf and Braveman 2011, WHO 2016) SDH are the social and economic living conditions in which people are born, age, develop, work and live.(WHO 2016) Inequalities in health arise from inequalities in these SDH (living conditions), related to the unequal distribution of the economic and social resources(including power and prestige).(WHO 2016)(Marmot 2007) The Commission on Social Determinants of Health proposed a framework to explain the complex systems that influence health inequalities and the role SDH.(World Health Organization 2010) They propose that economic and political mechanisms influence an individual’s Socio-Economic (SE) position, which results in populations being stratified according to gender, ethnicity, income, occupation, education among other factors.(World Health Organization 2010) The individual’s SE position shapes SDH (the conditions in which they live) and therefore determines an individual’s exposure to health compromising conditions, vulnerability to ill health and consequences of illness.(World Health Organization 2010) Illness can have consequences for an individual’s social position, for example by compromising employment opportunities and the income they have available.(World Health Organization 2010)

People are unlikely to have control over many of the SDH that influence their health outcomes.(Marmot, Atkinson et al. 2010) Common to groups that experience inequities (such as ethnic minorities, people with lower SES and women) is a lack of social, economic and political power.(WHO 2018) For those in a lower SE position it can be more challenging to engage in healthy behaviours; it costs three times the amount to get energy from healthy food than unhealthy food.(Jones, Conklin et al. 2014) Those living in more deprived areas experience greater exposure to health damaging conditions, such as poor sanitation, crime, noise, pollution, heavy traffic and vermin.(Phelan, Link et al. 2010) Whilst having less access to protective factors such as access to good quality education, green spaces to play and exercise, healthy food stores and the best health-care facilities and clinicians.(Phelan, Link et al. 2010)

1.3. Health inequalities and inequities in access to healthcare

Health equality is most often delivered by making sure everyone has access to the same resources, as in the NHS where access to healthcare is universally provided.(Goh 2017) Health inequalities refer to the uneven distribution of health and health resources.(Europe 2009) The term health equity recognises that equal provision is not enough to reduce health disparities particularly where there are historical and social barriers that mean not everyone can make use of the resources available to them.(WHO 2018) Health inequities are the unfair and avoidable differences in health status arising from unfair policies or human failure, resulting in avoidable deaths and illness.(Europe 2009) Inequity is often measured in terms of inequality of health or resources in situations where equality is expected, as in countries where there is universal health coverage (such as the NHS in the UK, or Medicaid in Australia).(Goh 2017) In these countries everyone has equal access to healthcare regardless of SE or cultural background.(Goh 2017) Any difference in access in these groups are the result of cultural exclusion, poor governance.(Rodney and Hill 2014, Goh 2017) For example, there is no reason why women and men should have differences in access to health resources within a country, other than a failure of governance, or prejudice.(Rodney and Hill 2014, Goh 2017) Health inequity can also be created in countries that provide universal access to healthcare such as the UK, where higher income groups also access private healthcare.(Goh 2017)

In addition to the influence of SDH, health disparities are exacerbated by inequity in access to health care services.(WHO 2007) Julian Tudor Hart in 1971 proposed that there was an ‘inverse care law’, which states: those most in need of healthcare were the least likely to receive it, and when they do it is of a lower standard.(Tudor Hart) He suggested that the inverse care law works more strongly when market forces are involved in medical care, and less so when they are not. In market driven systems, provision of healthcare is driven by profit rather than need and therefore provision is greatest where resources to pay for them are highest (i.e. amongst the wealthiest groups). However, there is still evidence of the inverse care law in healthcare systems where financial barriers have largely been removed as in the NHS in the UK.(Rodney and Hill 2014) This suggests there are different drivers involved rather than market forces alone.(Watt 2002)

There is evidence of the inverse care law in primary care within the UK.(Rodney and Hill 2014) These include findings that those living in areas of high SE deprivation have poorer quality services, that are more difficult to access.(Appleby and Deeming 2001) There are generally fewer doctors working in areas of high need such as economically deprived areas and inner cities.(Hutt and Gilmour 2010) System incentives to encourage General Practitioners(GPs) to work in ‘underdoctored’ areas have been unsuccessful.(Appleby and Deeming 2001) GPs in these areas tend to be more stressed due to managing a higher work load and sicker patients, which makes providing good quality consultations challenging. (Mercer and Watt 2007) Additionally, 'better' quality doctors are attracted to live and work in higher SE areas, which increases the quality of care in those areas.(Cartwright and O'Brien 1976) Patients in deprived areas wait longer for appointments, and had more problems to discuss but received shorter less satisfactory consultations.(Mercer and Watt 2007) In contrast, people with a higher SES receive longer consultations where more issues were discussed relative to those with lower SES.(Buchan and Richardson 1973, Cartwright and O'Brien 1976) Studies have indicated people from higher income groups expect and demand more from primary care consultations, which can also result in them receiving higher quality services.(Cartwright and O'Brien 1976)

Despite higher rates of cancer mortality and chronic conditions, rates of screening for cervical and breast cancer and the NHS Health Check are lower in more deprived areas.(Appleby and Deeming 2001, Department of Health 2012, Attwood, Morton et al. 2015) Quality of the treatment for people with chronic conditions in primary care has also been found to be lower in deprived areas, resulting in higher hospital admission rates and primary care visits.(Sallakh, Rodgers et al. 2017)

Equality in the offer of services or effective interventions is not enough to tackle health inequities. (O'Neill, Tabish et al. 2014) Health provision need to be usable, acceptable, effective in, and used by disadvantaged groups. (O'Neill, Tabish et al. 2014, Goh 2017) The use someone can make of a service is influenced by individual decision making, the resources available to them and their social networks.(Moore, Frost et al. 2015) People need to be treated equitably, according to their circumstance. (Dressel 2014) Those who are disadvantaged need to have more support and resources directed to them to ensure they have equal opportunity for good health.(Dressel 2014)

The importance of directing resources to those most in need has been highlighted in recent public health policy. The King's fund made several recommendations to the Clinical Commissioning Groups (now responsible for two thirds of the of the NHS England budget) to improve health outcomes, reduce health inequity and inappropriate hospital admissions for people with LTCs.(Imison, Naylor et al. 2011, NHSCC 2017) They recommended adopting proactive management with a particular focus on self-care, and redirecting resources to patients with the greatest need to "redress the 'inverse care law'". (Imison, Naylor et al. 2011) The World Health Organisation (WHO) and Marmot report laid out key objectives to provide universal coverage of health care for all with proportional intensity that reflects the level of disadvantage(known as proportionate universalism). (WHO 2007, Marmot, Atkinson et al. 2010) But within the current climate of budgetary constraints within the NHS, there are very few resources to redistribute. If they were redistributed this may result in increasing deprivation in other areas.(King's Fund 2015)

Self-care interventions have increasingly become the policy of the NHS- with the underlying assumption that this had the potential to reduce health inequity by providing healthcare where there was none, by encouraging people to be their own health resource.(Imison, Naylor et al. 2011) Patients have been described as the "biggest untapped resource in the NHS".(Health 2005, Imison, Naylor et al. 2011) However, this treatment model is based on the understanding that everyone has the same internal and external resources to self-manage and to make the necessary changes to their lives to maintain their condition.(Ellis, Boger et al. 2017) There is evidence that this is not the case, which will be presented in Chapter 2 section 2.2.4.

1.4. Potential for web-based self-care interventions

The rapid evolution of technology and access to the internet has naturally led to the development of web-based interventions applied to healthcare. Along with self-care, eHealth interventions have been proposed as an approach to address the crisis in healthcare services.(Castle-Clarke 2018) EHealth interventions are beginning to provide a wide range of healthcare services including: decision aids for clinicians, remote access to HCPs, remote monitoring and interventions to support people to self-care.(Turnbull, Redmond et al. 2015, Blair, Turnbull et al. 2017, NHS 2018) This thesis will focus on web-based self-care interventions, which have particular relevance to primary care. The potential benefits of these interventions are that they may offer improved access to care for LTCs, and the potential to improve symptoms while lessening demand through self-care.(Robinson, Patrick et al. 1998)

As with self-care, definitions of eHealth are varied and contested. Broadly, eHealth has been defined as "health services and information delivered or enhanced through the Internet and related technologies".(Eysenbach 2001) This provides a useful definition for the wide range of innovations that provide internet-based healthcare. However, this research focuses on the specific interaction between eHealth and self-care. Not only is the internet and healthcare component important, but the focus on the intervention being self-directed. In this thesis, the definition proposed by Barak et al.(2009) was adopted because it incorporates both web-based and self-care definitions.(Barak, Klein et al. 2009)

> *"a primarily self-guided intervention program that is executed by means of a prescriptive online program operated through a website and used by consumers seeking health- and mental-health related assistance. The intervention program itself attempts to create positive change and or improve/enhance knowledge, awareness, and understanding via the provision of sound health-related material and use of interactive web-based components."*

1.4.1. Implications of web-based self-care interventions for health inequities

There are two opposing arguments about the impact of web-based self-care interventions on health disparities. One view is that they will decrease health inequities by improving access to healthcare. In contrast to the current healthcare available in primary care in the UK where people are contending for appointments with HCPs, these interventions can be an infinitely reusable resource. Supporting an unlimited number of people from a single site to self-manage their condition. Web-based interventions also have the potential to improve usability by tailoring to accommodate different levels of health literacy or cultural specific preferences.(Murray 2012) There is evidence that they can be acceptable and feasible in populations that are traditionally viewed as underserved by health services.(Gustafson, Hawkins et al. 2002, Starren, Hripcsak et al. 2002, Pekmezi, Williams et al. 2010) These interventions may also redress power imbalances between patients and HCPs, by providing access to health information that was previously only available to clinicians.(Murray 2012)

On the other side of the argument, concerns have been raised about the ‘digital divide’ and how this may impact health equity. The digital divide refers to the gap between those who do have access to digital technology and those who do not.(Stellefson, Chaney et al. 2008) Those with lower levels of access to the internet in high income countries have historically been people from remote, rural or economically deprived areas, from minority ethnic groups or those with developmental disabilities, those with lower income and from lower SE groups.(Stellefson, Chaney et al. 2008) However, it has been suggested the digital divide in terms of access to the internet is narrowing across SE and cultural groups.(Stellefson, Chaney et al. 2008) In large part this has been due to increased Smartphone ownership and the reduction in the cost of technology.(Stellefson, Chaney et al. 2008, Stellefson, Chaney et al. 2013, Poushter 2016, Latulippe, Hamel et al. 2017) This is being reflected in studies of web-based interventions that have found access to the internet was not a barrier to use of online interventions in disadvantaged populations.(Safran 2003) However, the ability to connect to the internet alone is not sufficient to ensure equity in utilisation of technology. An individual must also be able to use the information that they access.(Stellefson, Chaney et al. 2008) It has been argued that the term ‘digital divide’ has now transitioned from issues around access to issues with usability.(Stellefson, Chaney et al. 2008) Internet health information has been found to be variable in quality, challenging to navigate and most is currently developed for those with higher school or greater reading ability.(Berland, Elliott et al. 2001, Gilmour 2007) Where interventions are developed for a cultural or ethnic majority and do not offer cultural tailoring, they may be less useful and effective for people from minority groups.(Pinnock, Parke et al. 2017) For example, by not accounting for religious or cultural dietary practices, or by not providing the intervention in the primary language of the minority group.(Pinnock, Parke et al. 2017) Therefore, even while access may no longer be a barrier, web-based self-care interventions have the potential to exacerbates health inequalities through design that is inaccessible for those with lower levels of education and literacy.

1.5. Summary and aims of the thesis

Chronic conditions are a considerable burden to patients and health services, and have been shown to have social patterning in severity and incidence.(Lewis and Dixon 2004, WHO 2004, Marmot 2007, Goodwin, Curry et al. 2010, Department of Health 2012) The complex needs of these conditions over sustained periods coupled with the increasing demand on primary and secondary health care services and staff, has meant that the development and promotion of self-care interventions has become a core strategy for the NHS.(Goodwin, Curry et al. 2010) The rapid evolution of technology and internet use has led to the development of web-based self-care interventions applied to healthcare. From a health services perspective, these web-based interventions have the benefit of being relatively low cost and could potentially reduce health inequality by increasing access to health care interventions. However, there is limited evidence available about the influence of eHealth interventions on health equity, and poor usability may create new barriers to healthcare access.

This research aimed to explore differences in the use and effectiveness of web-based interventions between groups with different social characteristics and why this may be occurring. The conditions of interest were four physical health conditions asthma, chronic obstructive pulmonary disease, diabetes and osteoarthritis.

1.6. Research questions

1.6.1. Primary research questions

1) Is there a difference in the use of web-based behavioural change interventions for the self-care of high burden chronic health conditions across SE and cultural groups?
2) For those who do use the intervention is there a difference in the effectiveness of web-based behavioural change interventions for the self-care of high burden chronic health conditions across SE and cultural groups?
3) What are the possible causes of differences in use or effectiveness by SE and cultural groups in study settings?
4) How and why do people with type 2 diabetes use web-based self-care technology and how their experiences vary?

1.6.2. Secondary research questions

1) Do studies adequately report modification of intervention use and effectiveness by participant characteristics?
2) Can differences in intervention effectiveness for different SE and cultural groups be attributed to the application of theory or behavioural change techniques (BCTs) to intervention design?

1.7. Choice of methods and epistemological position

To address the four primary research questions, it was necessary to adopt a mixed methods approach. Mixed methods research has been defined as a class of research where the researcher combines quantitative and qualitative research methods, concepts or approaches in a single study.(Johnson and Onwuegbuzie 2004, Bowers, Cohen et al. 2013) The decision to combine quantitative and qualitative methods was based on the philosophy of the pragmatic method or maxim.(Brewer and Hunter 1989, Johnson and Onwuegbuzie 2004) The pragmatic method is based on a practical, outcome-driven method of approaching research questions, where qualitative research is considered to be appropriate in some situations, and quantitative research is more appropriate in others. This approach acknowledged that both methodologies have their issues, and posits that insights and procedures from qualitative and quantitative approaches can be combined to create a ‘superior product’.(Johnson and Onwuegbuzie 2004)

For this project two systematic reviews were conducted to address primary research questions 1-3. These questions follow a positivist position of using quantitative research to uncover evidence of social trends.(Guba and Lincoln 1994, Broom and Willis 2007) This research aimed to establish whether there was any evidence of inequalities in use and effectiveness of web-based interventions and whether differences could be attributed to a particular cause.(Broom and Willis 2007) Qualitative methods were best placed to investigate primary question four. This question follows the interpretivist position-that individual experience is socially constructed, and that reality is multiple and relative.(Broom and Willis 2007) This methodology allowed the explorations of complex social systems involved in health behaviours. The two pieces of research when taken together explore the relationship between any inequity in use or effectiveness of web-based interventions and the subjective experiences of the people who use them.

The systematic review and qualitative project were conducted in parallel, with the systematic review beginning in advance of the qualitative study. The findings from the systematic review fed into the design and research questions addressed in the qualitative study. The abundance of available web-based interventions for T2D found relative to the other targeted health conditions guided the decision to focus on T2D in the qualitative project. The systematic review highlighted an absence of investigation into why there may be differences in web-based intervention use. The findings from the two studies and the four results sections were synthesised using the van Dijk’s model of Digital Technology Access in Chapter 8, to enrich the research and allow for a contextualised interpretation of the research questions.(Barbour 1999, O’Cathain, Murphy et al. 2010, Van Dijk 2012)

1.8. Structure of the thesis

An overview of the thesis structure is provided in Figure 1. Because the thesis includes two systematic reviews and a qualitative study which have quite different research approaches, the review of literature and methods are presented separately for these two approaches. The study is brought together as a whole in chapter 8, where findings are synthesised using existing theoretical models of behaviour change and the digital divide.

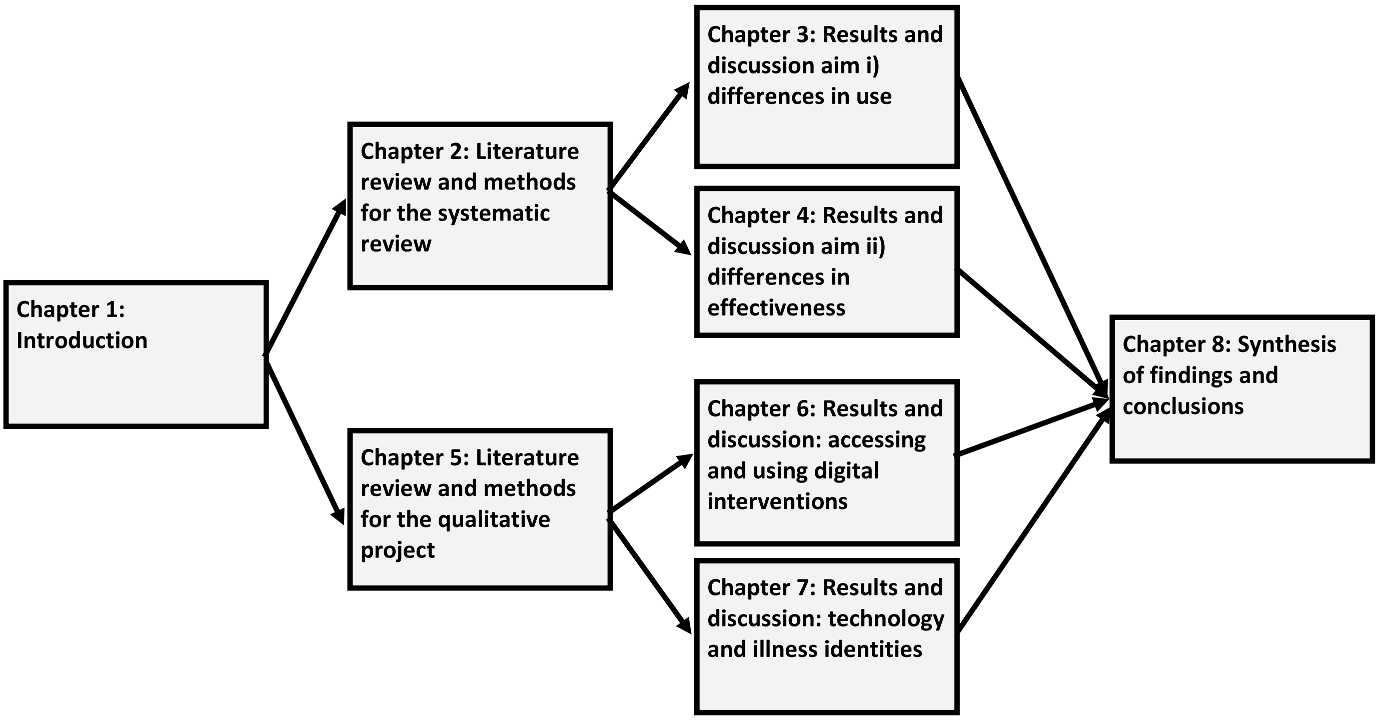


Figure 1: Thesis structure

Chapter 2: presents a review of the existing literature about the effectiveness and use of web-based self-care interventions for LTCs and discusses the extent to which interventions impact may vary between people with different social characteristics. The gaps in knowledge are highlighted, and the systematic review methods are presented. This chapter provides the background and methods for both chapters 3 and 4.

Chapter 3: presents the results and discussion for the systematic review for primary research questions 1) and 3) establishing whether there was a difference in the use of web-based behavioural change interventions for the self-care of chronic conditions in different SE and cultural groups in the study context. Possible reasons for differences in use were sought from the included publication where provided.

Chapter 4: presents the results and discussion for the systematic review for primary research questions 2) and 3) establishing whether web-based behavioural change intervention for the self-care of four physical high burden chronic conditions, are equally as effective for people in different social characteristics in the study context. Exploring whether any differences in effectiveness for people with different characteristics was the result of difference in the application of theory, behavioural change techniques, intervention or study design or intervention use.

Chapter 5: presents a review of the qualitative literature relevant to primary research question 4) how and why people with chronic conditions use web-based self-care technology and how their experiences vary. The methods for the qualitative study will also be presented.

Chapter 6: includes the results and discussion for the qualitative study, focussing on the experiences of accessing and using web-based for people with T2D with different characteristics.

Chapter 7: presents the results and discussion for the qualitative study, focussing on the role of technology in constructions of illness identities for people with T2D.

Chapter 8: is a synthesis of the overall findings from this thesis and concludes with recommendations for future web-based self-care intervention development, research and policy.

CHAPTER 2. LITERATURE REVIEW AND METHODS FOR THE SYSTEMATIC REVIEWS

2.1. Chapter overview

This chapter presents the literature review, rationale for condition selection and methods for the systematic reviews that address the following research questions:

Primary research question 1: *Is there a difference in the use of web-based behavioural change interventions for the self-care of high burden chronic health conditions across SE and cultural groups?*

Primary research question 2: *For those who do use the intervention is there a difference in the effectiveness of web-based behavioural change interventions for the self-care of high burden chronic health conditions across SE and cultural groups?*

> ***Secondary research question 2a:*** *Can differences in intervention effectiveness for different socio-economic and cultural groups be attributed to the application of theory or behavioural change techniques to intervention design?*

Primary research question 3: *What are the possible causes of differences in use or effectiveness by SE and cultural groups in study settings*

Therefore, the review focuses on literature exploring self-care as the prominent medical paradigm and literature relevant to these four research questions.

2.2. Literature review

2.2.1. Introduction

The prevalence of chronic conditions such as diabetes are increasing in high income countries and they have a great impact on the individual's quality of life, resulting in disability and premature death.(Alonso, Ferrer et al. 2004) There is a social gradient to chronic illness, whereby people with lower socio-economic status (SES) experience both a higher incidence and greater severity of chronic disease than average for the population.(Furler, Harris et al. 2011, Department of Health 2012) Health disparities are exacerbated by inequities in access to healthcare.(WHO 2007) In the UK, chronic conditions are usually managed in primary care. Primary care practices are struggling with increasing demand on services partly driven by increasing numbers of people with chronic conditions. (Epping-Jordan, Pruitt et al. 2004, Østbye, Yarnall et al. 2005, BMA 2016, Iacobucci 2018)

Two key approaches have emerged to address this gap in care for those with chronic illness, these are: an increased focus on self-care by patients, and the development of eHealth interventions.

Non-digital self-care interventions in the form of community-based training courses, have been found to improve health status, health behaviours and the quality of life of patients with chronic conditions.(Lorig, Sobel et al. 1999, Barlow, Wright et al. 2002, Bodenheimer, Lorig et al. 2002, Chodosh, Morton et al. 2005, Franek 2013) There is also some evidence that they reduce health care use.(Lorig, Sobel et al. 1999, Panagioti, Richardson et al. 2014) However, there is some evidence that there are barriers to accessing non-digital self-care interventions for disadvantaged groups.(Furler, Harris et al. 2011) These include the high levels of health literacy often needed to understand the training materials as well as language barriers where the training is only conducted in English.(Furler, Harris et al. 2011) Concurrently, eHealth has been proposed to improve quality of care and relieve pressure on healthcare services by increasing access to healthcare.(Murray 2012) More recently, combination of the two approaches, in the form of web-based self-care interventions has been adopted.(Murray 2012)

There are two theories about how web-based self-care interventions will contribute to health inequalities. They may reduce inequity by increasing access to healthcare by supporting an almost unlimited number of people from the same site, and by tailoring interventions to individual needs.(Gustafson, Hawkins et al. 2002, Starren, Hripcsak et al. 2002, Safran 2003, Pekmezi, Williams et al. 2010) Conversely they may increase inequity, where access and usability for disadvantaged groups remain barriers.(Stellefson, Chaney et al. 2008, Latulippe, Hamel et al. 2017) This literature review explores whether people from different social groups are more or less likely to use or benefit from web-based self-care behavioural-change interventions. This includes the role of behavioural-change theory and behavioural-change techniques (BCTs) in intervention development, and how this might contribute to differences in effectiveness across Socio-Economic (SE) and cultural groups.

2.2.2. Self-care, self-care interventions and health inequalities

Benefits of self-care interventions to health services and patients

Self-care is framed as beneficial for patients and health services, by concurrently improving health outcomes and reducing demand on services.(Barlow, Wright et al. 2002) From a patient perspective, when compared to usual care, self-care programmes have been found to provide short-term benefits for health outcomes, knowledge, and self-efficacy.(Barlow, Wright et al. 2002, Chodosh, Morton et al. 2005) From the health service perspective, there is some evidence that self-care programmes reduce health care use and translate into cost savings and reductions elsewhere in the health care system.(Lorig, Sobel et al. 1999, Groessl and Cronan 2000, Stearns, Bernard et al. 2000, Panagioti, Richardson et al. 2014)

Implications of self-care for health inequalities

The self-care model of chronic illness management champions individual responsibility.(Galvin 2002) It presumes an individual has both power and accountability to change the factors that affect their health.(Moore, Frost et al. 2015) Self-care is often framed as empowering to patients.(Goodwin, Curry et al. 2010) However, the concept that patients need empowering is problematic, as it places the agency on the health providers to hand over power, and characterises the patients as impotent.(Gomersall, Madill et al. 2011) Patients are provided with information about their condition that was traditionally held by the HCP and are given more control over their treatment decisions.(Moore, Frost et al. 2015) But as a trade-off for greater involvement in their care, the patient is expected to 'accept responsibility for their choices' by adhering to treatment programmes and by changing their lifestyle.(Department of Health 2010)

The model of individual responsibility neglects the importance of inequalities and the impact of the context in which people live.(Gomersall, Madill et al. 2011, Moore, Frost et al. 2015) The financial and social resources a person has at their disposal impact their ability to self-manage and to control their condition.(Link and Phelan 1995, Broom and Whittaker 2004, Phelan, Link et al. 2004, Phelan, Link et al. 2010) Those who have higher levels of education, have financial security and are socially connected, are better able to adapt to the lifestyle changes expected of those managing chronic conditions.(Moore, Frost et al. 2015) While those living in more constrained conditions have fewer resources available to them to help them control their lives generally as well as their condition.(Link and Phelan 1995, Phelan, Link et al. 2004, Phelan, Link et al. 2010) The implicit assumption in the self-care model is that a person has agency to control their symptoms. (Broom and Whittaker 2004, Gomersall, Madill et al. 2011, Ellis, Boger et al. 2017) This can increase health disparities between those who have the resources to exert control over their condition and those without.(Ellis, Boger et al. 2017) Additionally, those who are not successfully self-managing and need support from health services are breaking the unwritten contract of neoliberal societies.(Salzinger 2016) In this, a good citizen is self-sufficient and avoids taking from the state.(Salzinger 2016) This can result in a person being classified as the "undeserving sick", and can affect resources they are offered from health services and social networks in the future.(Ellis, Boger et al. 2017)

Equity in the use and usability of self-care programmes

There is evidence of issues with access and engagement with non-digital self-care education programmes for people with lower SES and across regional areas.(Pacaud, Kelley et al. 2012, Kennedy, Bower et al. 2013) The most disadvantaged groups are the least likely to access self-care programmes and there is lower provision in rural areas compared with urban areas.(Furler, Harris et al. 2011, Jaglal, Haroun et al. 2013) Participants who attend these programmes are more likely to be from majority ethnic groups, with high levels of income and education, and are not representative of the wider population of people with chronic conditions.(Eakin, Bull et al. 2002, Protheroe, Nutbeam et al. 2009, Jowsey, Gillespie et al. 2010, Furler, Harris et al. 2011, Kennedy, Bower et al. 2013) People from low income, underserved and ethnic minority groups have greater barriers attending these group-based meetings in the community, which include: transportation issues, limited financial resources and lack of childcare options.(Lasco, Curry et al. 1989, Luepker, Murray et al. 1994, Kong 1997, Litrownik, Elder et al. 2000) Self-management educational materials have also been found to be less accessible to people from more deprived groups due to issues with: health literacy levels and language barriers.(Jowsey, Gillespie et al. 2010, Furler, Harris et al. 2011)

Systematic reviews have found mixed evidence for the effectiveness of non-web behavioural-change interventions in disadvantaged groups.(Michie, Jochelson et al. 2009, Schaffler, Leung et al. 2018) Schaffler et al. (2018) assessed a wide range of outcomes(e.g. physiological, behavioural, knowledge, psychosocial) in adults with chronic physical health conditions.(Schaffler, Leung et al. 2018) But found only self-efficacy and disease specific quality of life were improved by the intervention for people with chronic conditions from low-income or low health literacy.(Schaffler, Leung et al. 2018) Michie et al.'s (2009) systematic review had mixed findings in adults, but overall reported that behavioural-change interventions can be effective in reducing smoking or increase physical activity and/or healthy eating in low income groups. Nine included interventions had positive effects, seven resulted in no change and one had an adverse effect.(Michie, Jochelson et al. 2009) A review of the self-management interventions for children and adults with asthma found that the interventions could improve markers of control and quality of life, and reduce interaction with primary and secondary care services, across a range of socio-demographic and cultural groups.(Pinnock, Parke et al. 2017) The authors also found evidence that interventions were more effective when they were culturally tailored to targeted groups.(Pinnock, Parke et al. 2017) The main limitation of the three reviews is that they cannot provide evidence into whether these interventions have an equalising effect, only that they can be effective in disadvantaged groups.

2.2.3. Behaviour change in the self-care of chronic conditions

What is meant by behaviour change?

International research has demonstrated that unhealthy lifestyles are implicated in the development of chronic illness, along with adverse social or physical environments.(WHO 2018) Lifestyle issues such as prolonged unhealthy nutrition, physical inactivity, tobacco and alcohol use, and psychological stress all increase the risk of Long Term Conditions(LTCs).(Newsom, Huguet et al. 2012) Consequently, the adoption of healthy behaviours is a central strategy for the prevention and treatment of LTCs.(Newsom, Huguet et al. 2012) Following the diagnosis of LTCs, behaviour change can reduce illness severity, increase functioning, and extend longevity.(Ronnevik, Gundersen et al. 1985, Williamson, Thompson et al. 2000, Aldana, Whitmer et al. 2003) Behavioural-change interventions can be defined as 'coordinated sets of activities designed to change specified behaviour patterns'.(Michie, van Stralen et al. 2011) Self-care is a popular term for describing these interventions in the context of the provision of support for people with LTCs to self-direct the change of unhealthy behaviours.(Lorig and Holman 2003)

Behavioural-change theories and behavioural change techniques

Evidence of the effectiveness of behavioural-change self-care interventions has been mixed under trial conditions. (Campbell, Murray et al. 2007, Michie and Johnston 2012) The designs of these interventions are often complex and are built up of a number of components that act independently as well as interacting.(Services and Board 2000, Campbell, Murray et al. 2007) To understand why and how the interventions are effective(or not) is essential to establish the causal processes and mechanisms underlying the behavioural-change.(Michie and Abraham 2004)

Historically, theory and the mechanisms of change were not always considered in intervention development or adequately described in research papers.(Michie, Fixsen et al. 2009, Morrison, Wyke et al. 2014) To address this issue, the Medical Research Council proposed a framework for the development and evaluation of complex interventions.(Campbell, Fitzpatrick et al. 2000, Services and Board 2000, Campbell, Murray et al. 2007) The framework indicated health intervention development should go through a ‘theory’ stage and a ‘modelling’ stage, followed by evaluation in a trial setting.(Services and Board 2000, Campbell, Murray et al. 2007, Michie, Johnston et al. 2008) In the theory stage, relevant background evidence is collected and a theoretical basis for the intervention is generated. In the next stage, the theoretical basis is ‘modelled’. This involves hypothesising and testing of which behavioural determinants to target and what Behavioural-Change Techniques(BCTs) should be used to change these determinants.(Michie, Johnston et al. 2008)

The role of theory and behavioural-change techniques in intervention development

Inconsistency in the application of theory to the development of the eHealth interventions is thought to contribute to the variability in the effectiveness of behavioural-change interventions.(Michie 2008, Webb, Joseph et al. 2010) Theory provides an understanding of the causal determinants of behaviour and theoretical mechanisms for change.(Michie, Johnston et al. 2008) Behavioural-change interventions are considered to have more potential to be effective if they target these determinants.(Michie, Johnston et al. 2008)There is evidence that having A theoretical basis to an intervention makes it more likely to be effective.(Dombrowski, Sniehotta et al. 2012, Taylor, Conner et al. 2012) However, whether a theory is applied is not the only consideration, how the theory has been applied also matters. Interventions that used theory more extensively have been associated with larger effect sizes for behavioural outcomes than interventions using less or no theory.(Rothman 2004, Marteau, Dieppe et al. 2006, Webb, Joseph et al. 2010)

It is also important to select the theory appropriate for the type of intervention, the target population and context in which they live.(Campbell, Murray et al. 2007) Webb et al.’s (2010) systematic review found that three behavioural theories were most often applied to the development of web-based self-care interventions: social cognitive theory; transtheoretical model; and, Theory of Planned Behaviour (TPB).(Webb, Joseph et al. 2010) The use of TPB in intervention development has been found to result in substantially larger effects than interventions that applied other behavioural theories or no theory.(Webb, Joseph et al. 2010) The effect sizes produced by interventions utilising TPB were small to medium, which is similar to those reported in reviews of non-web-based intervention using TPB.(Webb, Joseph et al. 2010) However, the theories of individual behaviour change that are often applied to the development of behaviour change interventions tend to emphasise individual motivation and capabilities, and often do not sufficiently consider the SE context.(Davis, Campbell et al. 2015) It is possible that these theories can support self-care and behavioural-change across the general population of people with chronic conditions, but because they underestimate the importance of SE context may not support disadvantaged groups. This will be discussed in section 2.1.3.

Michie et al. (2008) noted that there was little guidance how to operationalise theory when developing interventions, or how to change the identified behavioural determinants of health outcomes.(Michie, Johnston et al. 2008) Therefore, teams developing these interventions have been left to interpret the theory and select appropriate BCTs to alter the targeted behaviours.(Michie, Abraham et al. 2011) BCTs are the techniques used in interventions to change targeted behaviours.(Michie, Abraham et al. 2011) They are often referred to as the active ingredient in behavioural interventions.(Michie and Johnston 2012) The evidence base is limited as to which BCTs are likely to improve the performance of behavioural-change tools.(Michie, Fixsen et al. 2009) In the context of web-based interventions supporting the self-care of chronic conditions, one review found that there were two BCTs that were associated with the most substantial change in behaviour: i) stress management; and ii) general communications skills training.(Webb, Joseph et al. 2010) Although the authors noted that these BCTs were used in relatively few interventions.(Webb, Joseph et al. 2010) This and a second systematic reviews also noted that larger effect sizes were associated with interventions applying a larger number of BCTs.(Webb, Joseph et al. 2010, Aalbers, Baars et al. 2011) The authors of one review postulated that this could be because a greater number of techniques were available to address different aspects of the behavioural-change process, or different facets of the condition.(Webb, Joseph et al. 2010)

2.2.4. Health equity in the uptake and effectiveness of web-based self-care behavioural-change interventions

Relevant theory

Web-based self-care interventions have the potential to decrease health inequity by improving the quality of care, health outcomes and by increasing access to interventions.(Murray, Burns et al. 2005) However, this is dependent on people from disadvantaged groups using the interventions and deriving equal or greater benefit from them in comparison to more advantaged groups. The theory of fundamental causes (Link and Phelan 1995) provides the background of how available resources influence health inequity and theories of the digital divide describes the relationship between resources, access to and use of technology.

Link and Phelan (1995) proposed the theory of fundamental causes to explain why associations between Socio-Economic Status(SES) and mortality continued, despite significant improvements in living standards and provision of healthcare.(Link and Phelan 1995, Phelan, Link et al. 2004, Phelan, Link et al. 2010) They noted that social inequalities in health persisted under conditions that were designed to eliminate them, such as universal provision of healthcare by the NHS in the UK.(Link and

Phelan 1995, Phelan, Link et al. 2004, Phelan, Link et al. 2010) They asserted that health disparities were perpetuated through differences in access to resources that “can be used to avoid risks or to minimize the consequences of disease once it occurs”.(Phelan, Link et al. 2010) The resources include: financial resources, status, power, advantageous social connections, and knowledge.(Link and Phelan 1995, Phelan, Link et al. 2004, Phelan, Link et al. 2010) They cite an example of heart disease, where a person with greater resources has more opportunities to maintain a heart-healthy lifestyle and have access the best medical treatment.(Phelan, Link et al. 2010)

They proposed that the resources can be individual or societal. At the individual level, resources shape individual health behaviours by influencing whether people “know about, have access to, can afford, and receive social support for their efforts to engage in health enhancing or health-protective behaviours”.(Phelan, Link et al. 2010) In the physical and social context, resources available also influence access to healthy environments. For example, people with higher income are able to buy property in high SES neighbourhoods that have lower risk profiles and higher protective factors.(Phelan, Link et al. 2010) Risk profiles are influenced by factors such as levels of crime, noise, pollution, traffic and vermin.(Phelan, Link et al. 2010) Protective factors include access to the best health-care facilities, parks and healthy food stores.(Phelan, Link et al. 2010) In the high SES neighbourhood, where neighbours are also of high status, together influence is exerted to ensure risk profiles are minimised and protective factors are optimised.(Phelan, Link et al. 2010) The individual’s SES impacts access to both individual and community resources.(Phelan, Link et al. 2010) Web-based self-care interventions have the potential to create an equalising effect at both levels. At the individual level they can provide access to knowledge about minimising the consequence of disease after it occurs. At the contextual level, these interventions also address issues of unequal access healthcare by increasing availability of healthcare and removing costs of seeking healthcare (such as travel expenses and loss of earnings). However, this depends on people with lower SES being able to access and use the web-interventions.

Theories of the digital divide provide insight into how disparities in available resources may also influence inequalities in the access and use of the internet and digital technologies.(Yu 2006) One of the most influential theories of the digital divide is Van Dijk's Model of ‘Digital Technology Access’.(van Dijk 2005) In the theory, van Dijk (2005) proposed that there was a feedback loop where: inequalities in social position and characteristics result in inequalities in resources, which influence inequalities in access to technology, and lead to disparities in the individual ability to participate in society, and finally participation in the digital technologies influences social position.(Pick and Sarkar 2016) Therefore inequalities are perpetuated through the process of accessing and using technology, where unequal access to technology results from inequalities and creates inequalities.(Pick and Sarkar 2016) The model also differentiates between unequal motivation, material capability to access technology, skills to use the technology and differences in usage (e.g. frequency of use, number and diversity of applications of technology).(van Dijk 2005) Therefore, it not only considers differences in the physical access to the internet and digital technology, but also inequalities in skills that limit the ability for people to make use of the internet where they have access.(van Dijk 2005, van Deursen and van Dijk 2010) This has implications for web-based self-care health interventions, where people from a more deprived backgrounds, with fewer resources may not be able to access these health interventions (differences in access), or may be less able to use the interventions if they do have access (differences is usability). This would result in these interventions exacerbating health inequalities through people in more privileged social positions having greater access to these interventions and being better able to make better use of them.

Present evidence of differences in the use of web-based health interventions

Use of eHealth

There is some evidence that people from lower SES and those of older age have challenges accessing health information online. A study analysing four cycles (2011–2014) of the Health Information National Trends Survey(USA) and a literature review of factors that influence public engagement with eHealth both found that older people (median), those with lower SES and those with lower levels of internet skills were less likely to use eHealth services (e.g. health information seeking and appointment booking services online).(Hardiker and Grant 2011, Jacobs, Amuta et al. 2017) Issues in the design of online health information combined with lower levels of internet skills limit the usability of digital interventions for people of lower SES and older age.(Berland, Elliott et al. 2001, Rogers 2003, Gilmour 2007, van Deursen and van Dijk 2010) Internet health information has been found to be variable in quality, challenging to navigate and are mostly developed for those with higher school or greater reading ability.(Berland, Elliott et al. 2001, Gilmour 2007) Educational attainment has been found to be the strongest predictor of internet competence in four key internet skills: operational/basic skills (gaining access), formal skills (navigation and orientation), information skills(users try to fulfil their information needs), and strategic skills (capacity to use the internet to achieve goals).(van Deursen and van Dijk 2010) Older adults have been found to have lower levels of operational and formal internet skills compared to younger participants, but have no issues with information or strategic skills.(van Deursen and van Dijk 2010) Therefore, it is possible that issues with usability will also prevent of some groups from using web-based self-care interventions.

Differences in the use of web-based self-care interventions

Studies of web-based interventions have found that many people drop out of studies before study completion or stop using the intervention.(Eysenbach 2005) Higher use of web-based interventions has been associated with greater improvements in behavioural and clinical outcomes in chronic conditions.(Stellefson, Chaney et al. 2013) But there has been insufficient investigation of what characteristics distinguish high users from moderate, low and non-users.

Two recent systematic reviews have revealed a mixed picture of the characteristics associated with use of web-based behavioural-change interventions among adults with chronic and psychological conditions.(Beatty and Binnion 2016, Perski, Blandford et al. 2017) Both reviews found that women were more likely to engage with the interventions.(Beatty and Binnion 2016, Perski, Blandford et al. 2017) Perski et al.'s (2017) large (n=117 studies) review of web-based interventions for chronic conditions reported associations between age, gender, education, employment and ethnicity and engagement.(Perski, Blandford et al. 2017) The authors stated that there was a positive trend between engagement and being female, of older age, and of higher educational attainment.(Perski, Blandford et al. 2017) However, they did not draw firm conclusions about the size or direction of influence as no meta-analysis was conducted.(Perski, Blandford et al. 2017) Beatty et al.'s (2016) review (n=37 studies) of the number of people who adhered (defined as the amount of an intervention that an individual engaged with or completed) with psychological interventions in adults, reported mixed findings for age; with just over half indicating older people had better adherence and the rest suggesting younger people adhered more to the intervention.(Beatty and Binnion 2016) They did not find evidence of an association between adherence and ethnicity, education, employment, marital status or geographic region.(Beatty and Binnion 2016)

When taken together the picture is currently inconsistent, but there is some indication that there may be unequal access or usability of web-based interventions for chronic conditions. This has implications for health inequalities, if high users receive greatest benefit from interventions, then those with lower SES who may be less likely to have access to or make use of interventions will be disadvantaged.

Evidence of the equalising effects of behavioural-change web-based interventions

There is currently some evidence that web-based interventions designed specifically to support disadvantaged groups can equally benefit more and less advantaged groups. (Gustafson, Hawkins et al. 2002, Murray, Burns et al. 2005, Muller, Rowsell et al. 2017) For example, a web-based intervention designed to be accessible for those people with Type 2 Diabetes (T2D) and of lower health literacy were found to equally beneficial for those of lower and higher health literacy in terms of health literacy, behavioural and psychosocial outcomes.(Muller, Rowsell et al. 2017) There is also evidence that these interventions can reduce inequalities, where they are more effective in more deprived groups.(Gustafson, Hawkins et al. 2002, Murray, Burns et al. 2005) A study of a computer-based intervention for women with breast cancer (CHESS) reported that women from minority ethnic groups, with lower education and absence of insurance benefitted more from the intervention than the more advantaged group of women.(Gustafson, Hawkins et al. 2002, Murray, Burns et al. 2005) A systematic review investigated the effectiveness of web-based self-care interventions for older adults with chronic conditions. Stellefson et al. (2013) concluded that in this potentially disadvantaged population, use of these technologies was associated with improvements in self-efficacy, behavioural and clinical outcomes. (Stellefson, Chaney et al. 2013) However, they reported issues with recruitment of the samples in the reviewed studies as they mostly consisted of highly educated, white patients and people with lower SES and of low literacy were underrepresented.(Stellefson, Chaney et al. 2013) Therefore the study populations were not representative of the wider populations of older people with chronic conditions, which limits the generalisability of the results.(Stellefson, Chaney et al. 2013)

There is some indication that these interventions can benefit people from traditionally underserved groups. However, there is currently no systematic evidence exploring whether there is an interaction between social characteristics and web-based self-care intervention effectiveness. As such, there is no systematic evidence indicating whether these interventions might produce equal benefits across groups (not exacerbating inequalities), if disadvantaged groups may benefit more (creating an equalising effect), or disadvantaged groups might benefit less (exacerbating inequalities).

Potential mechanisms that may cause inequities in benefits of web-based behavioural-change interventions

The previous section has discussed the potential for inaccessible design of online health information to reduce use, which in turn may reduce the benefits disadvantaged groups can get from web health interventions. Here, the contribution of the chosen theory and BCTs in intervention development to equity in benefits from web-based interventions will be considered.

Application of theory and BCTs to web-based self-care intervention design and the influence on health inequities

To this author's knowledge, there has been no investigation undertaken to link theories or BCTs applied in behavioural-change interventions to equalities in effectiveness of web-based self-care interventions. However, Michie et al.'s (2009) review explored whether the application of theory and BCTs influenced the effectiveness of non-web behavioural-change interventions aimed at reducing smoking, unhealthy eating, or increasing physical activity in low income groups.(Michie, Jochelson et al. 2009) The authors reported that there was no clear pattern found between the theory used to develop the intervention and intervention effectiveness in the studies of low income groups. (Michie, Jochelson et al. 2009) They suggested that the lack of association may have been related to the dataset being too small for formal analysis, and issues with lack of detail of how theory was applied in designing the intervention.(Michie, Jochelson et al. 2009)

Michie et al. (2009) reported that none of the study teams explained how theory influenced selection of BCTs.(Michie, Jochelson et al. 2009) They also found no obvious difference in BCTs selected in the interventions that used theory compared to those that did not.(Michie, Jochelson et al. 2009) Due to heterogeneity in the application of BCTs across the studies they did not explore the contribution of individual BCTs, instead the authors compared the number of BCTs used in interventions that were effective and ineffective in low income groups.(Michie, Jochelson et al. 2009) Michie et al. (2009) found effective interventions for low income groups tended to have fewer BCTs then the interventions that were ineffective.(Michie, Jochelson et al. 2009) This is opposite to two previous reviews of web-based interventions not focussed on low income groups, that found larger effect sizes were associated with the use of more BCTs rather than fewer(discussed in section 2.2.3).(Webb, Joseph et al. 2010, Aalbers, Baars et al. 2011) Michie et al.(2009) suggested that there may be greater variation in the quality of the intervention delivery as the number of BCTs increase, increasing the possibility of inconsistent effects.(Michie, Jochelson et al. 2009) The team also suggested that the most common BCTs, providing information, prompting barrier identification, and facilitating goal setting may be helpful for low-income groups.(Michie, Jochelson et al. 2009)

It might be expected that interventions that are developed using theory that considers the social context and resources available to people, would find no evidence of a difference in effectiveness between social groups. Also, that BCTs selected influenced by these theories may also have an equalising effect. However, there is currently no systematic evidence investigating these concepts. There is also no investigation as to whether the application of theories of individual behavioural-change and BCTs result in inequities in benefits from web-based interventions for people from different SE and cultural groups

2.2.5. Summary and gaps in evidence and research questions

Web-based interventions have the potential to decrease health inequity by improving the quality of care, health outcomes and by increasing access to health-care.(Murray, Burns et al. 2005) There is evidence that people from disadvantaged groups and older adults are less likely to seek out health information online and have problems using the online information available.(van Dijk 2005, Gilmour 2007, Brouwer, Oenema et al. 2010, van Deursen and van Dijk 2010, Hardiker and Grant 2011, Kontos, Blake et al. 2014, Nölke, Mensing et al. 2015, Jacobs, Amuta et al. 2017) The systematic review evidence regarding the social characteristics that are associated with the use of web-based behavioural-change interventions is mixed.(Beatty and Binnion 2016, Perski, Blandford et al. 2017) Although, there is some indication people with chronic conditions from disadvantaged populations may be less likely to use these interventions.(Perski, Blandford et al. 2017) There is presently some evidence that web-based interventions designed specifically for those from underserved and disadvantaged groups can benefit these populations.(Gustafson, Hawkins et al. 2002, Murray, Burns et al. 2005, Muller, Rowsell et al. 2017) However, there is an paucity of systematic review evidence investigating whether interventions designed for a whole population of people with chronic conditions are equally used, and effective for people with different social characteristics. There is also an absence of evidence about the mechanisms that may result in unequal benefit from the interventions, including differences in use, variation in application of theory and BCTs to intervention design.

2.3. Methods

Two systematic reviews were conducted with a common methodology to answer the following research questions:

Primary research question 1*: Is there a difference in the use of web-based behavioural change interventions for the self-care of high burden chronic health conditions across SE and cultural groups?*

Primary research question 2*: For those who do use the intervention is there a difference in the effectiveness of web-based behavioural change interventions for the self-care of high burden chronic health conditions across SE and cultural groups?*

> Secondary research question 2a: *Can differences in intervention effectiveness for different socio-economic and cultural groups be attributed to the application of theory or behavioural change techniques to intervention design?*

Primary research question 3*: What are the possible causes of differences in use or effectiveness by SE and cultural groups in study settings.*

The systematic review exploring the differences in use aimed to answer primary research questions 1 and 3, the results and discussion are presented in Chapter 3. The systematic review exploring differences in effectiveness aimed to answer primary research questions 2 and 3, and secondary research question 2a, the results and discussion are presented in Chapter 4.

The methodology for the systematic reviews adhered to the Cochrane review guidelines(Henderson, Craig et al. 2010) and the reviews were reported using the PRISMA-Equity 2012 extension checklist was to ensure transparency of reporting.(Welch, Petticrew et al. 2012) Systematic review methodology was selected to answer these research questions because the evidence base was mixed, and it was necessary to critically appraise and synthesise relevant primary research to provide a consistent overview of the available evidence. This secondary research informed the primary research study presented in chapters 5-7.

A common protocol was used for both reviews, which was published on PROSPERO (https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=56163).

The use systematic review included meta-analysis where the data allowed. In the effectiveness systematic review, the possibility of meta-analysis was explored but not included due to heterogeneity of outcomes.

2.3.1. Searching

A comprehensive search strategy was employed to ensure all relevant studies were identified. Strategies used in previous reviews of web-based self-care interventions for chronic conditions informed the search strategy for this review. A preliminary scoping search exploring terms for web, health conditions, self-care or behavioural-change and terms for social determinants of health indicated very few studies consistently mentioned social determinant terms in the title or abstract. Therefore, terms for social determinants of health were not included in the search strategy. The final search strategy included terms for web, health conditions and self-care or behavioural-change. For each database, Medline thesaurus Medical Subject Headings (MESH) terms and additional key words were developed and refined iteratively. The search results were checked for known relevant Randomised Controlled Trials (RCTs) to test the validity of the search strategy. If they were not identified, the title, abstract and MESH terms were further refined. The search strategy was then sent to the University of Bristol medical library staff for review and the feedback was used to refine the terms further. The final search strategies are available in Appendix 2.3.

The databases searched were: OVID search (Medline, AMED (Allied and Complimentary Medicine), Embase, PsycInfo), Cumulative Index to Nursing and Allied Health Literature (CINAHL). There was no language restriction. The publication dates were limited from 1st January 2006 to 1st January 2016 to ensure the review included interventions with recent technology.

2.3.2. Inclusion/ Exclusion criteria

Population

Selection of high burden chronic health conditions

Included health conditions: asthma, diabetes mellitus, osteoarthritis, Chronic Obstructive Pulmonary Disease (COPD) /Chronic respiratory disease

Excluded health conditions: substance use disorders, unipolar depressive disorders

Six chronic health conditions were identified of potential interest for this systematic review using data of disease burden provided by WHO, Royal College of General Practitioners (RCGP) and Organisation for Economic Co-operation and Development (OECD). The dimensions considered were the global incidence, prevalence, and burden of disease measured by Years of life Lost to Disability (YLD) in high income countries (Appendix 2.2). The six conditions were asthma, diabetes mellitus, osteoarthritis, unipolar depressive disorders, substance use disorders (including alcohol use and other drug subgroups), and COPD/Chronic respiratory disease. All six cause considerable burden and disability to patients (WHO 2004) and health services, (Lewis and Dixon 2004, Goodwin, Curry et al. 2010) and have been shown to have social patterning in severity and incidence.(Marmot 2007, Department of Health 2012) Furthermore, all six have the potential for symptoms, severity and prognosis to be improved by changes to behaviour such as diet or physical activity.

The number of included conditions was further refined due to the high number of studies included at the data extraction stage (n=123 across both systematic reviews) covering the six health conditions. Therefore, the pragmatic decision was made to focus on the four physical health conditions. Several criteria were considered when deciding how to narrow the focus of the review, these included: level of burden of the health condition, novelty (few systematic reviews have targeted these conditions) and abundance of evidence. Theory was also considered, exploring: a) which conditions had a social gradient, and; b) where web-based self-care interventions could make the biggest difference to the health condition. Physical conditions were chosen as they fulfilled several of the criteria:

i) Novelty: there were few reviews of asthma, COPD and osteoarthritis
ii) Abundance of evidence: there were are a high number of studies focussing on diabetes
iii) Theoretically:
    a. Where the health condition has a social gradient: There is evidence of a social patterning in incidence of T2D across different SE and cultural groups. Including the clinically important sex and gender differences, mediated by psychosocial factors.(Kautzky-Willer, Harreiter et al. 2016)
    b. Where web-based self-care interventions have the potential to make biggest difference: Both asthma and diabetes involve a wide range of self-care activities that could be aided by a web-based behavioural-change intervention.

Four high burden physical health conditions were included: asthma, diabetes mellitus (Type 1 and Type 2), osteoarthritis (interventions targeting pain management were pulled for full paper screening to check for the explicit mention of osteoarthritis) and COPD.

Intervention

Included interventions: those that aimed to improve symptoms or prognosis. Delivered using computers, smartphones, handheld devices and other devices that allow access to the internet. Smartphone apps were included due to internet linkage. Static and interactive websites, chat rooms and forums are all included. In terms of the self-care element, human supported interventions were included if the intervention was predominantly reliant on the individual bringing about self-change without intensive contact with a therapist or clinician.

Excluded interventions: those that aimed to prevent the condition. Interventions without any web-based components. Short Message Service (SMS) interventions alone were not included unless a web element was mentioned. Interventions were excluded if they were aimed at carers of the person with the condition or if the intervention only offered remote care from a clinician without any web-based self-managed components.

Study types

Included study type: Randomised Controlled Trials (RCTs), observational studies, quasi-experimental designs, feasibility and pilot studies. Feasibility and pilot studies were included due to the difficulty with definitions of what constitutes these types of studies. Many studies mentioned that they are exploring the efficacy and feasibility of the intervention, but not that this was going to influence further development or the design of a full trial.

Excluded study type: protocol papers or those describing the development of an intervention but not evaluating it, qualitative studies, magazine articles or editorials, and systematic reviews.

Systematic review outcomes

Systematic review exploring differences in use:

Included outcomes: Studies were included that assessed the use of online elements of the intervention using any measure. These included self-report, system logs (time on the intervention, use of different elements of the intervention, frequency of logging into the intervention) types of users retrospectively generated from user logs, including binary (e.g. frequent users vs non-frequent users) and categorical (e.g. Low, medium and high users) variables.

Studies were included where the study teams had conducted analysis that explored differences in use by social characteristic, and the independent contribution of the social characteristic could be determined. Where estimates were not provided, a binary yes or no was accepted regarding the contribution of the social characteristic on differences in the outcome. This was because an association could be made between the category and the outcome (use or effectiveness) in these data, and the aims of the systematic reviews could be addressed.

Excluded data: differences in use between social characteristics were not reported, or where differences were reported in aggregate and the independent contribution of the social characteristic could not be determined.

Systematic review exploring differences in effectiveness:

Included outcomes: those that were believed to be associated with improved management of symptoms or prognosis of the target conditions:

1. Health outcomes- observed improvement in disease symptoms using standard clinical tools (e.g. blood glucose)
2. Behavioural outcomes- for example increase in activity levels using step count
3. Knowledge outcomes- increased knowledge of their condition
4. Psychosocial outcomes- where there are multiple presented with an association with SE or cultural categories are presented self-efficacy takes precedence

Quality of Life (QoL) was categorised as a health or psychosocial outcome depending on the content of the QoL tool. Where there was a balance of a greater health or disability questions in relation to psychosocial, the tool was classified as a health outcome. Where there is a greater balance of psychosocial questions, it was classified as a psychosocial outcome.

The types of data analysis involving social characteristics were grouped into standardised subcategories to allow for comparison. For the effectiveness systematic review, the types of analysis included fell into two categories, where they had: i) controlled for the social characteristic in the outcome analysis, and ii) explored whether the social characteristic had modified the effectiveness intervention on the outcome. Studies were the independent contribution of the PP category could be determined.

Excluded data: differences in effectiveness between social characteristics were not reported, or where the independent contribution of the social characteristic could not be determined.

Defining social determinants that contribute to unequal health status with PROGRESS-Plus

The PROGRESS-Plus framework was used in this systematic review to support the identification of social characteristic or social determinants of health that could contribute towards health inequalities in the included health conditions and in the context of internet interventions. PROGRESS is a framework developed by Evans and Brown (2003) to identify social determinants and factors that contribute to unequal health opportunities and outcomes.(Evans and Brown 2003) PROGRESS refers to place of residence (rural/urban/inner city), race/ethnicity/culture/language, occupation, gender/sex, religion, education, SES, and social capital.(Evans and Brown 2003) Recently the Cochrane Equity group have added the 'Plus' extension to the framework and adapted what was included in the PROGRESS element to include other elements that contribute to health inequities. The updated model is known as PROGRESS-Plus(PP).(Kavanagh, Oliver et al. 2008, O'Neill, Tabish et al. 2014) The Plus extension included all Socio Economic Position(SEP)(e.g. SEP income related, plus occupation, education, and elements of place of residence), age, disability, sexual orientation, and other vulnerable groups. They also adapted the terminology from the original PROGRESS framework by removing 'race' from race/ethnicity to highlight that the relevance of this category is socio-cultural as opposed to biological.(Kavanagh, Oliver et al. 2008)

The PP framework was selected for use in this thesis to support reporting because it was endorsed by the Campbell and Cochrane Collaborations, who recommended its use in the reporting guidelines for equity-focussed systematic reviews.(Welch, Petticrew et al. 2012) The Campbell and Cochrane collaboration is known internationally as a reputable source for policy due to their rigorous methods and transparent approach to research.(Tugwell, Maxwell et al. 2008) The framework is comprehensive and the components were selected based on evidence of their potential contribution to health inequities.(O'Neill, Tabish et al. 2014)

Included outcomes: Studies were included if they reported at least one of the PP categories that the study team had thought could possibly lead to health inequalities in relation to the included health conditions and in the context of internet interventions, these included:

- Gender
- Ethnicity
- Neighbourhood (e.g. urban/rural)
- Housing tenure
- Education
- Occupation
- Income- including indicators of low income such as free school lunches, Medicaid enrolment in studies based in the USA
- Family structure- e.g. lone parent families
- Age
- Sexuality
- Disability
- Health literacy
- Measures of SES (e.g. Indices of Multiple Deprivation(IMD))

Unpublished data

Authors were contacted:

i) Where the contribution of the PP categories had been reported collectively, to establish the independent contribution of each PP category.

ii) Where estimates had not been provided, the unpublished model was requested, where possible. Where unpublished data were available estimates and a measurement of uncertainty were requested.

For the second systematic review only:

iii) Where authors had conducted analysis exploring associations between PP and outcome, to establish whether they had *also* conducted analysis exploring whether intervention effect was modified by PP categories, but not published in the paper.

2.3.3. Article screening and selection

Title and abstract screening

The title and abstracts of the studies found by the search strategy from all databases were downloaded into EndNote to ensure that all the original studies were captured and saved in one location. The studies were de-duplicated in Endnote using the de-duping feature. All the remaining studies were transferred into the ACCESS database for review. For this review, a two-stage screening process was undertaken. This was informed by the preliminary scoping review, that had indicated that few studies consistently mentioned PP terms in the title or abstract. Therefore, at the abstract screening stage all of the studies were reviewed by the lead author and compared with the inclusion and exclusion criteria *only* relating to condition, intervention, study type and outcome. In-line with previous practice where a large number of studies were located, partial double screening with checks for accuracy were used.(Lucas, Cabral et al. 2015) In this case a random 10% sample of the abstracts and titles were screened by a second reviewer to check for agreement. Prevalence and Bias Adjusted Kappa (PABAK) was used to check for agreement between the reviewers because Kappa has been found to have limitations. Feinstein and Cicchetti(1989) discussed the 'Kappa Concordance Agreement Paradox' which explain that k is sensitive to the distribution of marginal totals in the table which limits its usefulness. (Feinstein and Cicchetti 1989) As the Kappa statistic is affected by both prevalence and bias PABAK has been proposed to overcome these issues.(Byrt, Bishop et al. 1993) Disagreement was resolved by discussion between the two reviewers, consensus was reached on all papers. The full texts were ordered where the studies met the inclusion criteria of condition, intervention study type and outcome. If only the conference abstract was publicly available, the corresponding author was contacted to requested full study details. If the reviewer could not find the contact details or full papers were not available, abstracts were excluded. Where it was unclear from title or abstract if the paper met the inclusion criteria, the full paper was pulled, for example 'mobile phone based, mobile technology, interactive multimedia, interactive media, virtual environments' which could involve apps with internet connectivity or phone calls, the full paper was pulled. At full screening stage, the papers were double-checked to ensure they met the above screening criteria and to establish whether they met the inclusion criteria for PP categories and available data.(Kavanagh, Oliver et al. 2008, O'Neill, Tabish et al. 2014)

2.3.4. Data extraction

Data were extracted into an ACCESS database designed based on the Cochrane data extraction and Assessment template.(Cochrane 2016) This provided the source data for the results section of the systematic reviews.

Risk of bias (quality) assessment

The Cochrane Collaboration Risk of Bias tool was used to assess the quality of RCT studies. This covered sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting and other biases.(Higgins, Altman et al. 2011) The Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) tool was used to assess the quality of non-RCT studies these included bias due to: confounding, selection of participants, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes and selection of reported result.(Sterne, Hernán et al. 2016) Using the tool, the studies were given an overall risk of bias rating, which was used to indicate the study quality.

2.3.5. Data analysis and synthesis

Descriptive tables were populated using the data from the ACCESS database, accompanied by a narrative synthesis presenting details of: study design, main results and an assessment of study quality. Meta-analysis was conducted in the case of a common outcomes and PP category.

A novel summary figure was developed for these systematic reviews, which was based on an adapted version of the Harvest plot, referred to here as the 'Adapted Harvest plot'. Summary figures were used in the absence of complete reporting of effect sizes by study authors. The Harvest plot was developed to provide a compact graphical overview of systematic review data in the context of social inequalities in smoking, where the use of meta-analysis and a Forest plot was not possible.(Ogilvie, Fayter et al. 2008) The Harvest plot has the benefits of displaying complex issues around the social determinants of health, but does not provide a measure of the strength of evidence. The Adapted Harvest plot allows for a direct comparison of the sample size of the studies where the effect was found (or not found), and an impression of the quality of the study through the risk of bias. In the absence of estimates, this gives an indication of the strength of the findings from each study, and across the studies. For example, the strength of evidence from two small studies of high-risk findings a positive association between older age and intervention use, is weaker than in two large low risk studies finding no association.

A key explaining the features and representation of the Adapted Harvest Plot is in Table 1, and information is provided in each plot. The data are presented in separate figures for each PP characteristic. The direction of the association between the PP category and intervention effectiveness or use are presented as three categories: positive (favours PP group e.g. older participants), no effect and negative (favours comparator group e.g. younger participants). To be inclusive, all reported trends (p<0.10) were included as evidence regardless of whether they fell under the standard <0.05 probability cut off. Therefore, an association was reported when p<0.10. Where the reported association was a trend not reaching the p<0.05 threshold but was p<0.10, this was highlighted in the text.

The studies are stacked on top of each other in the direction of effect category (positive, negative, no effect) depending on the evidence for that PP characteristic. The stack size represents the individual study sample size. The total size of the bar in any direction of effect category, is the combined sample size of all the studies that found evidence in that direction. The colour of each stack relates to the overall RoB. For the RCTs low is blue, red is purple, and grey is unclear. For the non-RCTs the colours correspond with the ROBINs-I assessment of bias where blue is low, yellow is moderate, orange is serious, and purple is critical. The pattern of the stack indicates whether the study is an RCT (solid colour) or a non-RCT (dot pattern). The numbers within the stacks correspond with the study ID, which is available in tables in the appendices of each chapter.

Table 1: Key to the Adapted Harvest plot

Feature	**Representation**
Direction of effect category	Positive- Favours PP group (p<0.10) No effect- study found no evidence of an effect (p≥0.10) Negative- favours the comparator group (p>0.10)
Stack height	Study size
Stack colour	Risk of bias assessment RCT studies: Low risk- blue, high risk- purple, unclear- grey Non-RCT studies: Low risk-blue, Moderate risk- yellow, Serious-orange, Critical-purple, Not enough information- Grey
Stack pattern	RCT studies: solid colours Non-RCTs: patterned with dots
Number within the stack	Study ID
Bar size	Total number of participants in the studies finding evidence of a positive association, no effect or a negative association with the outcome

2.3.6. Analysis of subgroups or subsets

For the second systematic review, mechanisms creating differences in benefits obtained from interventions across PP groups were explored. There were no agreed systematic methods for linking theory or BCTs to mechanisms of action of intervention. Therefore, for the subgroup analysis of the application of the theory to intervention development, theory was categorised by whether the authors had used single or multiple theories. Patterns were investigated between the use of single or multiple theories against the findings that some PP groups benefitted more, less or no evidence from the intervention. Studies drawing on behavioural theories that considered the social context were also compared against those focussing on individual behaviour. This was done to investigate whether the theories considering context prevent inequalities in benefits from these interventions or provide additional benefits for disadvantaged groups.

Michie et al. (2013) undertook extensive work to categorise BCTs used in behaviour change interventions and to create a consensually agreed hierarchically structured taxonomy of

BCTs.(Michie, Richardson et al. 2013) In BCT Taxonomy V1 93 BCTs were clustered into 16 groups. This Taxonomy is useful for providing standardised definitions of BCTs and for considering the higher-level groups they belong to. However, there is no guidance on how to operationalise these groupings in research. Therefore, for this review the BCTs as described by the authors were grouped into similar BCTs and given a standardised description, to provide consistent categorisation of BCTs and allow for comparison of BCTs applied across studies. These were then categorised into the 16 highest clustered groups presented in the taxonomy of BCTs.(Michie, Richardson et al. 2013) The lower level BCT definitions were not used because it was challenging to match the BCTs to the 93 categories proposed in the Taxonomy. In addition, the comparison of this number of categories was also unlikely to yield any meaningful results, considering the number of papers included in the systematic review. The BCTs were then mapped to the presence or absence of a differences in intervention effectiveness for people with different PP characteristics. Associations were sought between the application of different BCTs and finding of unequal benefits from intervention use for people with different PP characteristics.

CHAPTER 3. SYSTEMATIC REVIEW AND META-ANALYSIS RESULTS AND DISCUSSION 1: DIFFERENCES IN USE

3.1. Chapter overview

This chapter presents the results and discussion for the systematic review, exploring differences in the use of web-based interventions for the self-care of high burden chronic conditions by people with different social characteristics. Of the research questions outlined in Chapter 1 (Section 1.5), this review was designed to address the following primary research questions:

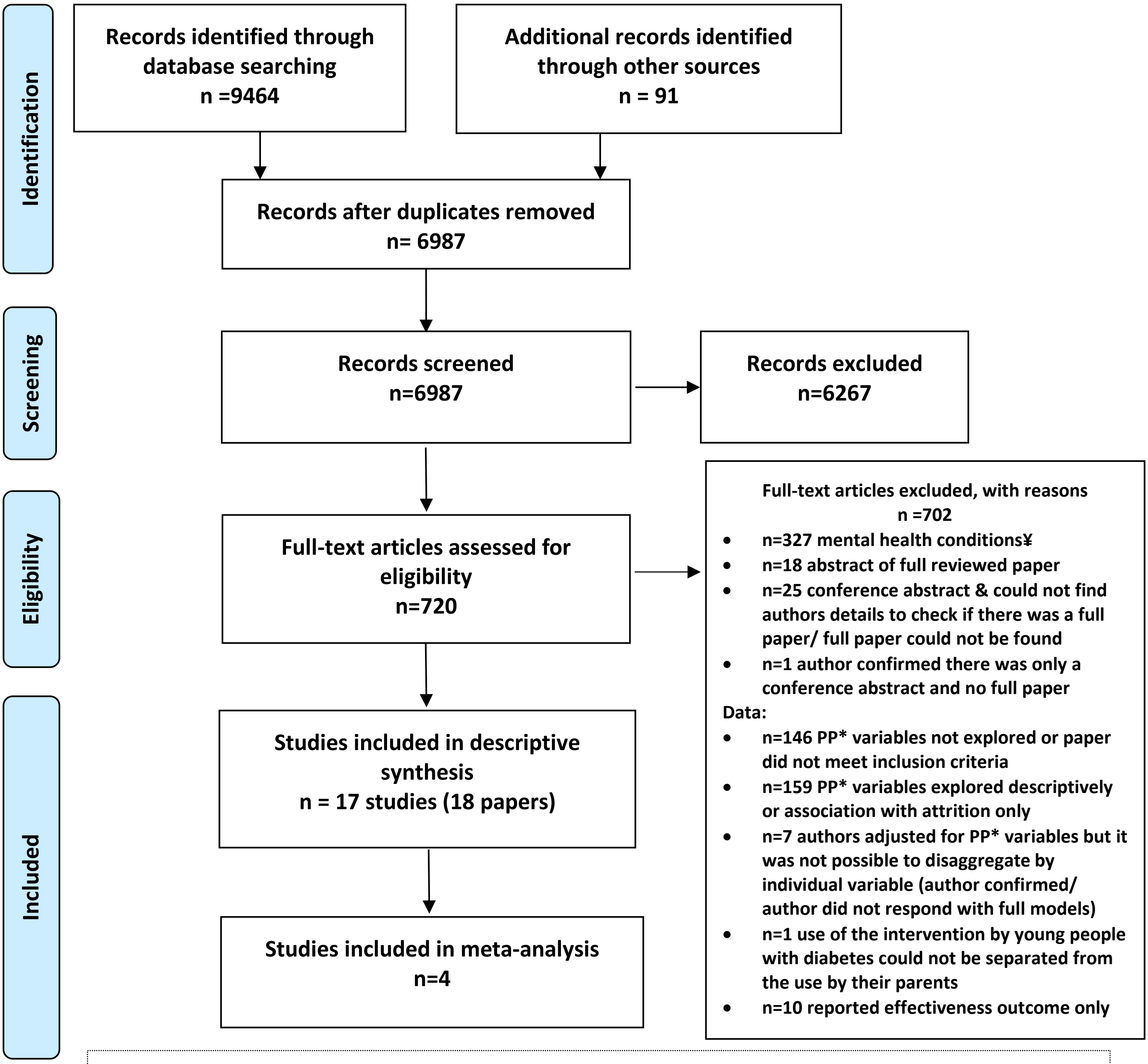
1) Is there a difference in the use of web-based behavioural change interventions for the self-care of high burden chronic health conditions across SE and cultural groups?

3) Why there may be any differences in use or effectiveness by socio-economic and cultural groups.

3.2. Results

3.2.1. Selection of studies

The PRISMA flowchart (Figure 2) gives an overview of the selection procedure. Four physical health conditions were included in the search: asthma, COPD, diabetes (Type 1 Diabetes (T1D) and Type 2 Diabetes (T2D)) and osteoarthritis. Following removal of duplicates, 6987 records were identified. Following screening based on title, abstract, 6267 articles were removed, with 10% assessed by two reviewers. The inter-reviewer agreement was 87.5% and the Prevalence and Bias Adjusted Kappa for the reviewers was 0.75 indicating good agreement, with a prevalence index of 0.74 and a bias index of -0.09.[4] Of the 720 full texts screened, 695 were excluded. Reasons for exclusion are available in Figure 2 and include 88 papers that addressed wed-based intervention engagement for depression and substance use. Table 12 (Appendix 3.1) outlines the papers that met the inclusion criteria but the analysis of interest was not presented, the data could not be disaggregated by PP group or where the paper could not be located. The table also provides details of steps taken to obtain the disaggregated data. Ultimately, 18 articles fulfilled the criteria representing 17 studies and two of the four target health conditions: diabetes (T1D and T2D) and osteoarthritis.



Full-text articles excluded, with reasons
n =702

- **n=327 mental health conditions¥**
- **n=18 abstract of full reviewed paper**
- **n=25 conference abstract & could not find authors details to check if there was a full paper/ full paper could not be found**
- **n=1 author confirmed there was only a conference abstract and no full paper**

Data:

- **n=146 PP* variables not explored or paper did not meet inclusion criteria**
- **n=159 PP* variables explored descriptively or association with attrition only**
- **n=7 authors adjusted for PP* variables but it was not possible to disaggregate by individual variable (author confirmed/ author did not respond with full models)**
- **n=1 use of the intervention by young people with diabetes could not be separated from the use by their parents**
- **n=10 reported effectiveness outcome only**

Footnote:
¥= The mental health conditions were excluded post hoc
*= PP(PROGRESS-Plus)

Figure 2:

3.2.2. Descriptions of included studies

Detailed information about the characteristic of included studies are provided in Table 2. Of the seventeen included studies, sixteen (reported across 17 publications) assessed use of diabetes interventions and 1 study assessed use of an osteoarthritis intervention.

Table 2: Characteristics of included studies and populations

Study ID, Author, year of publication,	**Study design**	**Study details (health condition, setting, location)**	**Study sample size**	**Inclusion and exclusion criteria**	**PROGRESS-Plus categories explored**	**Main outcome targeted by intervention**	**Measure of intervention use**
Diabetes							
ID 1, Case, 2014	This was a secondary analysis of a large (N=761) RCT(Lorig, Ritter et al. 2010) Details provided are from the main trial	T2D, Recruitment was largely via the Internet, print /broadcast media were also utilized. Special efforts were made to recruit AI/AN participants using websites and media associated with tribal and AI/AN organizations. USA	45	**Inclusion**: Aged ≥18 years, Physician-verified T2D, Had access to the Internet. **Exclusion**: Pregnant or in care for cancer	**Ethnicity**	**Health**: HbA1c, fewer symptoms **Behaviour**: Exercise **Psychosocial**: Self-efficacy	Messages left on the online bulletin board (forum), number and content
ID 2, Glasgow, 2011 ID 2a, Glasgow, 2014	RCT	T2D, Primary care clinics (selected based on variability in size, location, and SES, and to maximize percentage of Latino patients), USA	270	**Inclusion**: 25–75 years, T2 D diagnosed Body mass index > 25 and at least one other risk factor for heart disease, Access to telephone Internet, Read and write in English or Spanish, Able to perform mild to moderate physical activity.	**2)** **Ethnicity** **Education** **Health literacy** **2a)** **Age** **Gender** **Ethnicity** **Education** **Health literacy** **Numeracy** **Income**	**Health**: Blood pressure **Behavioural**: Behavioural change (overall behavioural change): eating habits, fat intake, physical activity & medical adherence **Psychosocial**: Self-efficacy	2a) 5 summary use variables i) Total number of visits; ii) participants that visited weekly; iii) total time spent on the website (minutes); iv) Self-monitoring (% of participants that tracked ≥1/week); v) Total number of action plans completed 2) People who had engaged with the intervention

Study ID, Author, year of publication,	**Study design**	**Study details (health condition, setting, location)**	**Study sample size**	**Inclusion and exclusion criteria**	**PROGRESS-Plus categories explored**	**Main outcome targeted by intervention**	**Measure of intervention use**
							≥1/month vs <1/month
ID 3, Goh, 2015	Not explicitly described but appears to be a single arm pre-post intervention study.	T2D, Primary care setting, Singapore	84	**Inclusion**: >21 years of age, T2D, ownership of smartphone on Apple iOS or Android platform, able to understand and use the iDAT app. **Exclusion**: Significant physical and/or cognitive impairment, T1D, Pregnant, Prior use of iDAT app, Not comfortable using apps, Could not understand English	**Age** **Gender**	**Behavioural**: Diet and Exercise	Category of user of the intervention (Minimal, intermittent-waning, and consistent)
ID 4, Heinrich, 2012	RCT	T2D, Conducted online. Participants recruited through a diabetes magazine, local flyering and via two websites, Netherlands	Not clearly given but looks like 166. n=135 used in analysis	**Inclusion**: Aged 40–70 years T2D **Exclusion**: Already used the intervention	**Age** **Gender** **Education**	**Knowledge**: Diabetes knowledge	Time spent on the website
ID 5, Holmen, 2014	RCT	T2D	164	**Inclusion**: ≥18 years,	**Age** **Gender**	**Health**: Change in HbA1c	Substantial users vs non-substantial users

Study ID, Author, year of publication,	Study design	Study details (health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	PROGRESS-Plus categories explored	Main outcome targeted by intervention	Measure of intervention use
		Participants were from the Northern and South-eastern part of Norway, no further details on setting provided		HbA1c level ≥7.1% (54.1 mmol/mol), Competent in Norwegian language, Cognitively able to participate, Able to use the system and devices provided, prior familiarity with mobile phones was not necessary.	**Education**		*Substantial user= performed ≥5 blood glucose measurements each of the ≥6 months and had ≥50 interactions in the parts of the diary*
ID 6, Huang, 2014	RCT	Chronic Illness (Inflammatory bowel disease (IBD), cystic fibrosis (CF), and T1D), Tertiary care paediatric academic medical centre, USA	81	**Inclusion**: 12-22 years, Patients with IBD, CF, or T1D, Without cognitive impairment	**Age**	**Health**: Disease status **Behavioural**: Self-management, **Psychosocial**: Self-efficacy	SMS use
ID 7, Lau, 2014	Retrospective observational study	T1D & T2D Vancouver, British Columbia, in a university/hospital/private practice setting BCDiabetes, Canada	157	**Inclusion:** ≥18 years, T1D/T2D	**Age** **Gender**	**Health:** HbA1c	Ever logged on (logged in ≥1 times) vs never logged on
ID 8, Lee, 2007	Two arm quasi-experimental study that used control groups and pre-tests	T2D, Metabolism Centre at Taipei Medical University Wanfang Hospital, Taiwan	274	**Inclusion**: No age specified, T2D, No severe complications affecting the patients' ability to follow physician's orders,	**Age** **Education**	**Health:** HbA1c **Knowledge**: Diabetes knowledge	Number of logins

Study ID, Author, year of publication,	Study design	Study details (health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	PROGRESS-Plus categories explored	Main outcome targeted by intervention	Measure of intervention use
				Had 'normal' level of consciousness, Could read/communicate with spoken language, Internet access			
ID 9, McCarrier, 2009	Pilot RCT	T2D, Diabetes Care Centre(DCC), a subspecialty clinic near the University of Washington Medical Centre, USA	78	**Inclusion:** 21-49 years, T1D ≥2 clinical encounters at the DCC, ≥A1C test result in the previous 12 months, Most recent A1C value was ≥7% **Exclusion**: No computer at home, Not receiving multiple daily injection therapy with insulin glargine, Receiving continuous subcutaneous insulin infusion, Terminally ill, Significant mental illness/substance abuse in their charts,	**Age** **Gender** **Ethnicity** **Education** **Marital status** **Health insurance status**	**Health:** HbA1c **Behaviour**: Self-management activities **Psychosocial**: Self-efficacy	User (>1 log on) vs non-user (1log on) to the program

Study ID, Author, year of publication,	**Study design**	**Study details (health condition, setting, location)**	**Study sample size**	**Inclusion and exclusion criteria**	**PROGRESS-Plus categories explored**	**Main outcome targeted by intervention**	**Measure of intervention use**
				Did not speak and read English.			
ID 10, Mulvaney, 2011	Pilot RCT	T1D, Academic paediatric diabetes clinic, USA	48	**Inclusion:** 13–17 years, Diagnosed with T1D for at ≥ six months, Access to the Internet, Spoke English, No cognitive/perceptual disabilities that precluded understanding website content.	**Age** **Gender**	**Health:** HbA1c **Behavioural:** Self-management	Website activities *Measured by the activities index e.g. posting on the forum*
ID 11, Nijland, 2011	Pilot mixed-methods longitudinal research design: including log files, interviews, usability tests, and a survey to identify user characteristics	T2D, Primary healthcare foundation in the Netherlands consisting of 10 primary health care practices and a home care organisation, Netherlands	50	**Inclusion**: No age specified, T2D, Motivated self-care, Access to the Internet, Sufficiently skilled to use the internet.	**Age** **Gender** **Education**	**Behavioural:** Self-care **Knowledge:** Diabetes knowledge	Highly active vs low/inactive *Highly active: Activity pattern: period of no activity <8 months* *Activity degree: 68%–100%* *Number of log-ins: 45–191.* *Low: Activity pattern: period of no activity <8 months* *Activity degree: 29%–67% (7–16 months use)* *Number of log-ins: 10–96.*

Study ID, Author, year of publication,	Study design	Study details (health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	PROGRESS-Plus categories explored	Main outcome targeted by intervention	Measure of intervention use
							Discontinued/Inactive users: Activity pattern: period of no activity ≥8 months *Activity degree: 0%–67% (0–16 months use)* *Number of log-ins: 0–56.*
ID 12, Pacaud, 2012, Canada	RCT	T2D, Participants recruited from the Building Healthy Lifestyles program that provides diabetes education with clinicians, Canada	79	**Inclusion**: No age specified, Newly diagnosed T2D, Access to a computer connected to the internet, Computer literate, No complicating health conditions, Not involved in another research study.	**Gender**	**Health**: HBA1C **Knowledge**: Diabetes knowledge **Psychosocial**: Self-efficacy	Total use over a year (study duration)
ID 13, Roelofsen, 2014	Cross-sectional analysis of data from a prospective cohort study	T2D, 46 general practices, Drenthe region of the Netherlands	405	**Inclusion:** ≥18 years, T2D, GP specified as main care provider, Part of the Drenthe shared care initiative, **Exclusion**: In psychiatric treatment for mental health	**Age** **Gender** **Education** **Employment**	**Health:** Health related Quality of Life	Ever logged on (logged in ≥1 times) vs never logged on

Study ID, Author, year of publication,	Study design	Study details (health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	PROGRESS-Plus categories explored	Main outcome targeted by intervention	Measure of intervention use
				disorder currently or in the past, Insufficient knowledge of Dutch language, Life expectancy <1 year due to other terminal illnesses, Cognitive impairment, Other complicating conditions			
ID 14, Skrovseth, 2012	Single-arm open ended study	T1D, Department of Endocrinology at the University Hospital of North Norway (Tromsø), Norway	30	**Inclusion:** No age specified, T1D, Attending the Department of Endocrinology at the University Hospital of North Norway (Tromsø).	**Age** **Gender**	**Health:** HbA1C	*a)* Overall usage: *the total number of blood glucose measurements, insulin injections, and food items recorded* b) Adopters vs Non-adopters *Adopters: patients who recorded data without considerable interruptions for ≥80 days*
ID 15, Umapathy, 2015	Two-group pre-post quasi-experimental design	Osteoarthritis, Recruited online through adverts on websites, including Arthritis Australia; Melbourne Physiotherapy Department; Centre for Health, Exercise and Sports Medicine; and the Sydney Medical School, Australia	277	**Inclusion**: ≥50 years, Self-assessed osteoarthritis in hip or knee joint, Access to the internet**.**	**Age** **Gender**	**Behavioural:** Self-care behaviours **Knowledge:** Osteoarthritis knowledge	Users vs non-users c) *Participants who indicated usage of the My Joint Pain website were classified as the intervention group, all other*

Study ID, Author, year of publication,	Study design	Study details (health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	PROGRESS-Plus categories explored	Main outcome targeted by intervention	Measure of intervention use
							respondents were classified as nonusers
ID 16, Wangberg, 2008	RCT	T1D & T2D, Conducted online, Norway	64	**Inclusion**: 17-67 years, T1D/T2D, Access to the internet.	**Age** **Gender** **Education**	**Behaviour**: Self-care	Low vs frequent users *Low users used the intervention once, and frequent users >1. They excluded people who never used the intervention*
ID 17, Whittemore,2013	RCT	T1D, Recruited from paediatric diabetes clinics associated with four university sites (Yale, The Children's Hospital of Philadelphia, University of Arizona, and University of Miami) representing a range of racial, ethnic, and socioeconomic backgrounds, reflective of the national prevalence of T1D in youth, USA	320	**Inclusion**: 11–14 years, T1D ≥ 6 months, In school grade appropriate for age, Never been exposed to coping skills training materials, No other significant health problem, Access to high-speed Internet service. Research staff assisted any adolescent without home internet to gain access at a school, local library, or clinic.	**Age** **Gender** **Ethnicity** **Income**	**Health**: HbA1c **Psychosocial**: Quality of life	Participators vs nonparticipators *Participators (completed at ≥4 sessions or 80%) and nonparticipators (completed <80%).*

Study design

Of the diabetes studies, ten were Randomized Controlled Trials (RCTs),(Wangberg 2008, McCarrier, Ralston et al. 2009, Lorig, Ritter et al. 2010, Mulvaney, Rothman et al. 2011, Glasgow, Kurz et al. 2012, Heinrich, de Nooijer et al. 2012, Pacaud, Kelley et al. 2012, Whittemore, Jaser et al. 2013, Huang, Terrones et al. 2014, Torbjornsen 2014): five were described as RCTs with no further detail,(Wangberg 2008, Lorig, Ritter et al. 2010, Glasgow, Kurz et al. 2012, Pacaud, Kelley et al. 2012, Huang, Terrones et al. 2014) two were pilot studies,(McCarrier, Ralston et al. 2009, Mulvaney, Rothman et al. 2011) one was a pre-test post-test trial (they included a pre-post control group and a post-test only control group to mitigate against the possible effects of completing the pre-test on knowledge scores in the control group),(Heinrich, de Nooijer et al. 2012) one parallel group study,(Whittemore, Jaser et al. 2013) and one 3-armed trial (Table 2).(Torbjornsen 2014) There were six non-RCTs: one pilot mixed methods longitudinal study,(Nijland, van Gemert-Pijnen et al. 2011) two two-arm quasi-experimental study,(Lee, Yeh et al. 2007) one cross-sectional analysis of data from a prospective cohort study,(Roelofsen, Hendriks et al. 2014) one retrospective observational study,(Lau, Campbell et al. 2014) and two single-arm pre-post cohort study.(Skrovseth, Arsand et al. 2012, Goh, Tan et al. 2015) The osteoarthritis study was a two-group pre-post quasi-experimental design.(Umapathy, Bennell et al. 2015)

Study participants

There was one osteoarthritis study, (Umapathy, Bennell et al. 2015) and 16 diabetes studies, of which, five focussed on T1D,(McCarrier, Ralston et al. 2009, Mulvaney, Rothman et al. 2011, Skrovseth, Arsand et al. 2012, Whittemore, Jaser et al. 2013, Huang, Terrones et al. 2014) nine on T2D,(Lee, Yeh et al. 2007, Lorig, Ritter et al. 2010, Nijland, van Gemert-Pijnen et al. 2011, Glasgow, Kurz et al. 2012, Heinrich, de Nooijer et al. 2012, Pacaud, Kelley et al. 2012, Roelofsen, Hendriks et al. 2014, Torbjornsen 2014, Goh, Tan et al. 2015) and two both.(Wangberg 2008, Lau, Campbell et al. 2014)

In terms of study population inclusion criteria, most of the studies described eligibility criteria based on condition (in all studies, either previously diagnosed or meeting pre-specified diagnostic criteria) and age (13 studies). Age ranges for the eligible criteria were between 11 and 70 years across the studies (some studies had no upper limit). Three of the diabetes studies focussed on younger people with a diagnosis of T1D: with participants aged 12-22 years,(Huang, Terrones et al. 2014) 11–14 years,(Whittemore, Jaser et al. 2013) and 13-17 years.(Mulvaney, Rothman et al. 2011) Nine of the diabetes studies focussed on adults and these included studies of people with both T1D and T2D. Five studies included only adults with T2D, aged 40–70,(Heinrich, de Nooijer et al. 2012), aged 25–75 years ,(Glasgow, Kurz et al. 2012), and aged >18 years. (Lorig, Ritter et al. 2010, Roelofsen, Hendriks et al. 2014, Torbjornsen 2014) Two studies included both people with T1D and T2D aged 17-67 years (Wangberg 2008), or any >18 years.(Lau, Campbell et al. 2014)Two included adults with T1D only, aged 21-49 years,(McCarrier, Ralston et al. 2009) and >21 years.(Goh, Tan et al. 2015) One study of people with T1D, (Skrovseth, Arsand et al. 2012) and three of people with T2D did not specify the age of participants.(Lee, Yeh et al. 2007, Nijland, van Gemert-Pijnen et al. 2011, Pacaud, Kelley et al. 2012) The study focussing on people with osteoarthritis included adults ≥50 years.(Umapathy, Bennell et al. 2015)

People were also excluded from studies if they did not have access to the internet,(Lee, Yeh et al. 2007, Wangberg, Bergmo et al. 2008, Case, Jernigan V Fau - Gardner et al. 2009, Glasgow, Christiansen et al. 2011, Mulvaney, Rothman et al. 2011, Nijland, van Gemert-Pijnen et al. 2011, Pacaud, Kelley et al. 2012, Glasgow, Strycker et al. 2014, Umapathy, Bennell et al. 2015) or access to the technology to run the intervention(e.g. smartphone),(Pacaud, Kelley et al. 2012, Goh, Tan et al. 2015)or understanding/skills to use the relevant technology or the internet,(Nijland, van Gemert-Pijnen et al. 2011, Pacaud, Kelley et al. 2012, Holmen, Torbjornsen et al. 2014, Goh, Tan et al. 2015) or did not understand the language of the intervention,(McCarrier, Ralston et al. 2009, Glasgow, Christiansen et al. 2011, Mulvaney, Rothman et al. 2011, Glasgow, Strycker et al. 2014, Holmen, Torbjornsen et al. 2014, Roelofsen, Hendriks et al. 2014, Goh, Tan et al. 2015) or they had existing or previous mental health conditions(2 studies),(McCarrier, Ralston et al. 2009, Roelofsen, Hendriks et al. 2014) or they had a cognitive impairment,(Lee, Yeh et al. 2007, Mulvaney, Rothman et al. 2011, Whittemore, Jaser et al. 2013, Holmen, Torbjornsen et al. 2014, Huang, Terrones et al. 2014, Roelofsen, Hendriks et al. 2014, Goh, Tan et al. 2015)or they were pregnant,(Glasgow, Christiansen et al. 2011, Glasgow, Strycker et al. 2014, Goh, Tan et al. 2015) or had other 'complicating' health conditions or were terminally ill,(Case, Jernigan V Fau - Gardner et al. 2009, McCarrier, Ralston et al. 2009, Pacaud, Kelley et al. 2012, Whittemore, Jaser et al. 2013, Roelofsen, Hendriks et al. 2014) or were not motivated to perform self-care activities,(Nijland, van Gemert-Pijnen et al. 2011) or had previously been exposed to coping skills training materials(Table 2).(Whittemore, Jaser et al. 2013)

In total, 3501 participants were included in these 17 studies. Study size ranged from 30 to 1378 (Table 2). The sociodemographic make-up of the sample is provided in Table 3. The average proportion of female participants was 49% and ranged from 29% (T2D study) to 77% (osteoarthritis study). Six of the 17 studies reported the ethnic composition of the study sample. Only one study claimed that the ethnic make-up of the study was representative of the country in which the study was conducted.(Goh, Tan et al. 2015) Two studies purposely recruited a highly ethnically diverse sample.(Glasgow, Christiansen et al. 2011, Whittemore, Jaser et al. 2013, Glasgow, Strycker et al. 2014) One study selected a subgroup of ethnically diverse participants to conduct a secondary analysis of a larger study.(Case, Jernigan V Fau - Gardner et al. 2009, Glasgow, Christiansen et al. 2011, Whittemore, Jaser et al. 2013, Glasgow, Strycker et al. 2014) Eleven studies provided information about the participant's educational attainment and two provided occupation information: most people had greater than 12 years of education and were employed (range 53-83%). Income data were provided in two studies; where 51% of had a household income of ≥$80,000/year in one study,(Whittemore, Jaser et al. 2013) in the other study 17.5% of participants had a household income of ≥$90,000.(Glasgow, Christiansen et al. 2011)

Table 3: Demographics of study samples

Study	**Study ID**	**Sample size**	**Age (median/mean years (±Standard Deviation(SD) /interquartile range(IQR) /Confidence interval(CI) where given))**	**Female (%)**	**Ethnic group (%)**	**Education (%)**	**Employment (%)**	**Income (%)**	**Other PP category (%)**
Case, 2014	1	45	*AIs/ANs 53.7, AAs 52.3, CC 50.5	NA	*AIs/ANs: 33.3 AAs 33.3 CC 33.3	Average (years) AIs/ANs 15.7, AAs 16.1, Caucasians 15.9	NA	NA	NA
Glasgow, 2011	2	270	58.4 ±SD 9.2	49.8	*AI/AN 6.7, Asian 1.6, AA 15.4, White 72.0, Latin 21.8	≤High school 19.1		< $49,999 47.3, $50,000 - $89,999 35.2, ≥$90,000 17.5	
Glasgow, 2014	2a	270	57.8 ±SD 9.3	48.1	*AI/AN 4.2 Asian 1.5 AA 18.1 White 67.4 Latin 22.3 Other 8.9	≤High school 20.4		< $49,999 44.8 $50,000 - $89,999 30.7 ≥$90,000 18.5 No info 5.9	
Goh, 2015	3	84	48.2 ± SD8.5	49.0	Chinese 54.0 Malay 27.0 Indian 12.0 Others 7.0	≤Secondary 46.0 Post-secondary 12.0 Diploma 21.0 ≥Degree 20.0	Retired 7.0 Homemaker 8.0 Unemployed 1.0 Employed 83.0		**Marital status** Single 12.0 Married 83.0 Divorced/Separated 5.0

Heinrich, 2012	4	135	Experimental group(A) 56.0± SD7.0 Control group (B)56.0±SD 7.0, Control group (C) 59.0± SD6.0	(A) 56.0, (B) 48.0, (C) 53.0		Low education group (A) 35.0 (B) 43.0 (C) 25.0, Middle (A) 35.0 (B) 30.0(C) 28.0, High (A) 30.0 (B) 27.0 (C) 47.0			
Holmen, 2014	5	164	57.0± SD12.0	41		<12 years of education 55.0	Employed 53.4, Unemployed 27.7, Retired 18.9		
Huang, 2014	6	81	17.0 (IQR 16.0–18.0)	54.3	*****White 33.3, Black 9.9, Hispanic 37.0, AI/AN 1.2, Other 6.2				
Lau, 2014	7	157	Complete data(CD) 54.73 ±SD 13.49, Propensity matched data (PMD) 51.92 ± SD13.51	CD 40.8, PMD 45.0					
Lee, 2007	8	274	Intervention(I): 61.15 ± SD12.67 Control(C)I: 65.97 ±SD 8.51	I: 43.0 C: 54.0		Illiterate: (I) 9.8, (C) 12.1 Elementary school/Junior high school: (I) 32.0, (C) 27.2 Senior high school: (I) 15.7, (C) 20.0 College/University: (I) 38.8, (C) 38.6 Master/PhD: (I) 3.7, (C) 2.1			
McCarrier, 2009	9	78	37.3± SD 8.1	32.5	Caucasian 96.1	Years in education mean 15.4± SD 2.08			**Marital status:** Married 54.2 **Insurance status**: Commercial 85.3 Medicaid 5.3 Medicare 1.3 Private (self-pay) 4.0 Other 4.0

Mulvaney, 2011	10	48	15.1± SD1.5	49.0					
Nijland, 2011	11	50	61.0(range 43.0-80.0)	26.0		Low 12.0 Medium 51.0 High 37.0			Nationality: Dutch origin 93.0%
Pacaud, 2012	12	79	54.2±SD 9.1	52.9					75.6% lived in an urban centre
Roelofsen, 2014	13	1378	64.1 ±SD10.1	45.8		None 1.1 Primary school 12.0 Low 43.3 Intermediate 27.7 High 15.9	Full-time 16.0 Part-time 12.0 Retired 51.0 Unemployed 4.0 'Full-time housekeeper' 12.4 Incapacitated 4.6		
Skrovseth, 2012	14	30	39.1± SD11.2	43.3					
Umapathy, 2015	15	277	61.0±SD8.6	76.5					
Wangberg, 2008	16	64	Low Self-efficacy matched group 37.3(CI 33.2-41.4), High self-efficacy matched group 42.9 (CI 38.0-47.9)	Low SE 63.0, high SE 50.0		≤12 years of education Low SE 11.0, high SE 8.0			
Whittemore ,2013	17	320	12.3 ±SD1.1	55.0	White 72.0			High family income (≥$80,000/year) 51.0	

*AI/AN=American Indian/Alaska Native, AA=African American, CC= Caucasian

Intervention content and targeted outcomes

Details of the interventions are provided in Table 4. An overview is also provided in the text below.

Table 4: Intervention description for studies exploring differences in use

Study ID, Author, year of publication	**Intervention type**	**Intervention content**	**Intervention features**	**Features to support engagement**	**External technology/ support**	**Duration of intervention (**maximum duration of use)	**Attrition (numerator number without outcome, denominator number randomised)**
ID 1, Case, 2014	Website	There were two versions of the intervention 1) Internet-based diabetes self-management program (IDSMP): based on English- and Spanish-language peer-led small-group diabetes self-management programs. Consisted of six weekly sessions. Included: Learning Centre (questions and actions). Discussion Centre: with bulletin boards populated by responses from the Learning Centre, and threads started by participants. My Tools with: exercise and medication logs, audio relaxation exercises, meal planning, and glucose-monitoring tools and links to other diabetes-related Web sites. Post Office: participants and facilitators could write private, individual messages to each other. 2) IDSMP plus list serve email reinforcement	1&2) Shaping knowledge, Goals and Planning Social support Problem solving Monitoring and feedback Communication/support from health professionals/study team	1&2) Available in Spanish and English Help: participants can e-mail the moderators or program administrators. The latter was also available via a toll-free telephone line. 2) Above plus: Email reinforcements	A book, Living a Healthy Life with Chronic Conditions. Specific sections of this book were referenced in the Learning Centre.	6 weeks,	0/45 0.0%
ID 2, Glasgow, 2011 ID 2a, Glasgow, 2014	Website	2) Computer-assisted self-management (CASM): Participants selected daily goals, recorded progress and received feedback on success reaching goals. The website	2&2a) Shaping knowledge, Goals and Planning, Monitoring and Feedback, Social support (forum)	2&2a) Included features to enhance user engagement, e.g. rotating quiz questions	None	Not clear	2&2a)0/270 0.0%

Study ID, Author, year of publication	Intervention type	Intervention content	Intervention features	Features to support engagement	External technology/ support	Duration of intervention (maximum duration of use)	Attrition (numerator number without outcome, denominator number randomised)
		graphically displayed the patient's HbA1c, blood pressure, and cholesterol results. There was a moderated forum and community resources. After 6 weeks, participants created new personalized goals, identified barriers to achieving the (revised) goal(s) , and chose from a list of problem-solving strategies. 2a) CASM+SS was the CASM program with the addition of 2 phone calls from an interventionist, and an invitation to attend three group visits with other participants.	Problem solving 2a) Above plus: Communication/support from health professionals/study team	Received prompts using a computer-based telephone system			
ID 3, Goh, 2015	App	iDAT app: was not diabetes-specific, but was selected because it was created for the local Singapore population, was freely available on the 2 most common smartphone platforms& targeted diet and exercise. The app included a calorie counter, weight goals and tracking of weight loss, logging of food consumed via a food database with estimated calories (including local ethnic foods). And social features (e.g. Facebook-sharing). A step counter and the smartphones' Global Positioning System was used to monitor fitness workouts and calculate estimated calories burned.	Monitoring and feedback Social support	Created for the local Singapore population- includes local ethnic foods	None	5 months	0/84 0.0%
ID 4, Heinrich, 2012	Website	Diabetes Interactive Education Programme: gave an overview of T2D	Shaping knowledge, Goals and Planning	Information was mostly presented in spoken	None	2 weeks	n = 31/166 18.7% (13 excluded, 9

Study ID, Author, year of publication	Intervention type	Intervention content	Intervention features	Features to support engagement	External technology/ support	Duration of intervention (maximum duration of use)	Attrition (numerator number without outcome, denominator number randomised)
		management in seven chapters. Information was provided on basic and more advanced levels. Each chapter closed with questions to the patient, and had a workbook with goal setting forms, checklists on self-management behaviours and space.to note down questions for their HCP.		language, supported by headlines, images, video and real patient experiences			dropped out before study start and 9 before the post-test)
ID 5, Holmen, 2014	App	Few Touch Application (FTA): diabetes diary app where participants measured blood glucose level with a glucometer (LifeScan OneTouch Ultra Easy), which automatically transferred the measurement to the app through Bluetooth connection. It provided visual graphs, trend reports, and feedback through colour coding (below normal, normal, and above normal). There was a food habit and physical activity registration, personal goal-setting, and general information system.. FTA-HC group received the FTA system, usual care, and health counselling for the first 4 months.	Monitoring and feedback Goals and Planning Shaping knowledge Communication/support from health professionals /study team	Training was in person; paper manual and a USB memory stick with further information were provided	Blood glucose monitor	12 months	31/164 19.0%
ID 6, Huang, 2014	Website	MD2ME: monitored disease symptoms, responded to monitoring with appropriate treatments, and actively worked with HCPs to manage care. Subjects logged in to a web site weekly to receive materials outlining common disease management,	Monitoring and feedback, Shaping knowledge Comparison of behaviours, Communication/support from health professionals/study team	SMS and queries were delivered (3–5messages/week) to ensure that participants received and understood intervention messages.	None	8 months	6/81 7.4%

Study ID, Author, year of publication	Intervention type	Intervention content	Intervention features	Features to support engagement	External technology/ support	Duration of intervention (maximum duration of use)	Attrition (numerator number without outcome, denominator number randomised)
		communication skills, and lifestyle tips. Disease-specific case studies were provided.MD2Me. An automated SMS algorithm provided disease management decision support, and a health care team communications portal. Subjects could use SMS to report health concerns. Subject concerns were relayed to the health care team depending on urgency.		Weekly reminder SMS messages were also delivered to reinforce previously introduced concepts and skills.			
ID 7, Lau, 2014	Website	The portal provided access to diabetes education material, personal laboratory values, and a messaging system allowing communication with the diabetes specialist and staff.	Shaping knowledge, Feedback Communication/support from health professionals/study team	None	None	Not clear, the study was conducted over 4 years 6 months and it appears that participants entered the study any time during this period	NA
ID 8, Lee, 2007	Website	POEM system: Web server was a repository for patients' medical care information and education materials. At each visit to the hospital, the doctor determined the patient's education need and these were converted into electronic notes and uploaded onto the server. The system monitored a patient's laboratory test results performed in the hospital and sent e-mails to educators for further investigation	Shaping knowledge, Communication/support from health professionals /study team	None	None	Not clear-they state the intervention was taken live in September 2003 and the study ran September 2003 to May 2004, and the final follow-up was in June.	NA- looking at intervention use. All included

Study ID, Author, year of publication	Intervention type	Intervention content	Intervention features	Features to support engagement	External technology/ support	Duration of intervention (maximum duration of use)	Attrition (numerator number without outcome, denominator number randomised)
		when the results were out of a predefined normal range. Reminders were sent by email and SMS to patients one week before their follow-up appointment.				So, it is likely the intervention ran for 9 months.	
ID 9, McCarrier, 2009	Website	The website enabled patients to access their electronic medical records; upload blood glucose readings; enter medication, nutrition, and exercise data into an online diary; communicate with providers by using clinical e-mail; and browse an education site with endorsed content. All data could be viewed by patients and providers in online displays that a nurse practitioner used to review cases weekly.	Shaping knowledge Feedback & monitoring Communication/support from health professionals /study team	None	None	12 months	Not relevant for use study, all intervention group included
ID 10, Mulvaney, 2011	Website	Multimedia problem-based stories that modelled problem solving psychosocial barriers to self-management created by patients and a multidisciplinary team of diabetes experts. Participant were prompted to complete six stories and two guided problem-solving cycles. Stories were broken down into segments, and participants were asked to relate their own experiences to those in the story. Problem solving cycles consisted of problem identification, solution generation, solution selection, implementation planning, evaluation, and revision. Participants were asked to return to	Problem solving Social support	Social networking and a peer forum. Participants could select an avatar, create a user profile, and view others' responses to the stories. Multimedia presentations were created regarding how to use the website and problem-solving steps. weekly email prompts to visit the website	None	11 weeks	7/48 14.6% randomised to intervention arm but did not use it so were not included in analyses

Study ID, Author, year of publication	Intervention type	Intervention content	Intervention features	Features to support engagement	External technology/ support	Duration of intervention (maximum duration of use)	Attrition (numerator number without outcome, denominator number randomised)
		the website to report on their progress in solving problems					
ID 11, Nijland, 2011	Website	DiabetesCoach: documentation of personal details (e.g. treatment plan, medication use), online monitoring (weight, blood glucose level, blood pressure, and cholesterol), email contact with nurse, online education, calendar (to write down comments, appointments, and personal goals), lifestyle coac (self-tests to support lifestyle changes). The nurses could: set individual goals for patients, add lifestyle programs, and highlights the appropriate chapter of the e-learning program. Patients measured metabolic values at home and at the primary-care practice during visits. The information provided in DiabetesCoach were in accordance with diabetes care standards and protocols in the Netherlands.	Feedback and monitoring Goals and Planning Communication/support from health professionals /study team	None	None	24 months	50 entered the study 43 provided demographic information
ID 12, Pacaud, 2012	Website	There were 2 interventions 1) Web static: e-mail with providers and a second type of eHealth technology (e.g. electronic blood glucose journal) to support their electronic learning. They received follow-up care via virtual appointments with providers using e-mail communication 2) Web interactive: used e-mail and private and public chats with providers and other patients and use	Communication/support from health professionals /study team Feedback and monitoring Shaping knowledge 2) Above plus: Social support	None	None	Not clear mentioned 3 months to 12 months in original BHL programme	11/79 13.9%

Study ID, Author, year of publication	Intervention type	Intervention content	Intervention features	Features to support engagement	External technology/ support	Duration of intervention (maximum duration of use)	Attrition (numerator number without outcome, denominator number randomised)
		of a third type of eHealth technology (electronic blood glucose journal and additional functional e.g. bulletin board) to support their electronic learning and to access education and tools. They received normal care via virtual appointments with providers using e-mail and private chats.					
ID 13, Roelofsen, 2014	Website	e-Vita online platform was designed to support various chronic illnesses (T2DM, COPD and chronic heart failure). It consisted of: graphics of monitored metabolic value (from check-ups). Goals setting and actions planning, patient-registered weight, BMI, blood pressure, and waist circumference. Education presented text and movies. Part of the education was patient-specific, based on the health data. Patients were also directed to a website (www.e-vita.nl) with information on T2DM in general.	Goals and Planning Monitoring and feedback Shaping knowledge	None	None	Intervention duration and follow-up not clearly specified. They state "In this ongoing study, participants were recruited from May 2012 onward. The presented analysis includes patients recruited from May 2012 until August 2013."	Not applicable- the focus of the study was uptake and engagement with the intervention
ID 14, Skrovseth, 2012	App	Few Touch Application (FTA): was developed for both T1D and T2D patients. The version for T1D used in this study included recording of insulin,	Monitoring and feedback	None	Blood glucose meter	6 months	6/30 20.0%

Study ID, Author, year of publication	Intervention type	Intervention content	Intervention features	Features to support engagement	External technology/ support	Duration of intervention (maximum duration of use)	Attrition (numerator number without outcome, denominator number randomised)
		symptoms, and comments but was "otherwise identical to the T2D version". *There have been multiple iterations of this intervention and it was not clear which version they were referring to* "The system includes an off-the-shelf blood glucose (BG) meter, a tailor-made step counter, and software for recording food habits and providing feedback on how users perform in relation to their own personal goals." The BG and exercise readings were transferred using Bluetooth.					
ID 15, Umapathy, 2015	Website	My Joint Pain website: Evidence-based information, on treatments and information on local health care services; videos including patient narratives and information about surgery. Users could complete validated risk assessments ,medication and treatment history, and prior consultation with health professionals. An osteoarthritis management algorithm based on the answer provided then created a customised management plan. Assessments allowed members to track pain, weight, treatments and medications, function, and quality of life. A detailed report was produced that could be discussed with their health care team.	Shaping knowledge, Monitoring and feedback	Tailored messages and prompts encouraged users to manage their disease.	None	12 months, 12 months	82/277 29.6%

Study ID, Author, year of publication	**Intervention type**	**Intervention content**	**Intervention features**	**Features to support engagement**	**External technology/ support**	**Duration of intervention (**maximum duration of use)	**Attrition (numerator number without outcome, denominator number randomised)**
ID 16, Wangberg, 2008	Website	The intervention was tailored to level of Self-Efficacy. Behaviour exercises that included monitoring and graphic feedback were central to the website. Information on health risks and benefits, self-care, overcoming barriers to lifestyle change and diabetes in general were delivered online. Quizzes with feedback and videos of peers interviewed about overcoming barriers to self-care were available. Videos of lectures from health personnel on self-care were available for download. Each intervention theme focused on one specific target behaviour.	Monitoring and feedback Goals and Planning Comparison of behaviours Shaping knowledge	None	None	1 month, 1-month follow-up	27/61 44.3%
ID 17, Whittemore,2013	Website	TEENCOPE: an internet program based on a successful in-person coping skills training program for youth with T1D. Including social skills training, cognitive behaviour modification, assertive communication, stress reduction, and conflict resolution. Five sessions were released weekly that were interactive and encouraged self-assessment and the use of coping skills. Upon completion of sessions, responses to interactive aspects were posted on a personal profile so that participants could learn from each other. At the end of each session, participants were asked to practice the new coping skills and to share	Goals and Planning, Motivational support, Social support, Communication/support from health professionals /study team	It was designed using a graphic novel format and a cast of ethnically diverse characters with T1D who present challenging social situations, approaches to solving problems, and consequences of decisions.	None	5 weeks, 1)3 months & 6 months follow-up 1a) 3 months, 6 months & 12 months follow-up	31/320 9.7%

Study ID, Author, year of publication	**Intervention type**	**Intervention content**	**Intervention features**	**Features to support engagement**	**External technology/ support**	**Duration of intervention (**maximum duration of use)	**Attrition (numerator number without outcome, denominator number randomised)**
		experiences on a discussion board moderated by a health professional.					

Diabetes

Of the 16 studies of web-based interventions for diabetes self-management, three were evaluating apps and 13 were evaluating websites. Two studies explored the use of the same Few Touch App (FTA) , one in people with T1D and the other in people with T2D.(Skrovseth, Arsand et al. 2012, Holmen, Torbjornsen et al. 2014) The intervention was designed for use by people with T1D and T2D, providing a diary app and a Bluetooth linked blood-glucose monitor. In one paper, the version of the intervention for people with T1D was described as having the additional features of recording of insulin, symptoms, and comments but was “otherwise identical to the T2D version”.(Skrovseth, Arsand et al. 2012) A three arm RCT study published in 2014 explored the use of the FTA by people with T2D.(Holmen, Torbjornsen et al. 2014) There was not enough information in the paper to establish if it was the same version of the FTA as in the study of people with T1D.

Details of the intervention content are provided in Table 4. The interventions used a range of Behavioural Change Techniques (BCTs). Using the 16 highest clustered groups presented in Michie’s taxonomy of BCTs,(Michie, Richardson et al. 2013) the most commonly used techniques were: monitoring and feedback (13 interventions), shaping knowledge (11 interventions), Communication or support from health professionals (10 interventions), goals and planning (8 interventions), social support (6 interventions), problem solving (3 interventions) and social comparison(2 interventions)(Table 4). In addition to providing interventions with the above features, three interventions provided external linked technology or materials. One study had an accompanying book, so the program consists of the online interactive training plus the book.(Case, Jernigan V Fau - Gardner et al. 2009) One study used the Global Positioning System (GPS) in the phone to monitor fitness workouts.(Goh, Tan et al. 2015) The two studies evaluating the use of the FTA provided a blood glucose monitor that enabled automatic transfer of measurements to the app through a wireless Bluetooth connection.(Skrovseth, Arsand et al. 2012, Holmen, Torbjornsen et al. 2014)

Eight studies also provided features aimed at enhancing engagement in the intervention, these were: Short Message System(SMS)/email prompts or support(4 interventions),(Case, Jernigan V Fau - Gardner et al. 2009, Glasgow, Christiansen et al. 2011, Mulvaney, Rothman et al. 2011, Glasgow, Strycker et al. 2014, Huang, Terrones et al. 2014)help and technical support to use the intervention(online/phone/manuals, 3 interventions),(Case, Jernigan V Fau - Gardner et al. 2009, Mulvaney, Rothman et al. 2011, Holmen, Torbjornsen et al. 2014) design to engage the user (e.g. quiz, motivational tips, presentation in multimedia, using spoken language, graphic novel style, 3 interventions),(Glasgow, Christiansen et al. 2011, Heinrich, de Nooijer et al. 2012, Whittemore, Jaser et al. 2013, Glasgow, Strycker et al. 2014) available in Spanish and English(1 intervention),(Case, Jernigan V Fau - Gardner et al. 2009) created for the local Singapore population(includes local ethnic foods, 1 study).(Goh, Tan et al. 2015), social networking site.(Mulvaney, Rothman et al. 2011)

Chapter 4 focuses on intervention effectiveness and provides a detailed overview of the outcomes that these interventions were designed primarily to address (Table 2).

Osteoarthritis

"My Joint Pain" website provided evidence-based information on osteoarthritis treatments (surgical and behavioural). The central BCTs were shaping knowledge and monitoring and feedback (tailored management plan and regular assessments). A detailed report could be produced that could be discussed with their health care team. Tailored messages were sent to prompt regular assessments and tracking of pain, weight, treatments and medications, function, and quality of life. (Umapathy, Bennell et al. 2015)

Duration of intervention

Intervention duration (maximum duration of use) varied from two weeks to 24 months, and duration was not clearly provided in four studies (Table 4). (Lee, Yeh et al. 2007, Glasgow, Kurz et al. 2012, Lau, Campbell et al. 2014, Roelofsen, Hendriks et al. 2014)

Study setting

For the diabetes studies exploring web-based intervention use in adults, four were conducted in (patients were recruited from) a primary care setting,(Roelofsen, Hendriks et al. 2014, Goh, Tan et al. 2015) (Glasgow, Christiansen et al. 2011, Glasgow, Strycker et al. 2014) including a primary health care foundation consisting of 10 primary health care practices and a home care organisation employing the diabetes nurses.(Nijland, van Gemert-Pijnen et al. 2011) One study was conducted in secondary care in a university hospital,(Lau, Campbell et al. 2014) four studies were conducted in specialist diabetes centres, (Lee, Yeh et al. 2007, McCarrier, Ralston et al. 2009, Skrovseth, Arsand et al. 2012) and one study recruited from a diabetes education programme.(Pacaud, Kelley et al. 2012) One study was conducted purely online.(Wangberg, Bergmo et al. 2008, Case, Jernigan V Fau - Gardner et al. 2009, Heinrich, de Nooijer et al. 2012) One study did not provide information on the study setting.(Holmen, Torbjornsen et al. 2014) The three studies that investigated intervention use in young people were conducted in paediatric settings: in an academic medical centre,(Huang, Terrones et al. 2014) and diabetes centres.(Mulvaney, Rothman et al. 2011, Whittemore, Jaser et al. 2013) Two studies specifically selected sites that were diverse in terms of ethnic and socioeconomic backgrounds.(Glasgow, Christiansen et al. 2011, Whittemore, Jaser et al. 2013, Glasgow, Strycker et al. 2014) The osteoarthritis study was conducted through online recruitment.(Umapathy, Bennell et al. 2015)

Study populations were based in the United States of America (USA) in six of the included diabetes studies,(Case, Jernigan V Fau - Gardner et al. 2009, McCarrier, Ralston et al. 2009, Mulvaney, Rothman et al. 2011, Glasgow, Kurz et al. 2012, Whittemore, Jaser et al. 2013, Huang, Terrones et al. 2014), three in the Netherlands,(Nijland, van Gemert-Pijnen et al. 2011, Heinrich, de Nooijer et al. 2012, Roelofsen, Hendriks et al. 2014) two in Canada,(Pacaud, Kelley et al. 2012, Lau, Campbell et al. 2014) three in Norway,(Wangberg 2008, Skrovseth, Arsand et al. 2012, Holmen, Torbjornsen et al. 2014) one in Taiwan,(Lee, Yeh et al. 2007) and one in Singapore.(Goh, Tan et al. 2015) The osteoarthritis study was conducted in Australia. (Umapathy, Bennell et al. 2015)

Measures of use

The measures of use broadly fell into two groups, studies that provided: 1) a clearly defined binary measure of ever vs never accessed the intervention, and; 2) a range of heterogeneous measures quantifying use in different ways. Three of the 17 studies reported the ever vs never measure (including the study focussing on osteoarthritis). Within this, two studies used the system logs to establish who logged into the system at least once or had not ever logged on,(Lau, Campbell et al. 2014, Roelofsen, Hendriks et al. 2014) and in one study the outcome was subjective, where participants with osteoarthritis were asked to self-report if they had ever used the intervention 12 months after entering the study.(Umapathy, Bennell et al. 2015)

Fourteen studies reported heterogeneous measures which are detailed in Table 2 and incorporate a range of definitions of use, including: the total time spent on the intervention,(Heinrich, de Nooijer et al. 2012) use of intervention features,(Lorig, Ritter et al. 2010, Huang, Terrones et al. 2014) the number of log-ons to the intervention.(Lee, Yeh et al. 2007, Pacaud, Kelley et al. 2012) Several study teams retrospectively generated measures of use from user logs to define types of users, including binary (e.g. frequent users vs non frequent users) and categorical (e.g. low, medium and high users) variables. (Wangberg, Bergmo et al. 2008, McCarrier, Ralston et al. 2009, Skrovseth, Arsand et al. 2012, Whittemore, Jaser et al. 2013, Glasgow, Strycker et al. 2014, Holmen, Torbjornsen et al. 2014, Goh, Tan et al. 2015) Others created summary measures of website activity patterns based on: the use of multiple elements of the intervention such as blood glucose monitors, forums and diaries,(Mulvaney, Rothman et al. 2011, Skrovseth, Arsand et al. 2012) or; combining multiple measures of engagement such as time spent on the intervention and number of log-ons. (Glasgow, Christiansen et al. 2011, Nijland, van Gemert-Pijnen et al. 2011)

Study ID 2 (Table 2) included two studies exploring different measures of use and different PP categories, these are referred to as Study 2(2011) and 2a(2014).(Glasgow, Christiansen et al. 2011, Glasgow, Strycker et al. 2014) In their 2011 (Study ID 2) paper they explored associations between participant characteristics(education, ethnicity and health literacy) and five summary use variables(Table 2) using Spearman nonparametric correlations.(Glasgow, Christiansen et al. 2011) In their 2014 paper(study ID 2a), they explored associations between a wider range of PP categories(age, gender, ethnicity, education, income, numeracy and health literacy) and a different measure of use (people who had engaged with the intervention at least monthly vs those who did not) using a different statistical methodology (recursive partitioning with signal detection analysis). Recursive partitioning with signal detection analysis identified groups of patients who use the intervention using an iterative approach ‘to identify non-overlapping, homogeneous, and maximally differentiated groups on dichotomous outcomes’.(Glasgow, Strycker et al. 2014)

None of the studies reported measures representing whether the participants received the intended self-managed “dose”/exposure to the intervention that would be sufficient to lead to a change in behaviour.(Eysenbach 2011) One study dichotomised participation of the intervention into two groups: participants classified those enrolled in the study as participant (completed ≥ 80% of sessions) and nonparticipators (completed <80% of sessions).(Whittemore, Jaser et al. 2013) The authors do refer to the importance of using intended dose in the discussion in the future direction of research section, but it is not clear whether this relates to the measure they used and the cut off of 80% was not justified in the paper.

Potential for meta-analysis of use measures

It was possible to conduct meta-analysis comparing differences in age and gender across the three studies reporting 1) ever vs never used the intervention.(Lau, Campbell et al. 2014, Roelofsen, Hendriks et al. 2014, Umapathy, Bennell et al. 2015) The I_2 for age was 13% and gender was 0% indicating low and no heterogeneity, although some caution should be taken interpreting this statistic considering the very small number of studies to be synthesised.(von Hippel 2015)

There were two common measures for the studies in group 2). However, it was not possible to undertake meta-analysis of these findings. Three studies reported total use as established by log-ons during the study period. In two studies there were no common PP variables: one looked for associations between total use and gender, (Pacaud, Kelley et al. 2012) and the other age and education.(Lee, Yeh et al. 2007) For the other study, the team no longer had access to the data to provide estimates.(Glasgow, Christiansen et al. 2011) Two studies presented the common measure of time spent on the intervention during the study duration.(Glasgow, Christiansen et al. 2011, Heinrich, de Nooijer et al. 2012) However, for one of the studies the team no longer had access to these data (Glasgow, Christiansen et al. 2011), so data were only available for one study.(Heinrich, de Nooijer et al. 2012)

In the section presenting the differences in intervention use, a narrative synthesis of outcome groups 1) and 2) together will be provided. The data will be combined in the novel adaptation of the Harvest plot. This will be followed by the presentation and discussion of meta-analysis of the subset of the three studies that presented data for 2) ever vs never used the intervention.

Risk of Bias assessment

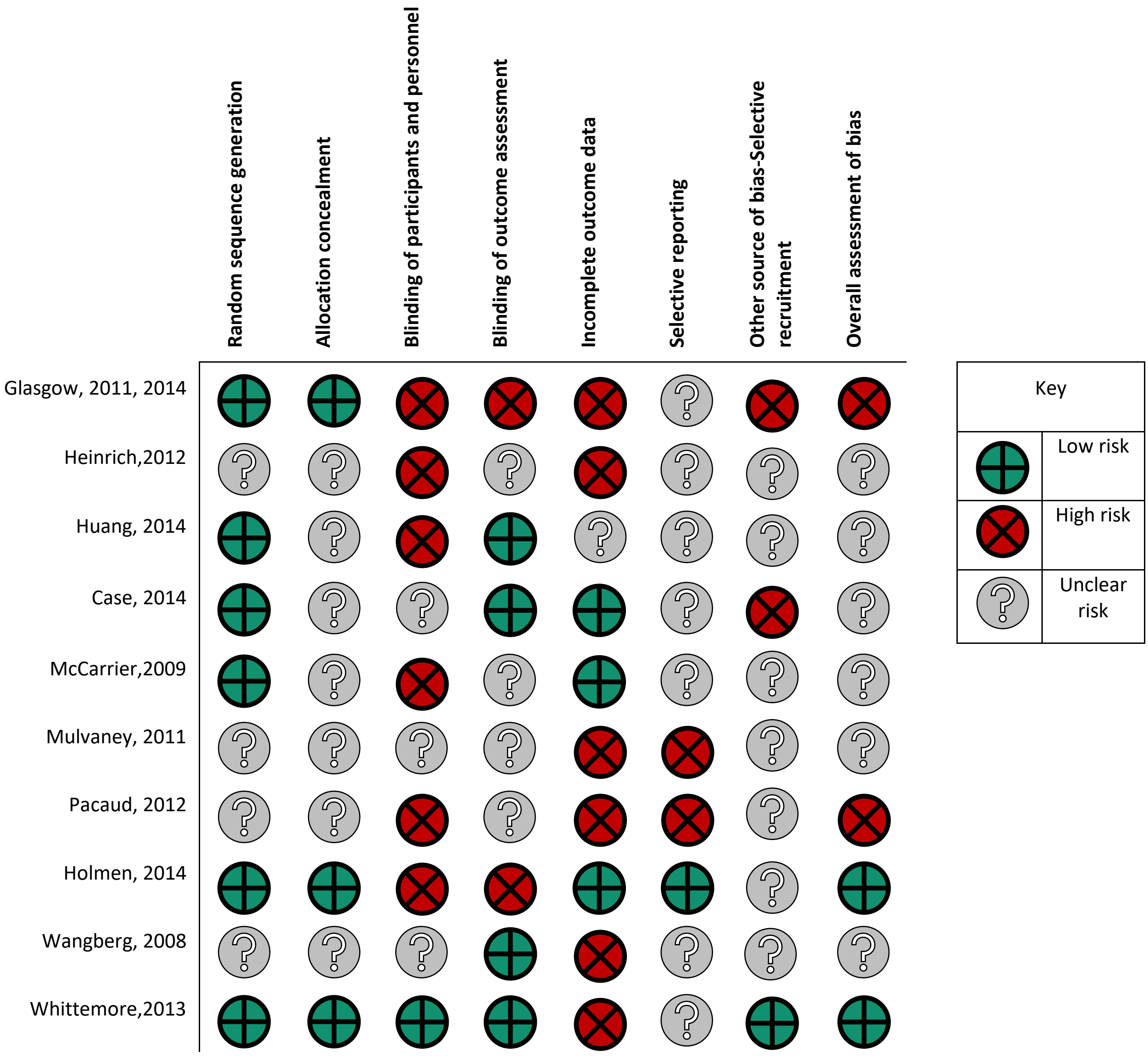
RCTs

Using the Cochrane Risk Of Bias(RoB) score, six of the ten included RCTs did not have enough information to establish the RoB and the overall assessment was unclear (Figure 3), (Wangberg, Bergmo et al. 2008, Case, Jernigan V Fau - Gardner et al. 2009, McCarrier, Ralston et al. 2009, Mulvaney, Rothman et al. 2011, Heinrich, de Nooijer et al. 2012, Huang, Terrones et al. 2014) two had an assessment of low risk, (Whittemore, Jaser et al. 2012, Whittemore, Jaser et al. 2013),(Holmen, Torbjornsen et al. 2014) and two high (Figure 3).(Glasgow, Christiansen et al. 2011, Pacaud, Kelley et al. 2012, Glasgow, Strycker et al. 2014) Random sequence generation was considered to be of low RoB in six studies and insufficient information was provided in four. Where the RoB was low, study teams used: random number tables,(Case, Jernigan V Fau - Gardner et al. 2009, Hanberger, Ludvigsson et al. 2013) computer programmes developed by the study statistician,(McCarrier, Ralston et al. 2009, Glasgow, Christiansen et al. 2011, Whittemore, Jaser et al. 2013, Glasgow, Strycker et al. 2014, Holmen, Torbjornsen et al. 2014) and random block assignment generated by the study statistician.(Huang, Terrones et al. 2014) It was not possible to establish the risk of the allocation concealment in seven studies and three had low RoB. In the studies where the RoB was low, the group was allocated remotely in one study,(Holmen, Torbjornsen et al. 2014) and using an automated email system in the other two.(Glasgow, Christiansen et al. 2011, Whittemore, Jaser et al. 2013, Glasgow, Strycker et al. 2014)

The blinding of participant and personnel was the highest RoB across the RCTs, with six studies being judged to be high risk and three unclear. The high risk came from studies that did not report any blinding or stated they did not blind the participants and personnel. The studies that were unclear, were those that referred to blinding participants and or personnel but did not provide detail on how it was achieved. For the blinding of outcome assessment, four studies were of low risk of bias, four were unclear and two were high risk. Of the low risk, data were collected online rather than by a study team member(Wangberg, Bergmo et al. 2008, Case, Jernigan V Fau - Gardner et al. 2009, Whittemore, Jaser et al. 2013) and assessors were blinded to intervention allocation.(Huang, Terrones et al. 2014)

Six of the RCTs had a high RoB for incomplete outcome data, three were low risk and one was unclear. High study attrition rates contributed towards the high risk with concerns about selective attrition,(Wangberg, Bergmo et al. 2008, Glasgow, Christiansen et al. 2011, Heinrich, de Nooijer et al. 2012, Pacaud, Kelley et al. 2012, Whittemore, Jaser et al. 2013, Glasgow, Strycker et al. 2014) as did exclusion of non-users of the intervention from analysis with no provision of participant characteristics.(Mulvaney, Rothman et al. 2011) Those at low risk had low attrition and there was no evidence of selective attrition.(Case, Jernigan V Fau - Gardner et al. 2009, McCarrier, Ralston et al. 2009, Holmen, Torbjornsen et al. 2014) In seven of the studies selective reporting was of unclear risk, two were of high risk and one was low. In the studies where the risk of selective reporting was unclear, protocols were not available. It was therefore not possible to establish whether the interaction analysis and measures of use were post-hoc decisions or predefined. Both papers that were considered to be at high risk of selective reporting, did not provide any rationale for the PP variables explored and no protocol was available.(Mulvaney, Rothman et al. 2011, Pacaud, Kelley et al. 2012) The study that was a low RoB the protocol was published and the analysis was outlined in the publication.(Holmen, Torbjornsen et al. 2014)

Although the representation of people with different groups may have been balanced in the arms of the RCT, this does not give an indication of whether the study sample represents the population of people with the condition. Six studies were classified as unclear risk of selection bias if the inclusion criteria potentially excluded people who experience greater health inequity (no access to the internet, not having the skills to use it, language barriers) and there was no discussion of the study population being representative of those with the condition.(Wangberg, Bergmo et al. 2008, McCarrier, Ralston et al. 2009, Glasgow, Christiansen et al. 2011, Mulvaney, Rothman et al. 2011, Pacaud, Kelley et al. 2012, Glasgow, Strycker et al. 2014, Holmen, Torbjornsen et al. 2014) Two further studies were rated as having unclear RoB for selective recruitment because they did not use any criteria that would exclude already disadvantaged groups from entering the study, but did not discuss whether the sample of participants were representative.(Heinrich, de Nooijer et al. 2012, Huang, Terrones et al. 2014) One study was classified as low risk because the authors specified participants needed access to the internet, but supported them to access the internet on site if they did not have access at home.(Whittemore, Jaser et al. 2013) Two studies were classified as high risk where they provided evidence that there were biases in the sample who entered the study. Glasgow et al.(2011 and 2014) compared with those who declined with those that entered the study and found those in the study, “were likely to be younger, less likely to be Latino, had higher incomes, were much more likely to have completed postsecondary education (79% vs 53.5%)”.(Glasgow, Christiansen et al. 2011, Glasgow, Strycker et al. 2014) The main RCT where the Case subgroup data came from also reported that the sample were “predominantly non-Hispanic white (76%), female (73%), married (66%), and well educated (mean of 15.7 years of education)”.(Lorig, Ritter et al. 2010) Case et al.’s(2014) sample therefore was likely to be bias.(Case, Jernigan V Fau - Gardner et al. 2009)



	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other source of bias-Selective recruitment	Overall assessment of bias
Glasgow, 2011, 2014	⊕	⊕	⊗	⊗	⊗	?	⊗	⊗
Heinrich,2012	?	?	⊗	?	⊗	?	?	?
Huang, 2014	⊕	?	⊗	⊕	?	?	?	?
Case, 2014	⊕	?	?	⊕	⊕	?	⊗	?
McCarrier,2009	⊕	?	⊗	?	⊕	?	?	?
Mulvaney, 2011	?	?	?	?	⊗	⊗	?	?
Pacaud, 2012	?	?	⊗	?	⊗	⊗	?	⊗
Holmen, 2014	⊕	⊕	⊗	⊗	⊕	⊕	?	⊕
Wangberg, 2008	?	?	?	⊕	⊗	?	?	?
Whittemore,2013	⊕	⊕	⊕	⊕	⊗	?	⊕	⊕

Key	
⊕	Low risk
⊗	High risk
?	Unclear risk

Figure 3: RoB table for RCTs

Non-RCTs

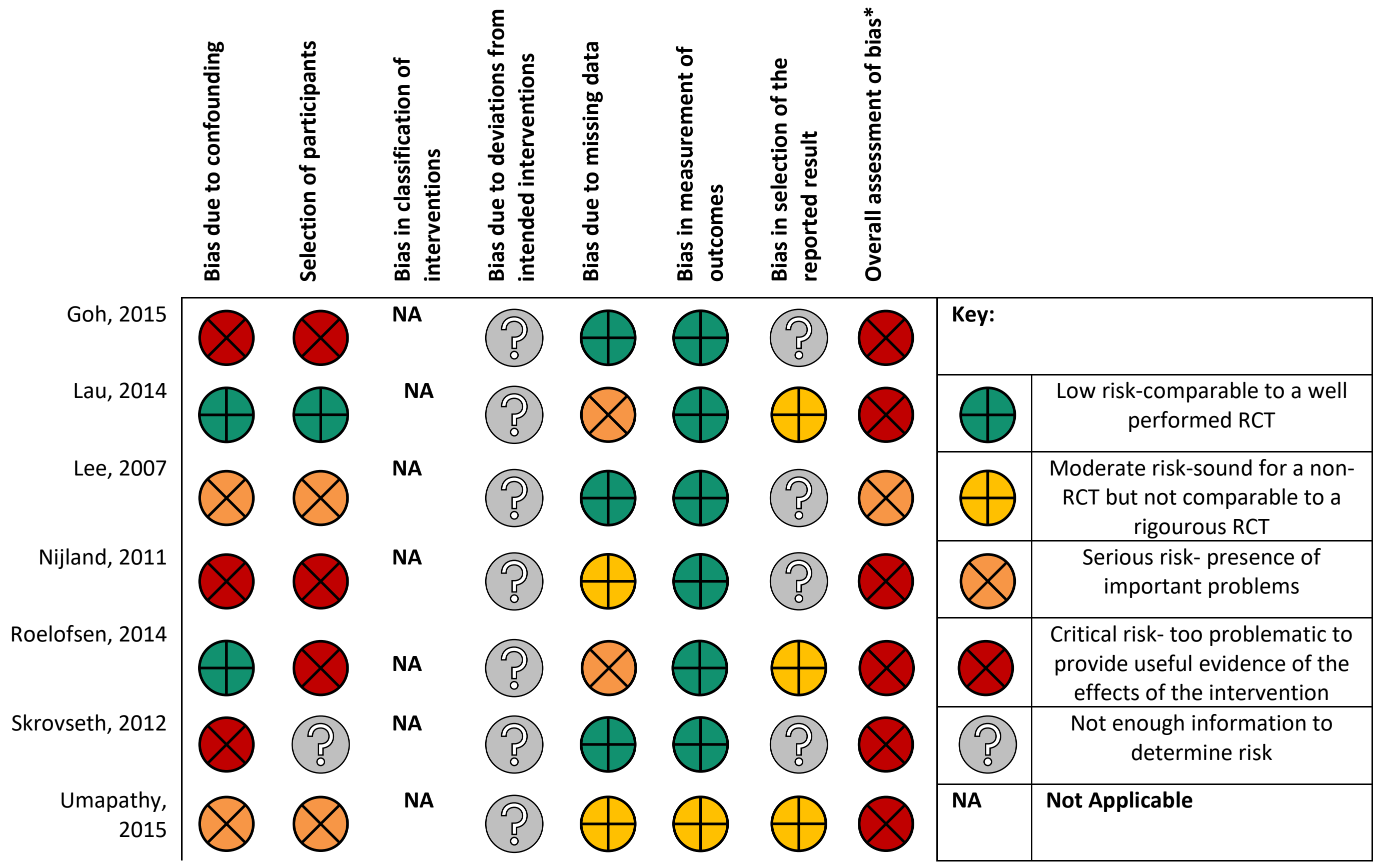
Using RoBINs-I, six of the seven included studies were considered to be critical RoB(Nijland, van Gemert-Pijnen et al. 2011, Skrovseth, Arsand et al. 2012, Lau, Campbell et al. 2014, Roelofsen, Hendriks et al. 2014, Goh, Tan et al. 2015, Umapathy, Bennell et al. 2015) and one was a serious RoB Figure 4.(Lee, Yeh et al. 2007) Bias due to confounding was of critical RoB in three studies, serious in two and low in two. Confounding was considered to be critical and serious risk in the studies where people had self-selected due to an interest in the intervention or because internet access, or smartphone ownership was an inclusion criteria, (Nijland, van Gemert-Pijnen et al. 2011, Goh, Tan et al. 2015) where there was no information on how participants were selected from those that were eligible,(Skrovseth, Arsand et al. 2012)(Lee, Yeh et al. 2007) and there was at least one known confounder not controlled for.(Umapathy, Bennell et al. 2015) The low risk studies used multivariate statistical methods to adjust for confounding,(Roelofsen, Hendriks et al. 2014) or used propensity matching to tackle differences in users vs non-users.(Lau, Campbell et al. 2014)

Selection bias was the greatest risk of bias for the non-RCTs. For all but one study, there was a serious or critical risk that those in the study were not representative of people with the condition in the general population. For the studies where the bias was serious or critical, assignment to a user category in the measure of use was determined by behaviour in the study(Umapathy, Bennell et al. 2015) study demonstrated differences between people entering the study and those who did not.(Nijland, van Gemert-Pijnen et al. 2011, Roelofsen, Hendriks et al. 2014) there was no information provided about who met the inclusion criteria,(Lee, Yeh et al. 2007) and eligibility criteria was adjusted after the start of recruitment.(Goh, Tan et al. 2015) The study that was of low RoB used propensity matching was to adjust for potential selection bias. (Lau, Campbell et al. 2014) One study did not provide information about how people were selected into the study.(Skrovseth, Arsand et al. 2012) One study investigated the difference between those interested in the intervention who subsequently entered the study and found they were more likely to be younger and found as the level of education increased so did the interest in the intervention. The team did not make any attempts to balance recruitment as a consequence of this finding.(Roelofsen, Hendriks et al. 2014)

The bias in classification of interventions was not applicable in these studies because all of the participants had been assigned to use the intervention. Bias due to deviations from intended interventions was unclear in all seven studies, as there was no information provided about intended intervention dose in any study.

For bias due to missing data three studies were low risk, two were moderate and two were serious risk. Two studies reported a low drop-out rate and were classified as low risk.(Lee, Yeh et al. 2007, Skrovseth, Arsand et al. 2012) For the moderate risk studies there was high attrition but the sample was clear,(Umapathy, Bennell et al. 2015) and there was missing data on the predictors found to be associated with use patterns but it was not clear if this affected the outcome.(Nijland, van Gemert-Pijnen et al. 2011) Studies were judged to be of serious risk because it was not clear whether missing data were associated with user characteristics: in one study the majority of the people interested in the study were not enrolled into the study by the clinician,(Roelofsen, Hendriks et al. 2014) and data were not reported for all matched pairs.(Lau, Campbell et al. 2014)

Bias in the measurement of outcomes and bias in selection of the reported result were the domains with the lowest overall RoB for the non-RCTs, with six studies classified as low risk and one moderate risk. For the bias in measurement of outcomes, the studies considered to be low risk provided clear measures that were collected from system logs reports of use. The moderate study asked participants to recall whether they had ever or never used the intervention at 12-month follow-up. For bias in selective reporting four did not provide enough information to judge on bias and three were moderate. For the studies that were unclear risk, protocols were not available to determine whether the different reported measures of use were selected from multiple outcomes or determined *a priori*. The studies that used the ever vs never outcome did not have a protocol available, however the bias in measurement of outcome was considered to be moderate risk. This was because the outcome was not likely to have been decided as a consequence of the post hoc examination of the data.(Lau, Campbell et al. 2014, Roelofsen, Hendriks et al. 2014, Umapathy, Bennell et al. 2015)



	Bias due to confounding	**Selection of participants**	**Bias in classification of interventions**	**Bias due to deviations from intended interventions**	**Bias due to missing data**	**Bias in measurement of outcomes**	**Bias in selection of the reported result**	**Overall assessment of bias***
Goh, 2015	🟥	🟥	**NA**	?	🟩	🟩	?	🟥
Lau, 2014	🟩	🟩	**NA**	?	🟧	🟩	🟨	🟥
Lee, 2007	🟧	🟧	**NA**	?	🟩	🟩	?	🟧
Nijland, 2011	🟥	🟥	**NA**	?	🟨	🟩	?	🟥
Roelofsen, 2014	🟩	🟥	**NA**	?	🟧	🟩	🟨	🟥
Skrovseth, 2012	🟥	?	**NA**	?	🟩	🟩	?	🟥
Umapathy, 2015	🟧	🟧	**NA**	?	🟨	🟨	🟨	🟥

Key:	
🟩	Low risk-comparable to a well performed RCT
🟨	Moderate risk-sound for a non-RCT but not comparable to a rigourous RCT
🟧	Serious risk- presence of important problems
🟥	Critical risk- too problematic to provide useful evidence of the effects of the intervention
?	Not enough information to determine risk
NA	**Not Applicable**

Figure 4: RoB assessment for the non- RCT studies

Overall the RoB indicated that the methodological quality was low. This was partly as a result of incomplete reporting of methodological features. Protocols were not published in the majority of the studies, so it was difficult to ascertain whether measures of use and analysis undertaken had been specified a priori or post hoc on examination of the data. There were issues with high attrition rates in the RCTs and selection bias in the RCTs.

3.2.3. Evidence of differences in intervention use by PROGRESS-Plus characteristics

Of the seventeen included studies, twelve found evidence of a differences in use by participant characteristics (Table 13, Appendix 3.2), including differences in health literacy and numeracy, income and marital status. Most of the evidence indicated there was no evidence of a difference in use by age, gender, education or ethnicity. . Summary figures have been developed based on an adapted version of the Harvest plot, these will be referred to as the Adapted Harvest plot. The data are presented in separate figures for each PP variable.

Age

Studies varied in the age categories that were compared and are reported here as simply favouring older or younger groups with detailed information about the age of participants included in the text which follows.

Heterogeneous measures of use

The majority of the evidence (8/15 studies) indicated that there was no difference in intervention use by age (Figure 5). However, all of the evidence indicating there was no evidence of an effect came from studies of unclear or high/critical RoB. There was some evidence age influenced use in six of the 15 studies, although the direction of the effect was not consistent: three studies found that older people (Study IDs 5,6 and 14) used the intervention more than younger people, and three (IDs 7,8 and 17) found the opposite.

Figure 3 summarises the size and quality of this evidence. The largest number of studies pointed to evidence of no evidence of an effect with an overall sample of 1411, but many were high/ critical or unclear RoB. Overall the evidence was stronger that indicated younger people used the intervention more than the evidence older people used them more. The studies supporting younger people benefitting more from the intervention came from a total sample size of 751, in comparison to a total sample of 274 from studies supporting older people using the intervention more. The two studies with a low RoB show a positive (Study ID 5, n=146) or negative (Study ID 17, n=320) association of increasing age on use of the interventions. Nine of the studies that reported no evidence of an effect, provided p-values for the association between age and use with values ranging from some indication of an effect p=0.26 to no evidence of an effect p=0.97. Definitions of use and diabetes types varied between studies, but four studies used a common comparison (used/never used) and a pooled estimate could be calculated.

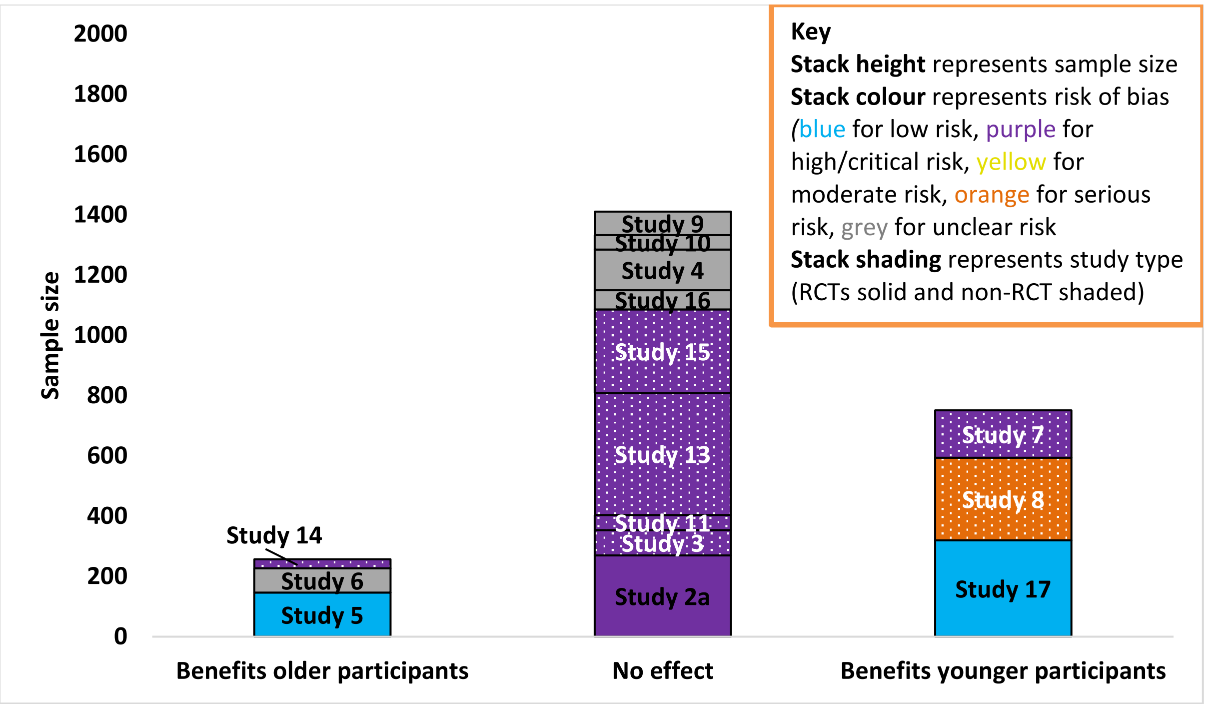


Figure 5: Differences in use by increasing age

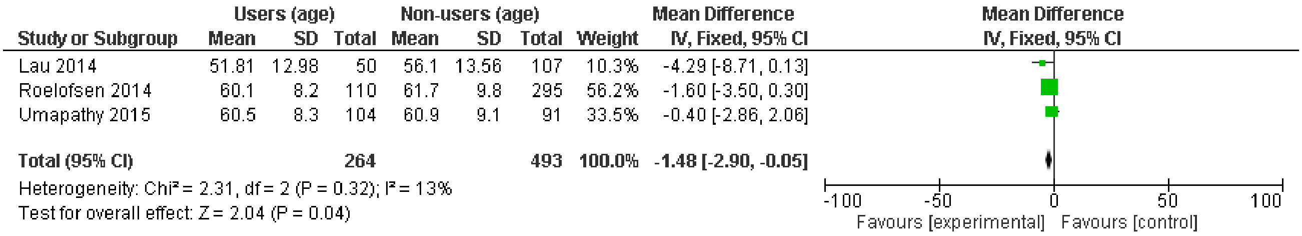
The strongest evidence that increasing age influences intervention use came from study ID 5, an RCT with 146 participants and a low RoB. Study 5 found that participants with T2D aged ≥63 years were more likely to be substantial users of an app (performed ≥5 blood glucose measurements each month and ≥50 interactions with the diary) of the app than the rest of the study population (OR 2.7; 95% CI 1.02-7.12; p=0.045).(Holmen, Torbjornsen et al. 2014) Study 6 of a web and SMS intervention for 12-20 year olds with chronic conditions including T1D did not report the interaction between PP variables and website use, but did report that those who used the SMS element of the intervention were on average older than those who did not (mean age of non-users 15 sd 2 vs users 17 sd 2 years, p = 0.01).(Huang, Terrones et al. 2014) Study 14 found that overall usage of their app for adults with people with T1D (number of items recorded by participants) was positively correlated with age (regression coefficient, 55.8 recordings/year; p=0.009), and adopters (defined as those without interruptions in their records) were more likely to be older than non-adopters (years mean difference 10.3, SE 3.80, p=0.01).(Skrovseth, Arsand et al. 2012)

The strongest evidence for the finding that younger people used the intervention more, came from study 17 an RCT with a low RoB and a sample of 320. The study found a trend for young people with T1D aged 11-12 being more likely to be participators (completed at least 4 sessions or 80%) (60.4%) than those aged 13-14 years (39.6%)($\chi 2$ 1=3.1, p=0.08).(Whittemore, Jaser et al. 2013) Study 8 found people in a younger subgroup (no study age range given) logged on more frequently to the POEM system (that provided medical care data and education program online) than people in older subgroups (degrees of freedom (d.f.) = 6, F = 7.813, p < 0.01).(Lee, Yeh et al. 2007) Study 7 explored the uptake of a web-portal for adults with T1 and T2 diabetes and found that users (≥1 log-ons) tended to be younger (mean difference of 4.28 years, p=0.061) than non-users.(Lau, Campbell et al. 2014)

Ever vs never measures of use

Meta-analysis was conducted for the three studies (Study IDs 7, 13 and 15) that reported the common outcome of ever accessed versus never accessed the intervention. Overall there was evidence that people who used the interventions were younger than those who did not (mean difference -1.48, 95%CI -2.90 to -0.05, z=2.04, p=0.04). Figure 6 shows the mean age of users and non-users, and the largest difference was found in Lau 2014 (Study ID 7).

Figure 6: Meta-analysis of the modification of intervention use by age



	Users (age)			Non-users (age)				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Fixed, 95% CI**
Lau 2014	51.81	12.98	50	56.1	13.56	107	10.3%	-4.29 [-8.71, 0.13]
Roelofsen 2014	60.1	8.2	110	61.7	9.8	295	56.2%	-1.60 [-3.50, 0.30]
Umapathy 2015	60.5	8.3	104	60.9	9.1	91	33.5%	-0.40 [-2.86, 2.06]
Total (95% CI)			**264**			**493**	**100.0%**	**-1.48 [-2.90, -0.05]**

Heterogeneity: Chi² = 2.31, df = 2 (P = 0.32); I² = 13%
Test for overall effect: Z = 2.04 (P = 0.04)

Gender

Heterogeneous measures of use

Most of the evidence (12/14 studies) indicated that use was not modified by gender (Figure 7). The overall sample of the studies finding no evidence of an effect was 2029 and the strongest evidence came from two low risk studies (ID 5 and 17, combined sample of 484). The other studies indicating no evidence of an effect were predominantly high/ critical risk of bias with three studies that were unclear. There was a weak indication that female participants engaged with the intervention more than males in two studies: study 3 was a non-RCT (n=84) had a critical RoB, and study 10 was an RCT (n=48) with an unclear overall risk. Eight of the studies finding no evidence of an effect provided p-values, and the range was some evidence of an effect p=0.10 (study 14), to no evidence p=0.97 (study id 13).Three studies used a common comparison (used/never used) and a pooled estimate could be calculated.

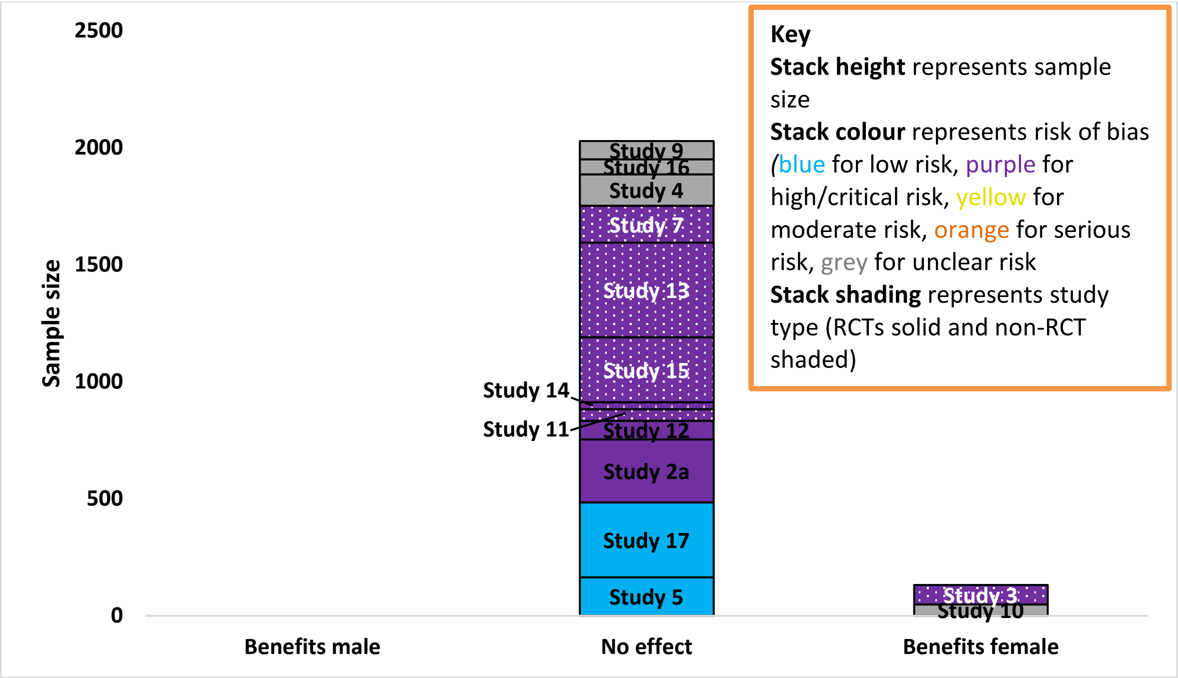


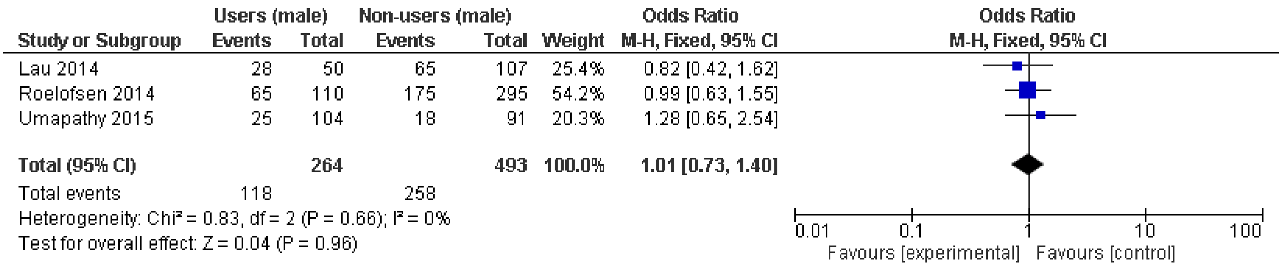
Figure 7: Differences in use by gender

Of the two studies that reported female participants used the intervention more than male participants, the strongest evidence came from the larger study (ID 3): they found that gender predicted which of the three groups of users the individual fell into, “minimal”, “intermittent-waning”, or “consistent users” in adults with T2D ages >=21 years. Female participants had higher odds of being “consistent users” (OR 19.55, 95% CI 1.78-215.42) than males in a multivariate logistic regression (but not in univariate analysis).(Goh, Tan et al. 2015) Study 10 explored the use of web-based problem-solving intervention by young adults aged 13-17 years with T1D. They found evidence that female participants engaged with the intervention more and consequently had a higher activities index (mean 22.6, SD 9.6; median 23) compared to the males (mean 16.5, SD 9.5; median 15; U=130.5, Z =2.08, p=0.038). They reported that this was a result of girls posting on the social forum considerably more often (Mean 7.1, SD 5.5; Median 6) than the boys (mean 3.6, SD 5.2; median 1; U=130.0, Z=2.13, p=0.03). (Mulvaney, Rothman et al. 2011)

Ever vs never measures of use

There was no evidence of a differences in use by gender across the three studies that explored the ever vs never used the intervention (Odds ratio 1.01, 95%CI 0.73 to 1.40, z=0.04, p=0.96) (Figure 8).

Figure 8: Meta-analysis of the modification of intervention uptake by gender



	Users (male)		Non-users (male)			Odds Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% CI
Lau 2014	28	50	65	107	25.4%	0.82 [0.42, 1.62]
Roelofsen 2014	65	110	175	295	54.2%	0.99 [0.63, 1.55]
Umapathy 2015	25	104	18	91	20.3%	1.28 [0.65, 2.54]
Total (95% CI)		**264**		**493**	**100.0%**	**1.01 [0.73, 1.40]**
Total events	118		258			

Heterogeneity: Chi² = 0.83, df = 2 (P = 0.66); I² = 0%

Test for overall effect: Z = 0.04 (P = 0.96)

Education

The eight studies that reported an interaction between education and use were conducted in four different countries with different education systems: Netherlands(Study IDs, 4,11 and 13)(Nijland, van Gemert-Pijnen et al. 2011, Heinrich, de Nooijer et al. 2012, Roelofsen, Hendriks et al. 2014) USA(Study ID 2, 2a and 9),(Glasgow, Christiansen et al. 2011, Glasgow, Strycker et al. 2014) Norway (Study IDs 5 and 16),(Wangberg, Bergmo et al. 2008, Holmen, Torbjornsen et al. 2014) and Taiwan(study ID 8).(Lee, Yeh et al. 2007) Each study used a reported different measure of educational attainment, including mean years of education, dichotomies of low/high education and qualifications attained(Figure 9).

Six of the eight studies reporting the interaction between education and intervention use found no evidence of an effect (Figure 9). The strongest evidence came from study 5 which indicated there was no evidence of an effect, with 164 participants and a low RoB. There was some evidence that people with higher levels of education were more likely to engage in the interventions in two (study 8 and 16), with a combined sample size of 338. Study 8 had a high RoB and study 16 had an unclear RoB. The studies where there was no evidence of an effect came from an overall sample of 1102, the majority of the studies were of high/critical risk, one study was low risk and two studies were unclear risk (studies 2a, 4, 5,9, 11 and 13). Three of these studies reporting an effect provided p-values: p= 0.77 (study ID 13) p=0.94 (study ID 11) and p=0.95 (study ID 9).

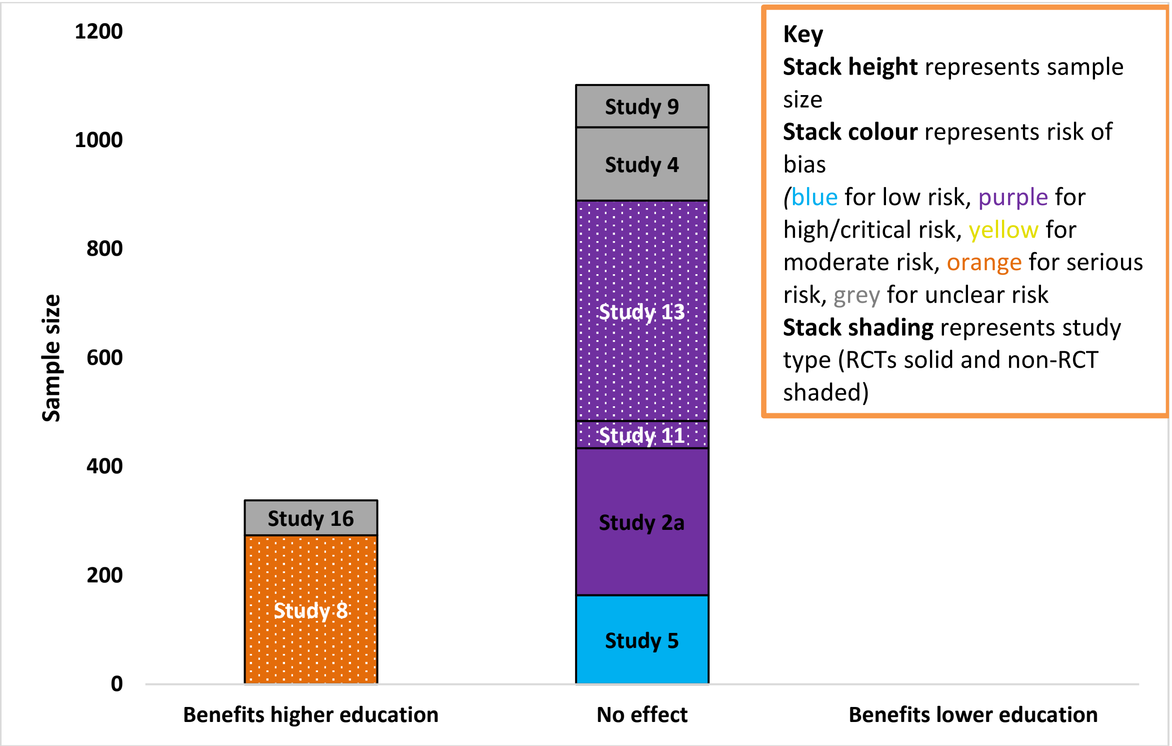


Figure 9: Differences in use by level of education

Of the two studies (ID 8 and 16) that found more educated people used the intervention more, the RoB was unclear and high. Study 8 was conducted in Taiwan (sample of 274 and a high RoB) reported that those who were educated to college or university level, logged onto the intervention more than those who had had elementary school/junior school education or were illiterate (d.f. = 4, F = 6.005, p < 0.01).(Lee, Yeh et al. 2007) Study 16 was conducted in Norway (sample size 64, RoB unclear) reported that average years in education was lower for those who those who logged on the website only once, (M = 2.1, CI = 1.6–2.7) compared with those who logged on more than once(M = 2.8, CI = 2.5–3.1).(Wangberg, Bergmo et al. 2008)

Health literacy and numeracy

One study (2 and 2a, high RoB n=270) explored the interaction between health literacy and different measures of use using two different methods of analysis. In Study ID 2 they found no strong association (p<0.19) between health literacy and five summary variables using Spearman nonparametric correlations.(Glasgow, Christiansen et al. 2011) In Study ID 2a the authors explored associations with engagement with the intervention at least monthly vs those who did not using recursive partitioning with signal detection analysis.(Glasgow, Strycker et al. 2014) Study ID 2 between health literacy and any of the five summary variables of use.(Glasgow, Christiansen et al. 2011) However, in Study 2a where the recursive partitioning approach was used to identify groups of people who engaged with the intervention most found that numeracy and health literacy, were significant predictors of website visits from baseline to 4 months.(Glasgow, Strycker et al. 2014) The approach considers the interaction between different groups rather than exploring dichotomous PP categories in isolation from one another. Glasgow et al. (2014) found those with higher numeracy (≥3.75) were more engaged with the intervention with 86.0% of them visiting at ≤1 a month compared to 70.2% in the lower numeracy group. Where higher numeracy and higher health literacy (≥5.00) intersected the level of engagement increased, with 88.6% being more engaged compared with those with lower health literacy (65.0%).(Glasgow, Strycker et al. 2014)

Ethnicity

All three of the studies that reported an interaction between ethnicity and intervention use were conducted in the USA.(Case, Jernigan V Fau - Gardner et al. 2009, Glasgow, Christiansen et al. 2011, Whittemore, Jaser et al. 2013, Glasgow, Strycker et al. 2014) The Adapted Harvest plot (Figure 10) presents analysis of differences between ethnic groups.

Two of the three studies that explored the interaction between ethnicity and intervention use, reported no evidence of an effect (overall sample size n=590). The strongest evidence came from study 17 which had a low RoB and a sample of 320 and indicated there was no detectable difference between ethnic groups compared. The remaining evidence of no evidence of an effect came from study 2(ID 2 and 2a) which was a study with a high RoB and study 9 which was unclear risk. One small study (ID 1, n=45) with an unclear RoB indicated that people from minority ethnic groups were less likely to use the intervention. Two of the studies that reported no evidence of an effect provided p-values, both indicating there was no association: p=0.37 (study 17) and p=0.75 (study 9).

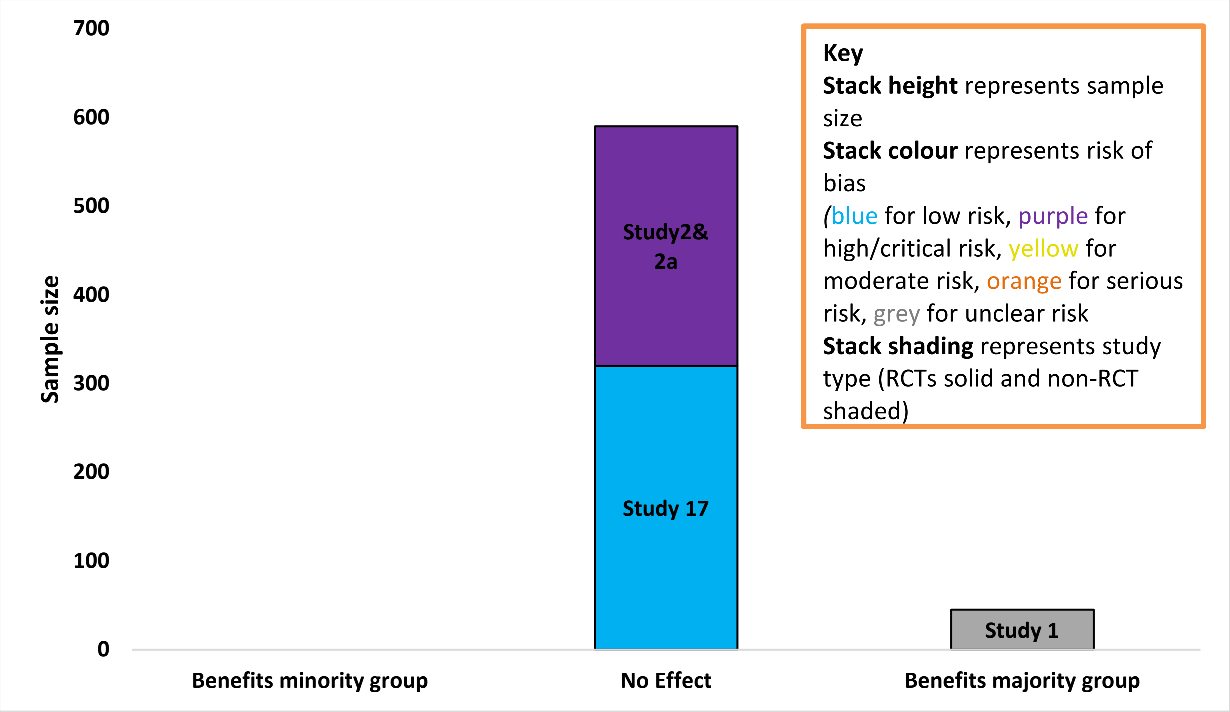


Figure 10: Differences in intervention use by ethnicity

Study 1 that found evidence of difference in use by ethnicity, reported bulletin board usage in a subset of 45 participants (15 each African American, Non-Hispanic white, and American Indians/Alaska Natives) from Lorig et al (2010) RCT.(Case, Jernigan V Fau - Gardner et al. 2009) The team found that African Americans wrote fewer posts overall (p=0.02) and American Indians/Alaska Natives wrote fewer action planning posts(p=0.05) in comparison to Caucasians. American Indians/Alaska Natives also logged into the programme for a shorter time than Caucasians (p=0.04).(Case, Jernigan V Fau - Gardner et al. 2009)

Income

Two studies explored the interaction between income and intervention use. One study indicated people with a higher income used the intervention more than those with lower incomes(study 17) and one indicated there was no evidence of an effect (study 2a) (Figure 11).(Whittemore, Jaser et al. 2013, Glasgow, Strycker et al. 2014) The strongest evidence was that income modified use and came from study 17 with low RoB (n=320),(Whittemore, Jaser et al. 2013) while the study 2 that found no evidence of an effect had a high RoB (n=463).(Glasgow, Strycker et al. 2014) In one study of youth aged 11-14 years with T1D there was evidenced that household income influenced engagement with the intervention ($\chi2$ 2=12.6, P=.002). Those in the lowest income group (annual household income <USA $40,000) were less likely to participate (complete <80% the sessions) in the intervention and those with the highest income (annual household income >USA $80,000) were most likely to participate(complete at least four sessions or >80%).(Whittemore, Jaser et al. 2013)

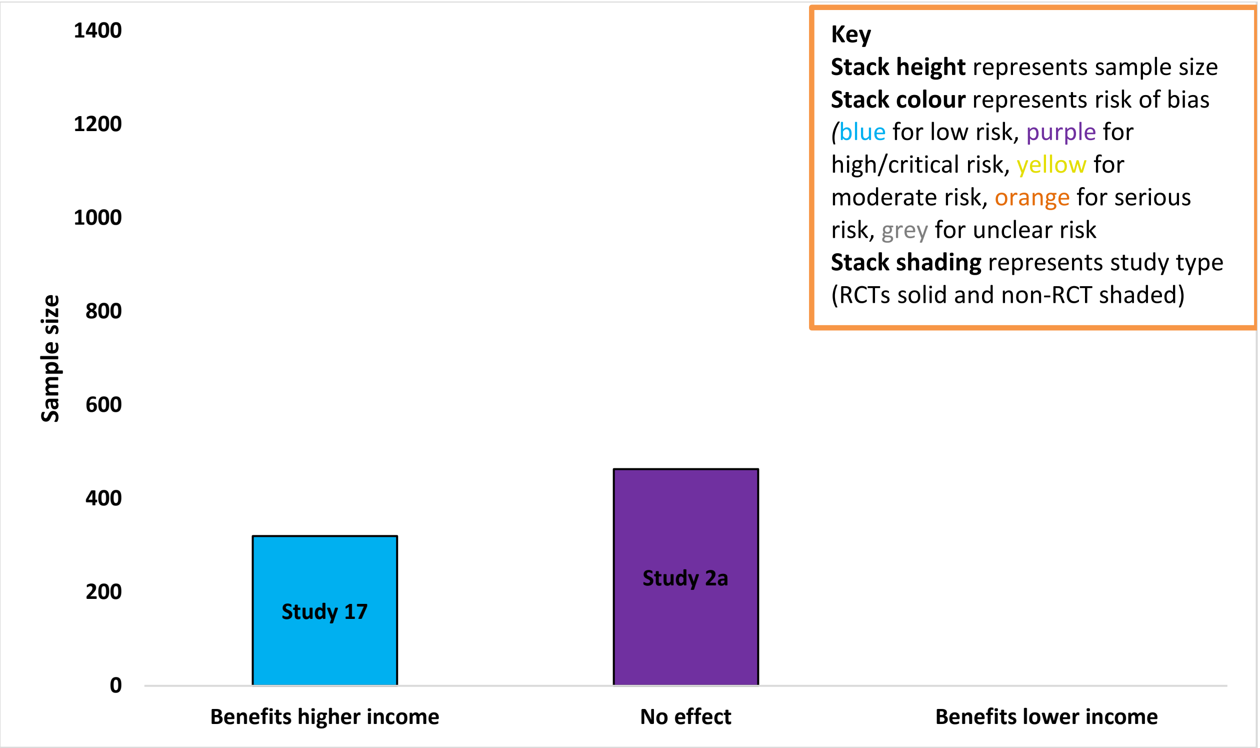


Figure 11: Differences in use by income

Employment and Health insurance status

Two other measures of available income reported were employment and health insurance status. There was no evidence of a differences in the characteristics of the people who ever vs never used the interventions in employment (categories provided in Table 3) in study 13,(Roelofsen, Hendriks et al. 2014) or health insurance status(categories provided in Table 3) in study 9.(McCarrier, Ralston et al. 2009)

Marital status

Two studies reported difference in intervention use by marital status, one found no evidence of a difference in use (study 2a) and the other found married people were more likely to use the intervention (study 9)(Figure 12). Study 9 that found evidence married people used the intervention more was unclear risk of bias and had a study sample of 73,(McCarrier, Ralston et al. 2009) while study 2a that found no evidence of a different was a larger study(n=270) with a high RoB.(Glasgow, Strycker et al. 2014) Study 9 found in people with T1D aged 21 to 49 years, there was evidence of a difference in the marital status of the non-users vs users A higher proportion of the users(engaged with at least one element of the web-based intervention on >one occasion) were married vs not married(68.8%) in comparison to the non-users (33.3%) (difference 35.4%, 95%CI 0.6- 62.3, Chi2=4.8, p=0.028). They did not investigate any interactions between gender and marital status on use.(McCarrier, Ralston et al. 2009)

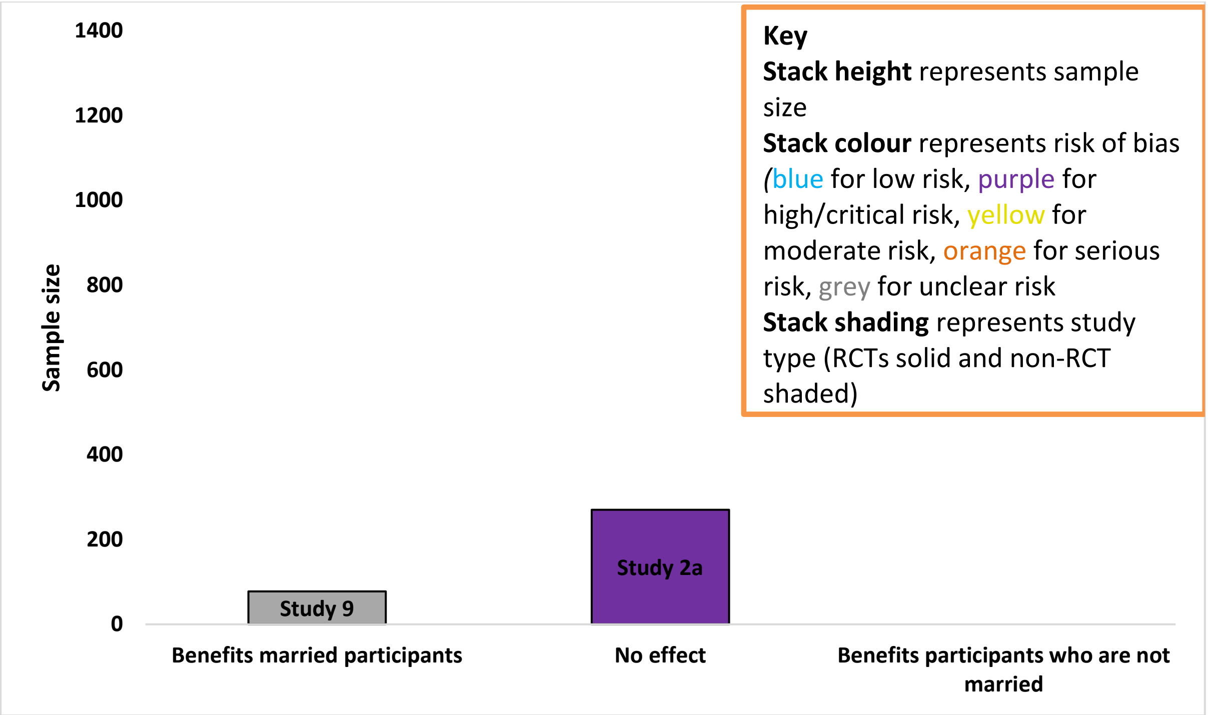


Figure 12: Differences in use for people by marital status

3.2.4. Potential explanations for the differences in use

No additional publications reporting interviews or any other investigation into why there were differences in intervention engagement or uptake were located.

3.3. Discussion

3.3.1. Summary of main findings

There was some evidence that people were more likely to use a web-based intervention if they had high health literacy, numeracy and income. However, most of this evidence came from a small number of studies with high RoB, so these conclusions should be treated with caution. The influence of marital status was unclear, with one small study of unclear RoB finding married people used the intervention more and one larger study with high RoB finding no evidence of a difference. The majority of the higher quality studies suggested there was no difference in use by gender, education or ethnicity. Modification of intervention use by employment and health insurance status were each examined in a single study, with no evidence of a differences found.(McCarrier, Ralston et al. 2009, Roelofsen, Hendriks et al. 2014) When the different measures of use were examined together, most of the evidence (all high/critical or unclear RoB) suggested that there was no difference in use by age. However, there were only two studies that were judged to be low RoB, both indicating age impacted on use but in different directions. One indicated older people with T2D used the intervention more than younger people in a study of adults (≥18 years old).(Holmen, Torbjornsen et al. 2014) The other study indicated that younger people used the intervention more in a sample of people with T1D aged 11–14 years.(Whittemore, Jaser et al. 2013) The meta-analysis of the studies that reported the ever vs never measure of use, indicated that people who ever accessed (i.e. including just once) the intervention were younger than people who never accessed the intervention. These mixed findings for age may be the consequence of differences in study age ranges, unrepresentative study populations, heterogeneity in measures of use or variation in the appeal of intervention designs. Summary of available data indicted issues with study size and high RoB across the included studies. There was no exploration of why the differences were occurring as reported by the study teams in these papers, and no further papers could be found investigation these differences.

3.3.2. Strengths and weaknesses

The review was rigorously conducted according to the Cochrane review guidelines(Henderson, Craig et al. 2010) and the chapter follows the PRISMA-Equity 2012 extension checklist.(Welch, Petticrew et al. 2012) The review involved a two-stage inclusion criteria, to capture relevant papers that had conducted analysis exploring modification of intervention use by participant characteristics but had not summarised these analyses or findings in the abstract. Study teams were contacted to obtain estimates for reported analysis when they were not included in the papers. Simple vote counting was not judged appropriate for synthesis of findings that could not be meta-analysed. Instead, a novel summary figure was created based on the Harvest plot referred to here as the ‘Adapted Harvest plot’. The Adapted Harvest plot provided an indication of strength of the evidence for narrative synthesis by including study size and risk of bias.

The breadth of the studies reviewed here is both a strength and a weakness of the methods used. Where similar outcomes were used across heterogeneous interventions for different conditions we can be confident all relevant studies were included and reviewed. However, the decision to investigate four different physical health conditions also meant that it was not possible combine the evidence in cases where the outcomes targeted were heterogeneous. This limits the possibility of extrapolating the findings to all high burden chronic conditions, or even to the four targeted by the systematic review.

The decision to report the two types of diabetes together is also a source of heterogeneity and difficulty in this review. In this systematic review both interventions for people with T1D and T2D were reported together. This decision was made because the intervention designs and outcomes were similar in studies targeting people with T1D and T2D. Several studies also explored the application of a single intervention for both conditions. The differences in the experiences of T1D and T2D will be discussed in Chapter 8.

The final issue with the methodology of this systematic review was that the majority of the screening was conducted by one person, and only 10% of the abstracts and titles were double reviewed. This is in-line with previous practice where a large number of studies were located, partial double screening with checks for accuracy were used.(Andrews, Thompson et al. 2012, Thompson, Vodicka et al. 2013, Vodicka, Thompson et al. 2013, Cabral, Horwood et al. 2014, Lucas, Cabral et al. 2015) This decision was made for pragmatic reasons because there were no resources to employ a second reviewer. Double assessment of bias was conducted on all of the included studies.

3.3.3. Limitations of the evidence base

There were several major limitations to the studies included in these systematic reviews. The evidence-base was dominated by diabetes studies, and with the exception of one study of osteoarthritis, evidence of differences in use came from these studies alone. Risk of bias was an issue in the majority of the studies. Due to the absence of published study protocols, it was not possible to establish whether there was selective reporting in measures of use or effectiveness. The measurements of use and effectiveness often appeared to be decided post-hoc from exploration of the data. None of the studies reported intended dose in comparison to actual dose. Therefore, it was not possible to establish whether the participant used the intervention enough to generate the intended change in behaviour, and whether this varied in people with different social characteristics. Inconsistencies in reporting of estimates and heterogeneity in use outcomes reported, meant it was not possible to meta-analyse most of the data and strength of associations could not be determined.

There was a high risk of selection bias across the included studies which may have excluded people from lower SES groups. Most of the studies used eligibility criteria that excluded people without access to the internet, digital tools to access the intervention (e.g. smartphone or computer at home) or skills to use the internet or intervention. People with lower SES and ethnic minority groups who are considered to be most disadvantaged in terms of health outcomes and access to healthcare have also been found to have lower levels of access to the internet and digital skills.(Stellefson, Chaney et al. 2008, van Deursen and van Dijk 2010, Furler, Harris et al. 2011) Therefore, while these are logical exclusion criteria for a study investigating web-based interventions, these digital specific inclusion criteria may be inadvertently creating barriers to study entry for those who are already disadvantaged in terms of health inequities in addition to previously evidenced barriers to involvement in research.(Mattson, Curb et al. 1985, Dennis and Neese 2000, Ford, Howerton et al. 2008, Ejiogu, Norbeck et al. 2011) Measures of deprivation were often not reported by study teams and representativeness of the study population in comparison to the general population of people with the condition was rarely discussed. Those studies that did comment on representativeness of the study population, indicated that the samples tended to be more white people, with higher levels of education. Those that expressed an interest in entering the non-RCTs studies may also be a self-selecting group of people interested in using technology. This not only limits generalisability of study findings, but also potentially masks differences in use that may have been present between more and less advantaged groups, because the sample is underpowered to detect difference in these subgroups.

The complexities of the literature of why social characteristics might impact use or engagement with online interventions was not considered carefully in the studies included in this review. The range of different PP characteristics explored and the comparisons within the PP characteristic appeared to be decided post-hoc and did not appear to be guided by theory. For example, studies of adults covered a range of ages. The study teams also used different age-related cut offs to define, older and younger groups. This may have contributed to the mixed findings for age. Consequently, the implications of findings for health inequities is unclear.

Evidence is beginning to mount that individual social characteristics do not work in isolation but interact in complex ways that influence health outcomes.(Collins and Blige 2016) As such, conducting analysis involving the comparison of individual groups may not be sufficient to establish how digital self-care interventions may impact health inequities (this will be discussed further in chapter 8). This was demonstrated by the two Glasgow et al.(2011 and 2014) papers that found no evidence of health literacy modifying use when considered in isolation, but when interacting with high numeracy, higher literacy was found to increase use.(Glasgow, Christiansen et al. 2011, Glasgow, Strycker et al. 2014)

Both the Cochrane RoB and the ROBINS-I tool had limitations in evaluating bias in the data that were important for this systematic review. The Cochrane RoB tool focuses on the importance of balancing the samples in the arms of the study but neglects the importance of ensuring that the sample was representative of the general population with the condition. If interventions (digital or otherwise) are not evaluated in a representative population, it is not possible to establish whether the intervention will be effective and be used by the whole patient population, or just the demographic of people who interacted with the research. The ROBINS-I tool addressed issues with recruitment bias, but it was not possible to use the ‘bias in intervention classification’ category because none of the studies had control groups that had not been provided an intervention.

This author could not locate published investigation of why differences were occurring in use and effectiveness of interventions by social groups. Therefore, it was not possible to establish the reasons for the differences. Reasons why people may or may not choose to use interventions in their everyday lives will be explored in a qualitative study covered in Chapters 5-7.

3.3.4. In the context of other literature

There have been two systematic reviews exploring differences in use of web-based behaviour change interventions in the literature. One review focussed on adherence (amount of the intervention completed) in psychological interventions, and the other, on engagement with interventions for chronic conditions.(Beatty and Binnion 2016, Perski, Blandford et al. 2017) In common with this review, a previous systematic review by Beatty et al.(2016) of adherence to online psychological interventions in adults also reported mixed findings for age; with five studies indicating older people had higher adherence and four indicating younger people had higher adherence.(Beatty and Binnion 2016) Perski et al.’s (2017) large review of web-based interventions for chronic conditions reported a trend towards older people using the intervention more than younger people.(Perski, Blandford et al. 2017) Both previous reviews found that women were more likely to engage with web-based psychological interventions and those for chronic conditions, whereas this review concluded there was no difference.(Beatty and Binnion 2016, Perski, Blandford et al. 2017) Beatty et al.(2016) found no evidence of an association between adherence and marital status, and this review found mixed evidence for this social characteristic.(Beatty and Binnion 2016) This review and the two previous reviews agreed that there was no evidence that ethnicity or employment modified use.(Beatty and Binnion 2016, Perski, Blandford et al. 2017) Neither of the previous reviews explored income, health literacy or numeracy.

Perski et al.(2017) also found that people with higher education used the intervention more, where this review and Beatty et al.'s(2016) review did not.(Beatty and Binnion 2016, Perski, Blandford et al. 2017) However, both health literacy and numeracy were found to interact with one another to influence use in this review. High numeracy interacted with higher health literacy which was associated with greater engagement with an intervention. Health literacy has been proposed to be involved in the underlying mechanisms that drives the well-documented relationship between lower levels of education and poorer health status.(van der Heide, Wang et al. 2013) Numeracy has also been associated with education and those with lower levels of numeracy (and literacy) have been found to be those from low income backgrounds and ethnic minorities.(Education 2018) Low attainment in numeracy and literacy has been associated with the complex interactions in the social environment.(Education 2018) Therefore, both health literacy and numeracy could be markers of educational attainment that influence and are influenced by the social context.

Eligibility criteria of the included studies may have masked the true barriers to using the included web-based interventions for those from lower SES and ethnic minority groups. Previous evidence has indicated that people are less likely to engage in a number of different eHealth activities (such as health information seeking) and non-digital self-care programmes if they are have lower incomes, lower education and are from an ethnicity minority group.(Gilmour 2007, Protheroe, Nutbeam et al. 2009, Brouwer, Oenema et al. 2010, Furler, Harris et al. 2011, Hardiker and Grant 2011, Kennedy, Bower et al. 2013, Kontos, Blake et al. 2014, Nölke, Mensing et al. 2015, Jacobs, Amuta et al. 2017) It could therefore be expected that people from these groups would also be less likely to use web-based interventions. This review did find some evidence that lower income participants engaged with interventions less, although there was not strong evidence those with lower education or from minority ethnic groups were less engaged with the interventions. The absence of evidence for differences in use by education and ethnicity may have been related to the exclusion criteria (internet access, digital skills, language barriers) used in most of the studies. Those with lower education and minority ethnic groups have been found to be less likely to have access to and use the internet or have skills to use the technology.(Stellefson, Chaney et al. 2008, Furler, Harris et al. 2011) Therefore, the studies may have excluded the more deprived groups from entering the study, resulting in a sample that was not diverse enough to detect a difference. This is likely to be particularly true for some of the non-RCT studies where people self-selected into the studies based on interest in the digital intervention. The mixed findings for age may be the consequence of differences in study age ranges, heterogeneity in measures of use, or variation in the usability and appeal of intervention designs.

3.3.5. Recommendations specific to the systematic reviews

Implications for intervention design, policy, practice will be covered in Chapter 8, only recommendations for research are made here.

For research into the effectiveness and use of web-based health interventions, teams should stipulate intended or minimum required levels of engagement *a priori*, and findings should be reported against these. This will provide a more meaningful measure of use that would establish whether the participant used the intervention enough to generate the intended change in behaviour. This will allow for useful comparisons of users and non-users and comparison between studies on this basis. This has been highly recommended in the CONSORT eHealth 2012 checklist.(Eysenbach 2011)

Study teams should routinely report modification of intervention use and effectiveness by participant characteristics to ensure groups of people are not excluded by new innovations in healthcare. Theory should be used to select PP groups that may be disadvantaged by the digital intervention and comparator categories within these groups. These analyses should be specified *a priori* in the study protocol rather than investigated post-hoc. Estimates and standard error should also be reported for all modification analysis rather than those that reach the p<0.05 cut off, so strength of the relationship can be established by other research groups.

Eligibility criteria and recruitment strategy should be carefully considered to ensure the intervention is evaluated in a population representative of those with the health condition. Study teams should consider whether their eligibility criteria will exclude disadvantaged groups and where possible take measures to adjust the design of the study so it is more inclusive. Study teams should report whether the sample is representative of the wider population with the health condition. Where samples are unbalanced, an additional focus should be made to recruiting a underrepresented groups to ensure intervention effectiveness and use is evaluated for people with different characteristics, rather than people who are the easiest to recruit.(Windsong 2018)

The Adapted Harvest plot provides a communication tool that could be used by other research groups to represent the strength and quality of evidence of difference in intervention effectiveness and use by social groups. Limitations in the literature exploring differences in intervention effectiveness and use include inconsistent reporting of statistics and heterogeneity of outcomes. These limitations mean that it is not always possible to conduct meta-analysis or produce Forest plots. The Forest plots have the benefit of providing a clear graphical depiction of the study size, direction of effect and strength of evidence through presentation of estimates. Ogilvie et al. (2008) developed the Harvest plot to provide a graphical synthesis of evidence in the context of social inequalities in smoking, in an attempt to tackle the complexities and diversity of the evidence base.(Ogilvie, Fayter et al. 2008) The Adapted Harvest plot was developed because the original Harvest plot did not provide a measure of the strength of evidence and was also challenging to replicate in software packages. This Adapted Harvest plot allows for the comparison of the strength of evidence through providing sample sizes and the quality of the evidence by presenting study RoB. The plot was generated using excel and would be easy to replicate by other researchers. Therefore, in a field where the limitations in the literature make the use of Forest plots largely unviable the Adapted Harvest plot concisely presents complex information and allows for visual comparison of the strength and quality of evidence.

3.3.6. Conclusions

There was some evidence that people were more likely to use a web-based intervention if they had high health literacy, numeracy and income. However, most of this evidence came from a small number of studies and had a high risk of bias so these conclusions should be treated with caution. The influence of marital status and age was unclear. There was no evidence of differences in use by gender, education, ethnicity, employment and insurance status. Several important limitations in methodology and reporting in the included studies contributed to issues with quality and consequently limited the strength of the evidence. Were these to be addressed by study teams developing and evaluating future interventions, the contribution to the literature would be significantly improved.

CHAPTER 4. SYSTEMATIC REVIEW RESULTS AND DISCUSSION 2: DIFFERENCES IN EFFECTIVENESS

4.1. Chapter overview

This chapter presents the results and discussion for the systematic review exploring differences in effectiveness of web-based interventions by people with different characteristics. Of the research questions outlined in Chapter 1 (Section 1.5), this review was designed to address the following primary research questions:

2) For those who do use the intervention is there a difference in the effectiveness of web-based behavioural change interventions for the self-care of high burden chronic health conditions across SE and cultural groups?

3) Why there may be any differences in use or effectiveness by SE and cultural groups?

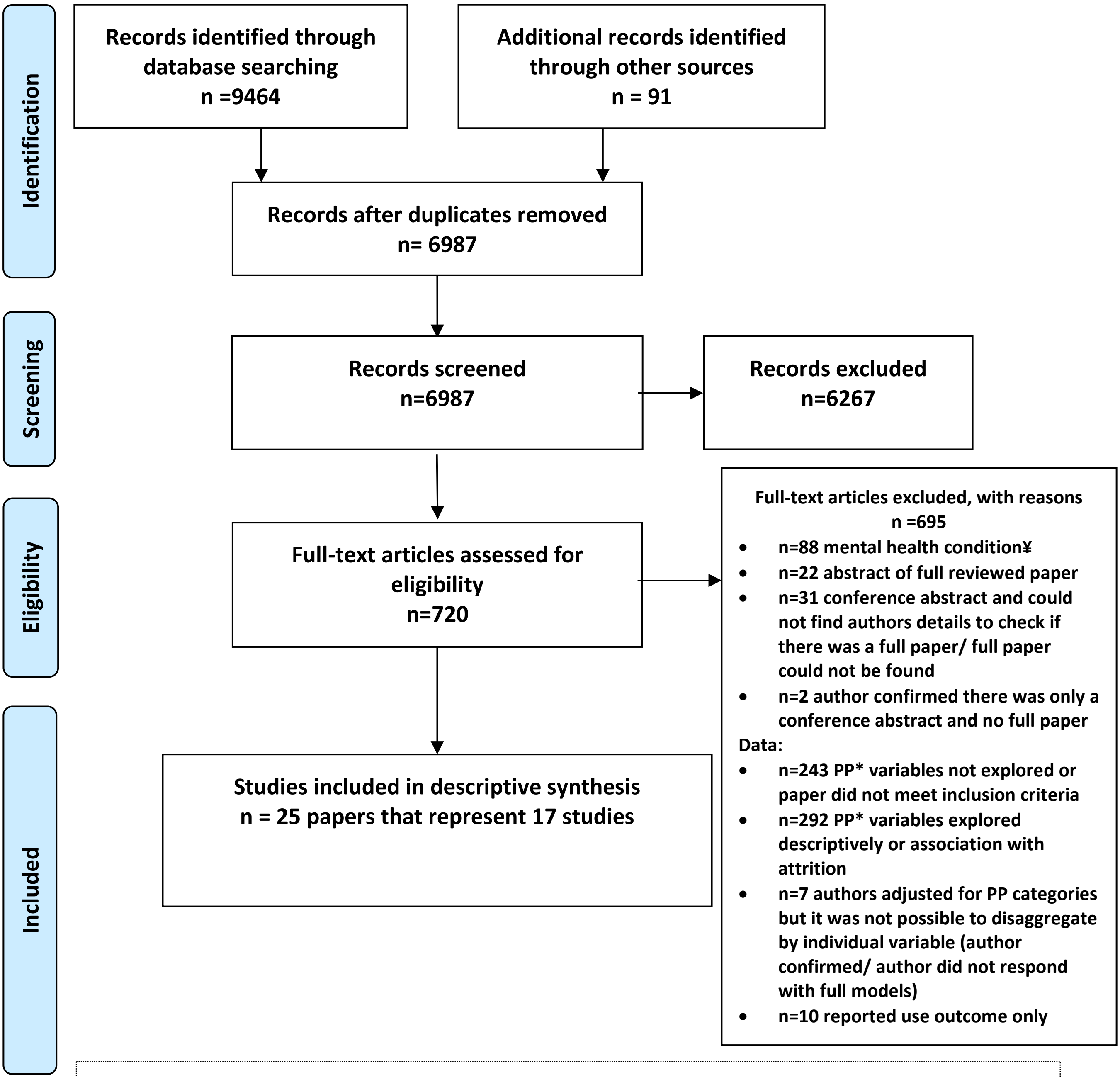
And, a secondary research question:

2) Can differences in intervention effectiveness for different SE and cultural groups be attributed to the application of theory or behavioural change techniques (BCTs)to intervention design?

4.2. Results

4.2.1. Selection of studies

The PRISMA flowchart in Figure 13 gives an overview of the selection procedure. Four physical health conditions were included in the search: asthma, Chronic Obstructive Pulmonary Disease (COPD), diabetes (T1D and T2D) and osteoarthritis. Following removal of duplicates, 6987 records were obtained. Following screening based on title, abstract, and full text, 6267 articles were removed. The agreement for the 10% of titles and abstracts screened by the two reviewers was 87.5% and the PABAK for the reviewers was 0.75 indicating good agreement, with a prevalence index of 0.74 and a bias index of -0.09.[4] Of the 720 full texts screened, 695 were excluded. Table 14 (Appendix 4.1) outlines the papers that met the inclusion criteria but the analysis of interest was not presented, the data could not be disaggregated by PP group or where the paper could not be located. The table also provides details of steps taken to obtain the disaggregated data. Reasons for exclusion are available in Figure 13. Ultimately, 25 articles fulfilled the criteria representing 17 studies and included all four of target health conditions.



Footnote:
¥= The mental health conditions were excluded post hoc
*= PP(PROGRESS-Plus)

Figure 13: PRISMA flow chart

4.2.2. Description of included studies

There was overlap in the studies investigated in this chapter and Chapter 3 where studies provided either a single paper covering difference in use and effectiveness by PROGRESS-Plus (PP) group or provided several papers that covered both separately. Of the 25 papers and 17 studies in this review, eight studies and nine papers were replicated that covered both effectiveness and use(highlighted in

Table 5).

Table 5: Characteristics of included studies and populations

Study ID, Author, year of publication	Study details (study type, health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	Main outcome targeted by intervention	Control/ Comparator	Covered in Chapter 3
Studies that reported the interaction between PP groups and intervention effectiveness						
ID 1, Moy,2015	RCT, COPD, Veterans from the United States and Puerto Rico identified from a national database of veterans who had received medical services in the previous year, USA	**239**	**Inclusion**: Aged ≥ 40 years, COPD, emphysema, or chronic bronchitis based on ICD-9-CM codes, Could walk a minimum of one block, Sedentary (< 150 min of self-reported physical exercise per week), Has health-care provider who can give medical clearance; Could provide informed consent, Checked email weekly, Access to a computer with internet, a USB port, and Windows XP, Vista, 7, or 8, Not involved in another pedometer-based walking program **Exclusion**:	**Health**: health related QoL **Behavioural**: physical activity	Control wait list-Control subjects were instructed to wear the pedometer every day. They received no instructions about exercise, were not assigned step-count goals, and had access to a webpage that only showed a count of what week they were in the study. At the end of the 12-month study, they were given the option to participate in the Internet-mediated intervention.	No-effectiveness only

Study ID, Author, year of publication	Study details (study type, health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	Main outcome targeted by intervention	Control/ Comparator	Covered in Chapter 3
			Belong to one of the Veterans Integrated Service Networks, where another study using the intervention platform was recruiting participants.			
ID 2, Voncken-Brewster, 2015	RCT, COPD, Recruited from the Dutch online panel assembled by the company Flycatcher Internet Research BV (www.flycatcher.eu) Netherlands	**1325**	**Inclusion:** Aged 40–70 years, Diagnosed with COPD or were at moderate or high risk for COPD, Proficient in Dutch, Access to the Internet, Basic computer skills.	**Behavioural**: smoking cessation and physical activity	Could receive usual care or use other resources in order to help them manage their disease or improve their lifestyle.	No-effectiveness only
ID 3, Glasgow, 2012, USA ID 3a, Glasgow, 2014	RCT, T2D, Conducted in five primary-care clinics within Kaiser Permanente Colorado (KPCO). Clinics were selected based on variability in size, location, and SES of neighbourhood, and to maximize percentage of Latino patients, USA	**3) 463** **3a) 270 (secondary analysis of 3))**	**Inclusion**: 25–75 years, T2 D diagnosed Body mass index (BMI) > 25 and at least one other risk factor for heart disease, Access to telephone Internet, Read and write in English or Spanish, Able to perform mild to moderate physical activity.	**Health**: blood pressure **Behavioural**:(overall behavioural change): eating habits, fat intake, physical activity & medical adherence **Psychosocial**: self-efficacy	Enhanced usual care- EUC provided computer-based health risk appraisal feedback and recommended preventive care behaviours using the same contact schedule as CASM but did not include the key intervention procedures. Eligible to participate in other traditional non-digital diabetes interventions (e.g. education classes)	Yes- Glasgow et al. (2012)was a new paper covering effectiveness only, Glasgow et al.(2014) covered both use and effectiveness and was included in Chapter 3
ID 4, Heinrich, 2012	RCT, T2D Conducted online, Netherlands	Not clearly given but looks like 166. n=135 used in	**Inclusion**: diagnosis of T2D aged 40–70 years **Exclusion**:	**Knowledge**: Diabetes knowledge	There were two control groups: with a pre-test (T0) and one post-test after two weeks (T1)	Yes- paper covered both use and effectiveness

Study ID, Author, year of publication	Study details (study type, health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	Main outcome targeted by intervention	Control/ Comparator	Covered in Chapter 3
		analysis, T2D	if they already used the Diabetes Interactive Education Programme		participants were allocated to the experimental group (A), the control group (B) or the post-test only control group (C). The latter was included to assess possible test effects of completing the pre-test on post-test knowledge scores. Only the experimental group (A) had access to DIEP for two weeks. Both control groups received access after the post-test.	
ID 5,Huang, 2014	RCT, Chronic Illness (Inflammatory bowel disease(IBD), cystic fibrosis (CF), and T1D) Tertiary care paediatric academic medical centre serving~1million adolescents, USA	**81**	**Inclusion**: Aged 12-22 years, IBD, CF, or T1D Without cognitive impairment	**Health**: disease status **Behavioural**: self-management, **Psychosocial**: self-efficacy	Controls received monthly messages via mail or e-mail (participant preference) addressing general health issues. Disease-specific information was provided as appropriate. Usual healthcare communication portals were available to controls.	Yes- paper covered both use and effectiveness
ID 6, Istepanian, 2009	RCT, T1D and T2D	**137**	**Inclusion**: >18 years	**Health**: blood pressure, blood glucose	Received their care from the diabetes	No-effectiveness only

Study ID, Author, year of publication	Study details (study type, health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	Main outcome targeted by intervention	Control/ Comparator	Covered in Chapter 3
	Thomas Addison Diabetes Centre at St George's Hospital in South London, UK which serves the inner-city population characterized by a diverse ethnic mix 22% of residents belong to a non-white minority ethnic group and a social deprivation score is higher than national average, UK		Ambulant, Diabetes and either receiving treatment for hypertension/with an untreated blood pressure > 130/80 mmHg **Exclusion**: Physical inability to self-monitor blood glucose/blood pressure, Pregnancy, Life threatening/ terminal illness, Inability to provide written informed consent.		centre and/or the local practitioners according to normal practices	
ID 7, Lorig, 2010	RCT, T2D, Recruitment via the internet, print and broadcast media. Special effort was made to recruit AI/AN participants using Web sites and media associated with tribal and AI/AN organizations, USA	**761**	**Inclusion** Aged ≥18 years, Physician-verified T2D, Not pregnant or in care for cancer, Access to the internet.	**Health**: HbA1c, fewer symptoms **Behaviour**: exercise **Psychosocial**: self-efficacy	Usual-care participants were not restricted from seeking additional care or programs. After 6 months, usual-care participants in AI/AN subgroup were offered the program. All other usual-care participants continued as control subjects through the 18 months of the study.	Yes- Chapter 3 included a paper by Case et al. which was a subset of this study.(Case, Jernigan V Fau - Gardner et al. 2009) The Lorig paper describes the full study.
ID 8, Pacaud, 2012	RCT, T2D, Study participants were recruited from the Building Healthy Lifestyles diabetes self-care education program,	**79**	**Inclusion**: Newly diagnosed T2D referred to the Building Healthy Lifestyles program, Access to a computer connected to the internet,	**Health**: HbA1c **Knowledge**: diabetes knowledge **Psychosocial**: self-efficacy	Control group: used synchronous interactions with providers through direct verbal communication and	Yes- paper covered both use and effectiveness

Study ID, Author, year of publication	Study details (study type, health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	Main outcome targeted by intervention	Control/ Comparator	Covered in Chapter 3
	Canada		Computer literate, No other complicating health conditions, Not involved in another research study.		used an eHealth technology to support, but not replace, their structured diabetes education and their face-to-face learning task. They received paper-based educational materials and normal follow-up care.	
ID 9,Whittemore, 2012 ID 9a) Grey, 2013	RCT, T1D, Recruited at paediatric diabetes clinics associated with four university sites (Yale, The Children's Hospital of Philadelphia, University of Arizona, and University of Miami) representing a range of racial, ethnic, and SE backgrounds, reflective of the national prevalence of T1D in youth, USA	**320**	**Inclusion**: Aged 11–14 years, T1D for ≥ 6 months, In school grade appropriate for age, Never been exposed to coping skills training materials, No other significant health problem, Access to high-speed Internet service Research staff assisted any adolescent without home Internet to gain access at a school, local library, or clinic.	**Health**: HbA1c **Psychosocial**: quality of life, self-efficacy as a secondary outcome. secondary outcomes could not be disaggregated by PP categories.	Managing diabetes- served as the attention control condition: five sessions were released weekly over 5 weeks. The sessions included case-studies with culturally relevant content and problem-solving activities. The sessions included images and were tailored and interactive.	Yes- Study covered in Chapter 3 in Whittemore et al. (2013)(Whittemore, Jaser et al. 2013) which covered use only. ID 9 and ID 9a cover differences in use only.
ID 10, Yu, 2014,	Single-arm pre-post cohort study, T2D, Two family practices and two endocrinology clinics in Toronto, Canada	**81**	**Inclusion**: Aged ≥ 25 years At least one of: HbA1c > 7.0% (53 mmol/mol), systolic blood pressure > 130 mmHg, low-density-lipoprotein cholesterol (LDL-	**Psychosocial**: self-efficacy	None	No-effectiveness only

Study ID, Author, year of publication	Study details (study type, health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	Main outcome targeted by intervention	Control/ Comparator	Covered in Chapter 3
			C) > 2.0 mmol/L, or body mass index (BMI) > 25 kg/m2. **Exclusion**: Had Canadian Cardiovascular Society class 3 or 4 angina, Did not speak English, Not available for follow-up, No regular access to telephone and internet.			
ID 11, Nevedal, 2013	One-group pre-test post-test, Pain (Including: joint, back, Osteoarthritis, migraine, neuropathy), Participants were employed by participating US companies or a member participating US health care plans. Participating employers and health care plans purchased the Web-based, digital pain management program (HealthMedia Inc. Care for your Pain digital health-coaching program), USA	**645**	**Inclusion:** Employed by participating US companies or a member of participating US health care plans	**Health:** pain experience (intensity, unpleasantness and impact on daily activities **Psychosocial:** depression and self-efficacy	None	No-effectiveness only
Studies were PP groups were investigated as predictors of outcomes						
ID 12, Edwards, 2006	RCT, T1D and T2D Conducted online, UK	**710**	**Inclusion**: Not clearly stated although participants were asked before randomisation about their last home blood glucose monitoring result or last HbA1c result to assess both familiarity with these	**Psychosocial**: conflict or uncertainty about control of diabetes	Control: provided with information based on British Medical Journal 'Best Treatments' without enhanced representation of information	No-effectiveness only

Study ID, Author, year of publication	Study details (study type, health condition, setting, location)	Study sample size	Inclusion and exclusion criteria	Main outcome targeted by intervention	Control/ Comparator	Covered in Chapter 3
			readings and with UK measurement scales.			
ID 13, Holmen, 2014 ID 13a, Torbjornsen, 2014	RCT, T2D Participants were from the Northern and South-eastern part of Norway, Norway		**Inclusion**: Aged ≥18 years, HbA1c level ≥7.1% (54.1 mmol/mol), Capable of completing questionnaires Norwegian, Cognitively able to participate and to use the system, although prior familiarity with mobile phones was not necessary.	**Health**: change in HbA1c	Usual care by their GP according to national guidelines. Additional visits were recommended to monitor HbA1c, fasting glucose, weight, and blood pressure every 2-6 months according to the needs of the patient	Yes- Holmen et al.(2014) covered both use and effectiveness and was described in Chapter 3. Torbjornsen et al.(2014) is a new paper covering only effectiveness
ID 14, Joseph, 2007 ID 14a, Joseph, 2010	RCT, Asthma, Recruited via caregivers in six Detroit public high schools, where 98% of students were African American and just over half qualified for free school lunches, USA	**314**	**Inclusion:** Asthma- defined as ever having a physician diagnosis of asthma accompanied by: daytime and/or night time symptoms, or the use of medication for asthma, symptoms in the past 30 days, medical care use for asthma in the past year, and ≥1 more refills of β-agonists in the past year. Or if they did not report a physician diagnosis, but answered positively to items from ISAAC, and reported symptom frequencies similar to those used in the EPRII for classification of mild, intermittent asthma	**Behaviour**: (controller medication adherence, rescue inhaler availability, and smoking cessation/reduction)	Control: were restricted to existing generic asthma sites and could not access links for outside programs or general-interest sites. To regulate dosage, control students were given four computer sessions for up to 30 minutes in line with the number of tailored sessions administered to the treatment group	No-effectiveness only

Study ID, Author, year of publication	**Study details (study type, health condition, setting, location)**	**Study sample size**	**Inclusion and exclusion criteria**	**Main outcome targeted by intervention**	**Control/ Comparator**	**Covered in Chapter 3**
ID 15, Skrovseth, 2015	RCT- stepped-wedge trial with two groups, T1D, Division of Internal Medicine, University Hospital of North Norway, Tromsø, Norway	**30**	**Inclusion:** >18 years, Diagnosis of T1D ≥1 year; Basic familiarity with mobile phones, Use a mobile phone on a daily basis. **Exclusion**: Pregnancy, Inability to understand the guidelines when presented with the app, Severe complications attributed to the diabetes that would render participation unethical or medically challenging	**Health**: number of hypoglycaemic and hyperglycaemic events	Control-Both group 1 and 2 received the intervention & had a period with no intervention	No-effectiveness only
ID 16, Wangberg, 2008	RCT, T1D and T2D, Conducted online, Norway	**61**	**Inclusion**: Aged 17-67 years, T1D/T2D Access to the internet.	**Behaviour**: self-care	None	This is the primary paper for the Wangberg et al.(2008)use analysis presented in Chapter 3.(Wangberg, Bergmo et al. 2008)
Wyatt, 2008, USA	One-group pre-test post-test quasi-experimental design, Asthma Recruited from participating rural public elementary schools, USA	**35**	**Inclusion**: Ability to complete assent forms, Without cognitive, psychiatric, or behavioural disturbances identified by the school nurse, Moderate to severe asthma based on the NAEPP-recommended rating scale	**Knowledge**: asthma **Psychosocial**: attitude	None	No-effectiveness only

Study design

The studies included a mixture of RCTs and non-RCTs. Of the 17 included studies, 14 were RCTs,(Edwards, Thomas et al. 2006, Joseph, Peterson et al. 2007, Wangberg 2008, Istepanian, Sungoor et al. 2009, Lorig, Ritter et al. 2010, Glasgow, Kurz et al. 2012, Heinrich, de Nooijer et al. 2012, Pacaud, Kelley et al. 2012, Whittemore, Jaser et al. 2012, Huang, Terrones et al. 2014, Torbjornsen 2014, Moy, Collins et al. 2015, Skrovseth, Arsand et al. 2015, Voncken-Brewster, Tange et al. 2015): eight were described as RCTs with no further detail,(Joseph, Peterson et al. 2007, Wangberg 2008, Lorig, Ritter et al. 2010, Glasgow, Kurz et al. 2012, Pacaud, Kelley et al. 2012, Huang, Terrones et al. 2014, Moy, Collins et al. 2015, Voncken-Brewster, Tange et al. 2015) one was a two by two factorial design(this review only),(Edwards, Thomas et al. 2006) one was a pre-test post-test trial,(Heinrich, de Nooijer et al. 2012) two parallel group studies,(Whittemore, Jaser et al. 2012) and one this review only,(Istepanian, Sungoor et al. 2009) one stepped-wedge trial,(Skrovseth, Arsand et al. 2015) and one 3-armed trial.(Holmen, Torbjornsen et al. 2014, Torbjornsen 2014) There were three non-RCTs: one single-group pre-test post-test quasi-experimental design pilot study,(Wyatt and Hauenstein 2008) and two single-arm pre-post cohort study.(Nevedal, Wang et al. 2013, Yu, Parsons et al. 2014)

Study participants

There were two asthma studies;(Joseph, Peterson et al. 2007, Wyatt and Hauenstein 2008, Joseph 2010) two COPD studies;(Moy, Collins et al. 2015, Voncken-Brewster, Tange et al. 2015) 12 diabetes studies, of which three focussed on T1,(Whittemore, Jaser et al. 2012, Huang, Terrones et al. 2014, Skrovseth, Arsand et al. 2015) six on T2,(Lorig, Ritter et al. 2010, Glasgow, Kurz et al. 2012, Heinrich, de Nooijer et al. 2012, Pacaud, Kelley et al. 2012, Torbjornsen 2014, Yu, Parsons et al. 2014) and three both;(Edwards, Thomas et al. 2006, Wangberg 2008, Istepanian, Sungoor et al. 2009) and one study explored the effectiveness of a pain management intervention and included people with osteoarthritis.(Nevedal, Wang et al. 2013)

All studies described patient eligibility criteria based on condition (either previously diagnosed or meeting pre-specified diagnostic criteria). The majority of the studies also specified an age range. Age ranges for the eligible criteria were between 12 and 75 years across the studies (some studies had no upper limit). Both asthma studies focussed on children: one school aged children,(Joseph, Peterson et al. 2007) the other children aged 8 to 11 years.(Wyatt and Hauenstein 2008) Both COPD studies focussed on older adults: one Veterans from the United States and Puerto Rico aged ≥ 40 years old,(Moy, Collins et al. 2015) and the other 40-70 years.(Voncken-Brewster, Tange et al. 2015) Of the 12 diabetes studies, two focussed on younger people with T1D : one teen and young adults aged 12-22 years,(Huang, Terrones et al. 2014) and one youth ages 11–14 years.(Whittemore, Jaser et al. 2012) Ten of the diabetes studies focussed on adults, including both T1D and T2D. Of these, five investigated adults with T2D only, aged: 25–75 years,(Glasgow, Kurz et al. 2012) 40–70 years,(Heinrich, de Nooijer et al. 2012) >18 years,(Torbjornsen 2014) ≥ 25 years, (Yu, Parsons et al. 2014) and one did not specify an age group.(Pacaud, Kelley et al. 2012) One study focussed on people with T1D only aged >18 years.(Skrovseth, Arsand et al. 2015) Three studies included people with both T1D and T2D aged: 17 - 67 years ,(Wangberg 2008) >18 years,(Istepanian, Sungoor et al. 2009, Lorig, Ritter et al. 2010) and one did not specify an age group.(Edwards, Thomas et al. 2006)

The study that included people with osteoarthritis did not specify an age range, but the participants were all of employment age and were being supplied the intervention as part of their health care plan.(Nevedal, Wang et al. 2013)

People were also excluded from studies if they did not have access to the internet,(Wangberg 2008, Lorig, Ritter et al. 2010, Glasgow, Kurz et al. 2012, Pacaud, Kelley et al. 2012, Glasgow, Strycker et al. 2014, Yu, Parsons et al. 2014, Moy, Collins et al. 2015) have access to the technology to run the intervention(e.g. smartphone),(Pacaud, Kelley et al. 2012, Yu, Parsons et al. 2014, Moy, Collins et al. 2015) or understanding/skills to use the relevant technology or the internet,(Pacaud, Kelley et al. 2012, Holmen, Torbjornsen et al. 2014, Skrovseth, Arsand et al. 2015) that they checked their emails once or more a week,(Moy, Collins et al. 2015)did not understand the language of the intervention,(Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014, Holmen, Torbjornsen et al. 2014, Voncken-Brewster, Tange et al. 2015) they had existing or previous mental health conditions(2 studies), they had a cognitive impairment,(Wyatt and Hauenstein 2008, Istepanian, Sungoor et al. 2009, Whittemore, Jaser et al. 2012, Holmen, Torbjornsen et al. 2014, Huang, Terrones et al. 2014, Moy, Collins et al. 2015, Skrovseth, Arsand et al. 2015) having a level of physical ability, (Istepanian, Sungoor et al. 2009, Moy, Collins et al. 2015) were pregnant,(Istepanian, Sungoor et al. 2009, Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014, Skrovseth, Arsand et al. 2015) had other ‘complicating’ health conditions or were terminally ill,(Istepanian, Sungoor et al. 2009, Lorig, Ritter et al. 2010, Pacaud, Kelley et al. 2012, Whittemore, Jaser et al. 2012) or had previously been exposed to coping skills training materials(Table 5).(Whittemore, Jaser et al. 2012)

In total, 5611 participants were included in the 17 studies. Study size ranged from 30 to 1378 (Table 6). Just over half of the participants across the studies were female (53%) and the percentage varied between 6% (COPD study) and 76.5%(T2D study). Ten of the 17 studies reported ethnicity. Only one study reported that the ethnic make-up of the study was representative of the country the study was conducted in.(Wyatt and Hauenstein 2008) Four studies purposely recruited a highly diverse sample in terms of ethnicity,(Istepanian, Sungoor et al. 2009, Lorig, Ritter et al. 2010, Whittemore, Jaser et al. 2012, Glasgow, Strycker et al. 2014) and one study recruited from schools where over 98% of students were African American.(Joseph, Peterson et al. 2007) Six studies provided information about the participants educational attainment and four provided occupation information: most people had greater than 12 years of education (range 39%-89%) and were employed (range 51-69%). Income data were provided in three studies: where 51% of had a household income of ≥$80,000/year in one study,(Whittemore, Jaser et al. 2012), one study 17.5% of participants had a household income of ≥$90,000,(Glasgow, Kurz et al. 2012) and in the final study 42% had a household income of ≥ $60000-$89999.(Yu, Parsons et al. 2014) One study reported that the patients enrolled in the study were representative of the population with diabetes.(Istepanian, Sungoor et al. 2009)

Table 6: Demographics of study samples

Study	Study ID	Sample size	Age (median/mean years (measure of error where provided®)	Female (%)	Ethnic group (%)	Education (%)	Employment (%)	Income (%)	Other PP category (%)
Studies that reported the interaction between PP groups and intervention effectiveness									
Moy,2015	1	239	67 ±SD 9.0	6					Rural residence 45.0
Voncken-Brewster, 2015	2	1325	57.6±SD 7.2	52.0	Primary school/basic vocational school 29.5 Secondary vocational school/high school degree 32.7 Higher professional degree/university degree 37.8		Employed 51.3 Not employed 48.7		**Marital status:** Single/divorced/widowed 26.6 In relationship/living together/married 73.4
Glasgow, 2012, USA	3 & 3a	3)463 3a)219	58.4 ±SD 9.2	49.8	*AI/AN 6.7, Asian 1.6, AA 15.4, White 72.0, Latin 21.8	≤High school 19.1		< $49,999 47.3, $50,000 - $89,999 35.2, ≥$90,000 17.5	
Heinrich, 2012	4	135	Experimental group(A) 56.0± SD7.0 Control group (B)56.0±SD 7.0, Control group (C) 59.0± SD6.0	(A) 56.0, (B) 48.0, (C) 53.0		Low education group (A) 35.0 (B) 43.0 (C) 25.0, Middle (A) 35.0 (B) 30.0(C) 28.0, High (A) 30.0 (B) 27.0 (C) 47.0			
Huang, 2014	5	81	17.0 (IQR 16.0–18.0)	54.3	*White 33.3, Black 9.9, Hispanic 37.0, AI/AN 1.2, Other 6.2				
Istepanian, 2009	6	137	61.0		Caucasian 41.0 African-Caribbean 23.0				

					Indo-Asian 35.0 Other 1.0				
Lorig, 2010	7	45	*AIs/ANs 53.7, AAs 52.3, CC 50.5	NA	*AIs/ANs: 33.3 AAs 33.3 CC 33.3	Average (years) AIs/ANs 15.7, AAs 16.1, Caucasians 15.9			
Pacaud, 2012	8	79	54.2±SD 9.1	52.9					75.6% lived in an urban centre
Whittemore,2012 Grey, 2013	9 & 9a	320	12.3 ±SD1.1	55.0	White 72.0			High family income (≥$80,000/year) 51.0	
Yu, 2014,	10		20–39 years 9.0 40–59 years 46.0 60–79 years 44.0 > 80 years 1.0	46.0	White 62.0 Asian 30.0 African American 7.0 Hispanic 1.0	< High school 1.0 High school 14.0 College 26.0 University 59.0	Employed 56.0 Retired 30.0 Unemployed 9.0 Disability 2.0 Student 4.0	<$15000: 21.0 $15000-29999: 10.0 $30000-59999: 27.0 $60000-$89999: 28.0 >$90000:14.0	
Studies were PP groups were investigated as predictors of outcomes									
Edwards, 2006	11	710		60.8	White British 86.4 Other white 5.3 Asian British 1.8 Mixed white and Asian 1.0				**Country of origin**: United Kingdom 93.9 USA 0.8 Missing data 1.8
Holmen, 2014 Torbjornsen, 2014	12 & 12a	164	57.0± SD12.0	41		<12 years of education 55.0	Employed 53.4, Unemployed 27.7, Retired 18.9		
Joseph, 2007 Joseph, 2010	13 & 13a	314	15.3± SD 1.0	63.4	>98% of students in the participating schools were African American			Estimated/person, mean (SD) $12,049 ± SD$2,442).	average of 52% of students qualified for federal school lunch programs
Nevedal, 2013	14	645	22-29 years 2.2 30-39 years 8.4	69.3	White 78.8 African American 8.4		Professional 18.7		

			40-49 years 17.2 50-59 years 33.5 60-69 years 23.1 70-91 years15.7		Hispanic 5.9 Other 6.9		Clerical/admin support 21.7 Not working outside home 31.5 Sales/tech support service 15.7 Executive/senior manager/administration 5.9 Production/operator/labourer 6.6		
Skrovseth, 2015	15	30	39.70± SD 10.8	63.3					
Wangberg, 2008	16	64	Low SEMμ group 37.3(CI 33.2-41.4), High SEMμ group 42.9 (CI 38.0-47.9)	Low SEMμ 63.0, high SEMμ 50.0		≤12 years of education Low SEMμ 11.0, high SEMμ 8.0			
Wyatt, 2008, USA	17	35	8 years 43.0 9 years 20.0 10 years 26.0 11 years 11.0	46.0	Non-Hispanic white 57%				

*AI/AN=American Indian/Alaska Native, AA=African American, CC= Caucasian

®(±Standard Deviation(SD) /interquartile range(IQR)/range/Confidence interval(CI))

μ Self-efficacy matched

Intervention content and outcomes targeted by the intervention

Descriptions of interventions are provided in Table 7 and summarised below. The Behavioural Change Techniques(BCTs) and theory used in intervention design are discussed. The authors described applying a diverse range of BCTs to bring about the desired change in their participants. Descriptions of BCTs were not standardised, with the exception of one study, which described their BCTs in the context of Michie's Behavioural Change Wheel.(Michie, van Stralen et al. 2011) To allow for comparison of BCTs applied across the included studies, the BCTs were categorised into the highest hierarchical levels presented in Michie's Taxonomy of BCTs.(Michie, Richardson et al. 2013) The BCTs mapped on to seven of the 16 high level BCT groups described in Michie's Taxonomy of BCTs: Goals and Planning; Feedback & monitoring; Self-belief; Comparison of behaviours; Shaping knowledge; Social support, and; Reward and threat (Appendix 4.2).

Asthma

Both Asthma studies were developed in the USA and aimed at school-age children. 'Puff City' was a web-based programme designed specifically with urban African American children in mind. It consisted of four consecutive educational computer sessions that made use of both normative ("compared with other students") and ipsative feedback ("compared with their last session"). Messages were voiced-over to accommodate low literacy. The BCT used was shaping knowledge and the intervention was developed based on the Transtheoretical and the Health Belief Model. The intervention was designed to target three core behaviours: medication adherence, "rescue inhaler availability", and smoking cessation.(Joseph, Peterson et al. 2007)

'Okay with Asthma' was an online program, developed for school nurses to use with children in health offices. The content included traditional Asthma management and psychosocial management strategies in a multimedia technique using a digital story, designed to support conflict resolution. The BCT used by the intervention was shaping knowledge and the psychosocial management strategies utilised by the intervention were based on the bio-behavioural family model.(Wood & Miller, 2002) The target outcomes were Asthma knowledge and the psychosocial outcome of change in attitude.(Wyatt and Hauenstein 2008)

COPD

'Taking Healthy Steps' (THS) was an internet-mediated pedometer-based walking intervention developed in the USA, aimed at improving health-related QoL and physical activity. The BCTs used were goals and planning, feedback and monitoring, shaping knowledge and social support through online communities. The intervention was developed based on self-regulation theory., and the goal setting was "based on Lock and Latham's demonstration that high, hard goals improve performance as long as the goals are not too high".(Moy, Collins et al. 2015)

'MasterYourBreath' was a web-based application developed in the Netherlands providing computer-generated tailored feedback to encourage smoking cessation and physical activity. The BCTs used were feedback and monitoring, goals and planning, comparison of behaviours and self-belief. They used the I-Change theoretical framework to support the development of their intervention. This framework includes the Attitude-Social Influence, Self-efficacy model, which incorporates ideas from the Theory of Planned Behaviour, the Social Cognitive Theory, the Transtheoretical Model, the Health Belief Model, and Implementation and Goal setting theories. (Voncken-Brewster, Tange et al. 2015)

Diabetes

Of the 12 web-based interventions for diabetes self-management, three were evaluating apps and nine were evaluating websites. Two studies explored the effectiveness of two different versions of the same app both in people with T1D. The early iteration was referred to as the Few Touch App (FTA), and the second as Diabetes Diary. (Holmen, Torbjornsen et al. 2014, Skrovseth, Arsand et al. 2015)

Intervention content and behavioural change techniques

Details of the intervention content are provided in Table 7. The interventions used a BCTs. Using the 16 highest clustered groups presented in Michie's taxonomy of BCTs,(Michie, Richardson et al. 2013) the most commonly used techniques were: Shaping knowledge (15 studies), feedback and monitoring (13 studies), goals and planning (9 studies), comparison of behaviours (6 studies), social support (5 studies), self-belief (5 studies), and reward and threat (1 study)(Table 7). In addition to providing interventions with the above features, three interventions provided external linked technology or materials. One study had an accompanying book, so the intervention consisted of the online interactive training plus the book.(Lorig, Ritter et al. 2010) The three studies (two studies evaluating the use of the FTA/Diabetes Diary app) provided a blood glucose monitor that enabled automatic transfer of measurements to the app through a wireless Bluetooth connection.(Istepanian, Sungoor et al. 2009, Holmen, Torbjornsen et al. 2014, Skrovseth, Arsand et al. 2015)

In four studies there were two different versions of the intervention being investigated. In all studies the second version provided the main intervention plus addition external support (e.g. email, or phone support).(Lorig, Ritter et al. 2010, Glasgow, Kurz et al. 2012, Pacaud, Kelley et al. 2012, Torbjornsen 2014)

Theory

Five of the 12 interventions reported that the intervention was developed based on a specific theory. Four used social cognitive theory, two used this theory alone,(Wangberg 2008, Huang, Terrones et al. 2014) and two used it alongside another theory, one with the addition of the social-ecological model,(Glasgow, Kurz et al. 2012) one with the addition of the stress adaption model.(Whittemore, Jaser et al. 2012) One intervention was developed using self-efficacy theory.(Yu, Parsons et al. 2014)

Targeted outcomes

Seven of the interventions were designed to primarily address a single outcome:

1) Health outcomes: one intervention aimed to lower HbA1c in people with T2D,(Torbjornsen 2014) one blood pressure in people with both T1D and T2D (Istepanian, Sungoor et al. 2009)

and one the number of hypoglycaemic and hyperglycaemic events for people with T1D.(Skrovseth, Arsand et al. 2015)

2) Behavioural outcomes: one intervention addressed change in self-care in people with T1 and T2D.(Wangberg 2008)
3) Knowledge outcome: one aimed to improve diabetes knowledge in people with T2D.(Heinrich, de Nooijer et al. 2012)
4) Psychosocial: one focused on self-efficacy in T2D (Yu, Parsons et al. 2014) and one conflict or uncertainty about control of diabetes in people with both T1D and T2D.(Edwards, Thomas et al. 2006)

Five of the interventions were designed to target multiple outcomes. Two targeted multiple outcomes in people with T1D. One aimed to change disease status, self-care and self-efficacy in adolescents transitioning to adult care with chronic illnesses including inflammatory bowel disease, cystic fibrosis.(Huang, Terrones et al. 2014) One aimed to lower HbA1c and improve psychosocial QoL in adults with T1D.(Whittemore, Jaser et al. 2012)

Three focused on changing multiple outcomes in people with T2D. One targeted blood pressure, a combined measure of behavioural change (eating habits, fat intake, physical activity & medical adherence) and self-efficacy;(Glasgow, Kurz et al. 2012) one HbA1c, exercise and self-efficacy,(Lorig, Ritter et al. 2010) and; one HbA1c, diabetes knowledge and self-efficacy.(Pacaud, Kelley et al. 2012) There was no clear differentiation between the outcomes selected for the interventions explored in people with T1D, T2D or in both conditions.

Studies that explored intervention effectiveness in both T1D and T2D

Four interventions explored the effect of the intervention on both T1D and T2D. Each of the four interventions targeted one main outcome : conflict or uncertainty about control of diabetes,(Edwards, Thomas et al. 2006) blood pressure,(Istepanian, Sungoor et al. 2009) and self-care.(Wangberg 2008) None of these studies provided a different version of the interventions depending on type of diabetes or addressed the possibility that the people with the two different types of diabetes may respond differently to the intervention. Three of the studies reported the proportion of people with T1D and T2D in the sample and discussed this in terms of representation of the general population.(Edwards, Thomas et al. 2006, Wangberg 2008, Istepanian, Sungoor et al. 2009) Two mentioned that socio-demographic and treatment variables(Edwards, Thomas et al. 2006) and baseline characteristics(Wangberg 2008)were controlled for in the intervention, but they did not specify which variables and diabetes type were not mentioned. None of the four studies explored difference in intervention effectiveness between the two types of diabetes.

Osteoarthritis

The 'HealthMedia Inc. Care for your Pain digital health-coaching program' was a web-based coaching program that provided behaviourally orientated tailored content, that aimed to emulate the interaction with a behavioural pain management expert. It was designed to improve pain to different patient populations including osteoarthritis. The BCTs used were shaping knowledge, goals and planning, self-belief and feedback and monitoring. The intervention was developed using evidence-based theories of "cognitive behavioural treatment, chronic disease self-management, motivational enhancement, and theories of health behaviour change, including social cognitive theory, theory of reasoned action, theory of planned behaviour, and self-determination theory".(Nevedal, Wang et al. 2013) The aim of the intervention was to reduce pain experience (intensity, unpleasantness and impact on daily activities), decrease depression and improve self-efficacy.(Nevedal, Wang et al. 2013)

Studies exploring multiple chronic conditions

One study explored intervention effectiveness in adolescents aged 12-20 years old with inflammatory bowel disease (IBD), cystic fibrosis (CF), and T1D transitioning into adult care.(Huang, Terrones et al. 2014) The intervention was designed to target disease management, self-efficacy and communication and therefore did not differ from the studies that were focussing on diabetes alone. The purpose of the study was to investigate whether a generic intervention could support a range of chronic illnesses and selected the conditions for their diversity in clinical course and disease burden. They thoroughly addressed the decision to explore the three conditions, made appropriate statistical adjustments and discussed the implications. Disease-specific case studies were provided. They provided proportions of the three disease types in sample and controlled for disease group in the effectiveness analysis, finding no evidence of a modification of intervention effect on the outcomes.

Another study explored the effectiveness of a pain management programme on adults who self-reported chronic pain and were either employed by participating US companies or participated in health plans that offered the 'HealthMedia' programme as part of their population health offerings and/or health benefit structure. One of the key aims of the study was to establish baseline characteristics that were associated with response (clinically meaningful change in pain composite score) or non-response to the intervention. Of the 645 people who consented into the study,27% indicated they suffered from osteoarthritis. The study team explored difference in intervention responsiveness in those with different types of pain as one of the baseline measures and reported those where the *P* value <.05. They found that self-reported back pain, fibromyalgia and neuropathy modified intervention responsiveness.(Nevedal, Wang et al. 2013)

Modification of intervention design for the needs of the target group

None of the studies adapted the intervention for the populations they targeted, other than having the intervention available in Spanish and English.(Lorig, Ritter et al. 2010, Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014) The study that targeted AI/AN also had the intervention available in Spanish, but this is unlikely to have had an impact as this is not the native language of this group.(Lorig, Ritter et al. 2010)

Table 7: Intervention description

Study ID, Author, Year of publication, Condition	**Type of intervention**	**Intervention content**	**Intervention features Categorised using Michie's higher levels of the Behaviour change Taxonomy**	**Applied Theory**	**External technology or support**	**Duration of intervention, Follow-up**	**Attrition (numerator number without outcome, denominator number randomised)**
Studies that reported the interaction between PP groups and intervention effectiveness							
ID 1, Moy,2015, COPD	Website	Taking Healthy Steps (THS): Internet-mediated, pedometer-based walking program to promote physical activity. Provided iterative step-count feedback, individualized step-count goals, education on disease self-management, motivational support, and an online community of social support. Tailored algorithms based on the data provided dynamic individualised incremental walking goals and feedback about success at meeting goals. Online communities allowed users to interact by posting messages.	• Goals and planning • Feedback and monitoring • Social support • Shaping knowledge	Self-regulation theory. Goal setting is based on Lock and Latham's demonstration that high, hard goals improve performance as long as the goals are not too high	None	12 months, 4-month follow-up	13/239 5.5%
ID 2, Voncken-Brewster, 2015, COPD	App	"MasterYourBreath": web-based application providing computer-generated tailored feedback. The app had two behaviour-change, smoking cessation and physical activity modules. Modules were divided into six intervention components: (1) feedback on the behaviour based on Dutch guidelines; (2)feedback on perceived positive and negative consequences of the behaviour; (3) feedback on the social influences on the behaviour; (4) goal setting and action plans; (5) self-efficacy: (6) maintenance: feedback in order to maintain the healthy behaviour.. Feedback was personalised using participants' names and	• Feedback and monitoring • Goals and planning • Comparison of behaviours Self-belief	I-Change model as theoretical framework in their intervention. This model includes the Attitude-Social influence-Self-efficacy model, which incorporates ideas of the Theory of Planned Behaviour, the Social Cognitive	None	Use the application ad libitum for 6 months, 6-month follow-up	254/1325 19.0%

		tailored to participants' characteristics and key behaviour determinants of psychosocial constructs(I-Change model theoretical framework).		Theory, the Trans-theoretical Model, the Health Belief Model, and Implementation and Goal setting theories			
ID 3, Glasgow, 2012, USA, T2D ID 3a, Glasgow, 2014, T2D	Website	3) Computer-assisted self-management (CASM): Participants selected daily goals, recorded progress and received feedback on success reaching goals. The website graphically displayed the patient's HbA1c, blood pressure, and cholesterol results. There was a moderated forum and community resources. After 6 weeks, participants created new personalized goals, identified barriers to achieving the (revised) goal(s) , and chose from a list of problem-solving strategies. 3a) CASM+SS was the CASM program with the addition of 2 phone calls from an interventionist, and an invitation to attend three group visits with other participants.	• Feedback and monitoring • Comparison of behaviour • Social support • Goals and planning • Shaping knowledge • Self-belief • Reward and threat	Social cognitive theory and a social-ecological model were the primary intervention frameworks used.	None	Not clear, 4 months & 12 months follow-up	3 &3a) 105/463 22.7%
ID 4, Heinrich, 2012, T2D	Website	Diabetes Interactive Education Programme: gave an overview of T2D management in seven chapters. Information was provided on basic and more advanced levels. Each chapter closed with questions to the patient, and had a workbook with goal setting forms, checklists on self-management behaviours and space.to note down questions for their HCP.	• Shaping knowledge • Goals and planning	Not specified, however, they mention selecting theory-based methods	None	2 weeks, 2 weeks follow-up	n = 31/166 18.7% (13 excluded, 9 dropped out before study start and 9 before the post-test)
ID 5,Huang, 2014, Chronic Illness (Inflammatory bowel disease(IBD), cystic fibrosis (CF), and T1D)	Website	MD2ME: monitored disease symptoms, responded to monitoring with appropriate treatments, and actively worked with HCPs to manage care. Subjects logged in to a web site weekly to receive materials outlining common disease management, communication skills, and lifestyle tips. Disease-specific case studies were	• Feedback and monitoring • Shaping knowledge • Self-belief	Bandura's Social Cognitive Theory.	None	8 months, 2 months & 8 months follow-up	6/81 7.4%

		provided.MD2Me An automated SMS algorithm provided disease management decision support, and a health care team communications portal. Subjects could use SMS to report health concerns. Subject concerns were relayed to the health care team depending on urgency.	• Comparison of behaviours				
ID 6, Istepanian, 2009, T1D & T2D	App	Mobile Health: structured into three main elements: 1) blood glucose and blood pressure devices with Bluetooth connectivity. Recordings were performed weekly. The mobile phone signalled when a measurement was due. 2) The web interface and patients journals could be accessed by the nurse or the doctor 3) Web-based patient journal that allowed the patient to interact with the nurse.	• Feedback and monitoring	None mentioned	Blood glucose monitor	Not covered- mentions weekly recordings- reported number of readings uploaded in 7.5 months, Recorded weekly up until 9 months	Not covered- drop outs after baseline. Only numbers at randomisation given
ID 7, Lorig, 2010, T2D	Website	There were two versions of the intervention 1) Internet-based diabetes self-management program (IDSMP): based on English- and Spanish-language peer-led small-group diabetes self-management programs. Consists of six weekly sessions. Activities included: Learning Centre (questions and actions). Discussion Centre: with bulletin boards populated by responses made in the Learning Centre, and new threads started by participants. My Tools with: exercise and medication logs, audio relaxation exercises, meal planning, and glucose-monitoring tools and links to other diabetes-related Web sites. Post Office: participants and facilitators could write private, messages to each other. 2) IDSMP plus email reinforcement	• Feedback and monitoring • Social support • Goals and planning • Shaping knowledge • Comparison of behaviour	None provided	A book, Living a Healthy Life with Chronic Conditions. Specific sections of this book were referenced in the Learning Centre.	6 weeks, The subgroup analysis was reported at 6-month follow-up only	29/761 3.8%
ID 8, Pacaud, 2012, T2D	Website	There were 2 interventions 1) Web static: e-mail with providers and a second type of eHealth technology (e.g. electronic blood	• Feedback and monitoring	None mentioned- custom built eHealth system,	None	Not clear mentioned 3 months to 12	11/79 13.9%

		glucose journal) to support their electronic learning. They received follow-up care via virtual appointments with providers using e-mail communication 2) Web interactive: used e-mail and private and public chats with providers and other patients and use of a third type of eHealth technology (electronic blood glucose journal and additional functional e.g. bulletin board) to support their electronic learning and to access education and tools. They received normal care via virtual appointments with providers using e-mail and private chats.	• Shaping knowledge • Social support	developed by the research team in consultation with a diabetes education clinic		months in original BHL programme, 3, 6, 9- & 12-months follow-up	
ID 9,Whittemore, 2012, T1D ID 9a, Grey, 2013, T1D	Website	TEENCOPE: an internet program based on a successful in-person coping skills training program for youth with T1D. Including social skills training, cognitive behaviour modification, assertive communication, stress reduction, and conflict resolution. Five sessions were released weekly that were interactive and encouraged self-assessment and the use of coping skills. Upon completion of sessions, responses to interactive aspects were posted on a personal profile so that participants could learn from each other. At the end of each session, participants were asked to practice the new coping skills and to share experiences on a discussion board moderated by a health professional.	• Shaping knowledge • Comparison of behaviour • Goals and planning • Self-belief • Social support • Feedback and monitoring	Social cognitive theory and the Stress Adaption Model	None	5 weeks, 1)3 months & 6 months follow-up 1a) 3 months, 6 months & 12 months follow-up	Psychosocial 103/320 32.2% Health outcome 48/320 15.0%
ID 10, Yu, 2014, T2D	Website	Diabetes online companion: self-contained diabetes self-management website, incorporating evidence-based content and behaviour-change strategies and followed the principles of user-centred design. Consisting of four main components: 1) general information (static), 2) tailored information (interactive), 3) self-monitoring logs (interactive), and 4) a blog (interactive).	• Feedback and monitoring • Shaping knowledge	Self-efficacy theory	None	Not clear-mention completing surveys up until 9 months after they have been given access to the intervention,	8/81 10.0%

		Initially one blog was posted a wee. After four weeks of limited user activity, this was increased to two per week and email prompts were added with each new posting. .Participants received weekly email reminders to visit the site, complete their self-management trackers and notices of any new content.				Questionnaires were obtained every three weeks for nine months	
Studies were PP groups were investigated as predictors of outcomes							
ID 11, Edwards, 2006, T1D & T2D	Website	Four intervention groups received enhanced information resources: (1) detailed numerical information (absolute/relative risk, numbers-needed-to-treat); (2) 'anchoring' to familiar risks or descriptions; (3) graphical (bar charts, thermometer scales, crowd figure formats); (4) combination of 1–3	• Shaping knowledge	None mentioned	None	Not clear, quantitative data follow-up not clear	202/710 28.5%
ID 12, Holmen, 2014, T2D ID 12a, Torbjornsen, 2014, T2D	App	Few Touch Application (FTA) provided a diabetes diary app designed to increase self-management through awareness, and motivational feedback through symbols such as smiling faces and colour codes in the app. participants measured blood glucose level with a glucometer (LifeScan OneTouch Ultra Easy), which enabled automatic transfer of the measurement to the app through a wireless Bluetooth connection and provided visual graphs, trend reports, and feedback through colour coding (below normal, normal, and above normal). There was a food habit and physical activity registration, personal goal-setting, and general information system.. FTA-HC group received the FTA system, usual care, and health counselling for the first 4 months.	• Feedback and monitoring • Goals and planning • Shaping knowledge	None mentioned for the app, However, health counselling was based on the tran-stheoretical model of stages of change.	Blood glucose monitor	1) 4 months, 4 months follow-up 1a) 1 year, 12 months follow-up	1) 20/164 12.0% 1a) 31/164 19.0%
ID 13, Joseph, 2007, Asthma	Website	Program content for Puff City was based the National Asthma Education and Prevention Program's "Guidelines for the Diagnosis and	• Shaping knowledge	Trans-theoretical and the Health Belief Model	None	Students were given 180 days post-baseline to	0/314 0.0%

ID 13a, Joseph, 2010, Asthma		Management of Asthma: Expert Panel Report II” (EPRII) and includes concepts from other nationally accredited sources. The web-based program consisted of four educational computer sessions. Messages were voiced over to accommodate low literacy. Participant-specific information necessary for tailoring was obtained at baseline and during the four sessions.				complete the four sessions, 12-month follow-up	
ID 14, Nevedal, 2013, Pain (Including: joint, back, osteoarthritis, migraine, neuropathy)	Website	HealthMedia Inc. Care for your Pain: the program was a commercially available (not directly to consumers) that used patient self-report data and algorithms developed by expert clinicians to provide tailored information and interventions based upon participant’s pattern of responses to an interactive consultation.	• Shaping knowledge • Goals and planning • Self-belief • Feedback and monitoring	The program integrated evidence-based theories of cognitive behavioural treatment, chronic disease self-management, motivational enhancement, and theories of health behaviour change, including social cognitive theory, theory of reasoned action, theory of planned behaviour, and self-determination theory	None	Not clearly expressed “During the study period [October 10, 2007 and September 15, 2011], participants engaged with the program at-will via unlimited access to the action plan, online tools, and library to self-manage their chronic pain”, 6 months	Non-RCT included 645 who provided data at 1- and 6-months follow-up. Not clearly stated if all outcome data were available for two main outcomes
ID 15, Skrovseth, 2015, T1D	App	Diabetes Diary (DD): *This was developed as a later iteration of the Few Touch Application (FTA).* *They state that* “the basic version was offered to the public after the study started, whereas the participant's version additionally had wireless transfer of blood glucose (BG) values by pairing the mobile phone with a Bluetooth adapter connected	• Feedback and monitoring • Goals and planning • Knowledge shaping was provided by	Basic Diabetes diary theory not specified None specified for the Diastat element-‘	Blood glucose monitor	12 weeks after commencement, Group 1 was invited to a final meeting, and Grp 2 was invited to a follow-up meeting where they received DD with	8/30 27.0% missed follow-up measurement at time T1, 6/15 40.0% missed it at T2

		by wire to a BG meter.” *They did not describe what the basic version contains and reference a paper that describes all of the learning they did from the different FTA applications, but not specifically what the Diabetes Diary consists of.* They were also testing an additional aspect: a data-driven feedback module called Diastat that consisted of three parts: BG periodicity graph., BG trends, situation matching.	the nutritionist outside the digital intervention			Diastat. At 23 weeks, Group 2 was invited to a final meeting, 4 weeks follow-up	
ID 16, Wangberg, 2008, T1D & T2D	Website	The intervention was tailored to level of Self-Efficacy(SE). Behaviour exercises that included monitoring and graphic feedback were central to the website. Information on health risks and benefits, self-care, overcoming barriers to lifestyle change and diabetes in general were delivered online. Quizzes with feedback and videos of peers interviewed about overcoming barriers to self-care were available. Videos of lectures from health personnel on self-care were available for download. Each intervention theme focused on one specific target behaviour.	• Feedback and monitoring • Shaping knowledge • Comparison of behaviour	Social cognitive theory	None	1 month, 1-month follow-up	27/61 44.3%
ID 17, Wyatt, 2008, Asthma	Website	Okay with Asthma: online program, for school nurses to use in health offices. The child could also complete the intervention independently in the office without the school nurse. The content includes traditional asthma management as well as psychosocial management strategies in a multimedia innovative technique using a digital story (information communicated in storyline with characters)	• Shaping knowledge	Psychosocial management strategies were based on the bio-behavioural family model (Wood & Miller, 2002)	None	Not explicitly covered but it appears one session, week 1 & week 2 follow-up	2/35 6.0%

Overall Duration of intervention and follow-up

The duration of the intervention varied from a single session to 12 months and six studies did not clearly provide information on duration.(Edwards, Thomas et al. 2006, Istepanian, Sungoor et al. 2009, Glasgow, Kurz et al. 2012, Pacaud, Kelley et al. 2012, Nevedal, Wang et al. 2013, Yu, Parsons et al. 2014)

There was a diverse range of follow-up times, from 2 weeks to 12 months, and follow-up time point was not clear for two studies.(Edwards, Thomas et al. 2006, Istepanian, Sungoor et al. 2009)

Setting

Study populations were based in the United States (US),(Joseph 2007, Wyatt 2008, Joseph, Havstad et al. 2010, Lorig 2010, Glasgow 2012, Whittemore 2012, Grey 2013, Nevedal 2013, Glasgow 2014, Huang 2014, Moy 2015) the United Kingdom,(Edwards 2006, Istepanian 2009) the Netherlands,(Heinrich 2012, Voncken-Brewster 2015) Canada, (Pacaud, Kelley et al. 2012, Yu 2014) and Norway.(Wangberg 2008, Holmen 2014, Torbjornsen 2014, Skrovseth 2015) The two asthma studies were conducted in schools : one in a primary school,(Wyatt and Hauenstein 2008) and the other in a high school where over 98% of students were African American and just over half qualified for free school lunches.(Joseph, Peterson et al. 2007, Joseph 2010) The COPD studies were undertaken with Veterans from the United States and Puerto Rico identified from a national database of veterans,(Moy, Collins et al. 2015) and from the Dutch online panel was assembled by the company Flycatcher Internet Research (www.flycatcher.eu).(Voncken-Brewster, Tange et al. 2015) The two diabetes studies that explored intervention effectiveness in young people were conducted in a specialist paediatric centres.(Whittemore, Jaser et al. 2012, Grey 2013, Huang, Terrones et al. 2014) The adult diabetes studies were conducted in: primary care clinics.(Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014) a university hospital,(Skrovseth, Arsand et al. 2015) a diabetes education program,(Pacaud, Kelley et al. 2012) a specialist diabetes centre,(Istepanian, Sungoor et al. 2009) a family practice and endocrinology clinic(Yu, Parsons et al. 2014) and online.(Edwards, Thomas et al. 2006, Wangberg 2008, Lorig, Ritter et al. 2010, Heinrich, de Nooijer et al. 2012) One did not clearly report study setting, but stated that they recruited participants from the Northern and South-eastern part of Norway.(Holmen, Torbjornsen et al. 2014, Torbjornsen 2014) Three of the diabetes studies specifically selected sites that were diverse in terms of ethnic and socioeconomic backgrounds.(Istepanian, Sungoor et al. 2009, Glasgow, Kurz et al. 2012, Whittemore, Jaser et al. 2012, Grey 2013, Glasgow, Strycker et al. 2014) The osteoarthritis study recruited people who were employed by participating USA companies or a member participating USA health care plans.(Nevedal, Wang et al. 2013)

Types of analysis

The data available from studies where the independent contribution of the PP group on the outcome could be determined fell into two distinct groups: (i) studies where PP categories were investigated as predictors of outcomes, and; (ii) studies that explored the modification of the intervention effect by PP categories. A variable that predicts outcome regardless of allocation to the intervention is known as a predictor and a variable that identifies for whom and under what conditions treatments have a difference effect is known as a moderator.(Kraemer, Wilson et al. 2002) Data in group (i) could provide an insight into the influence of PP on outcomes in the target conditions, but not whether this was influenced by the intervention. Only the data in group (ii) could address the aim of difference effectiveness of internet interventions for different PP groups. Therefore, data from group i) are reported but reasons for differences are not sought. Findings from the studies with data in categories i) and ii) will be compared to explore commonalities in differences by PP characteristics.

Potential for meta-analysis:

It was not possible to conduct meta-analysis due to variation in reported PP categories and outcomes across the studies and consequently a high level of heterogeneity. Narrative synthesis was used to present findings in relation to the research questions for each of the four health conditions. Common outcomes and details about the possibility for meta-analysis is discussed below:

Predictors of outcome

In the eight studies that explored association between the PP categories and the outcome, three diabetes studies reported the common outcome HbA1c. Of which, two provided estimates, one for the model of age, gender, education and the other for the model including age, gender, income, ethnicity. Although age and gender were present in both models, it was not possible to meta-analyse these two variables without considering the influence of the other co-variates in the models. There were no common outcomes for the three asthma studies.

Modification of intervention effect

Three pairs of studies presented modification analysis of common outcomes and common PP categories. These were two studies exploring difference of the intervention effect on HbA1c by gender;(Pacaud, Kelley et al. 2012, Whittemore, Jaser et al. 2012) two studies looking at differences in blood glucose levels by ethnicity, (Istepanian, Sungoor et al. 2009, Glasgow, Kurz et al. 2012) and; two studies presenting the same self-care outcome and gender.(Pacaud, Kelley et al. 2012, Yu, Parsons et al. 2014) It was not possible to synthesise the data for the studies exploring HbA1c or self-care with gender, as study teams were either unreachable or did not have access to the data anymore. The two studies exploring HbA1c and gender were investigating different populations, one was youth aged 11-14 years with T1D,(Whittemore, Jaser et al. 2012) and the other was of people with T2D(no age limit given).(Pacaud, Kelley et al. 2012) Furthermore, the I_2 for these two studies was 94% and therefore no meta-analysis was attempted. No common outcomes were available for the two studies that focused on COPD and there was a single study exploring osteoarthritis.

Methodological quality

RCT studies

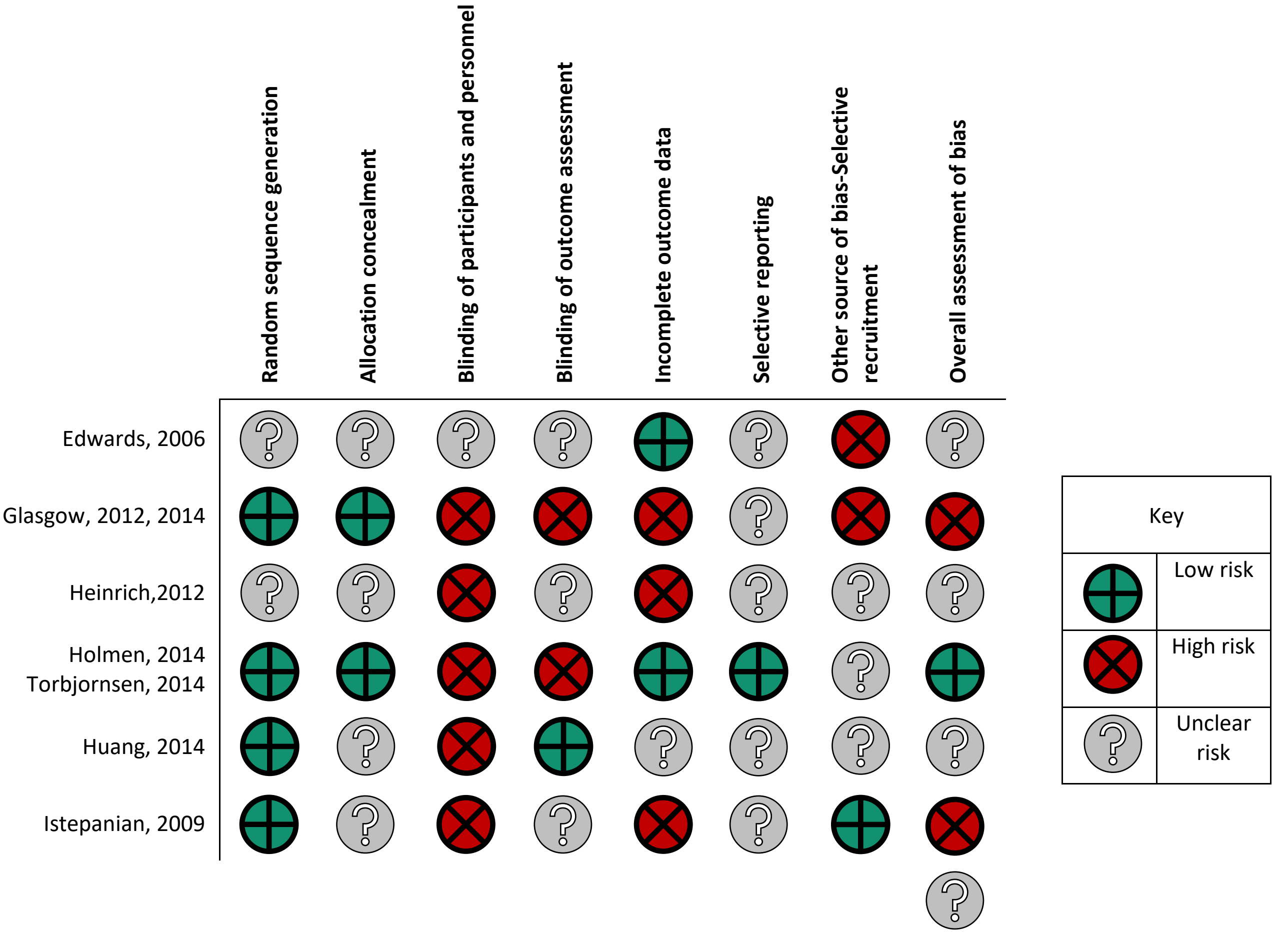
Using the Cochrane RoB score, for six of the fourteen included RCTs there was not enough information to establish the risk of bias (RoB) and the overall assessment was unclear (Figure 3),(Edwards, Thomas et al. 2006, Joseph, Peterson et al. 2007, Wangberg 2008, Lorig, Ritter et al. 2010, Heinrich, de Nooijer et al. 2012, Huang, Terrones et al. 2014) three had an assessment of low risk,(Whittemore, Jaser et al. 2013, Holmen, Torbjornsen et al. 2014, Torbjornsen 2014, Moy, Collins et al. 2015) and five high.(Istepanian, Sungoor et al. 2009, Glasgow, Kurz et al. 2012, Pacaud, Kelley et al. 2012, Glasgow, Strycker et al. 2014, Skrovseth, Arsand et al. 2015, Voncken-Brewster, Tange et al. 2015)

Random sequence generation was considered to be of low RoB in nine studies and insufficient information was provided in five. Where the RoB was low, study teams used: random number tables,(Lorig, Ritter et al. 2010) computer programmes developed by the study statistician,(Joseph, Peterson et al. 2007, Istepanian, Sungoor et al. 2009, Joseph 2010, Glasgow, Kurz et al. 2012, Whittemore, Jaser et al. 2012, Grey 2013, Glasgow, Strycker et al. 2014, Holmen, Torbjornsen et al. 2014, Torbjornsen 2014, Moy, Collins et al. 2015) random block assignment generated by the study statistician,(Huang, Terrones et al. 2014) and stratified randomisation by researcher not involved in data collection.(Voncken-Brewster, Tange et al. 2015) There was not enough information to establish the risk of the allocation concealment in ten studies and four had low RoB. In the studies where the RoB was low, the group was allocated remotely in two studies,(Holmen, Torbjornsen et al. 2014, Torbjornsen 2014, Voncken-Brewster, Tange et al. 2015) and using an automated email system in the other two studies.(Glasgow, Kurz et al. 2012, Whittemore, Jaser et al. 2012, Grey 2013, Glasgow, Strycker et al. 2014)

The blinding of participant and personnel was the highest RoB across the RCTs, with 11 studies being judged to be high risk and three unclear. The high risk came from studies that did not report any blinding or stated they did not blind the participants and personnel. The studies that were unclear, were those that referred to blinding participants and or personnel but did not provide detail on how it was achieved. For the blinding of outcome assessment, six studies were low risk of bias, five were unclear and three were high risk. Of the low risk, data were collected online rather than by a study team member(Wangberg 2008, Lorig, Ritter et al. 2010, Whittemore, Jaser et al. 2012, Grey 2013, Moy, Collins et al. 2015, Voncken-Brewster, Tange et al. 2015) and assessors were blinded to intervention allocation.(Huang, Terrones et al. 2014)

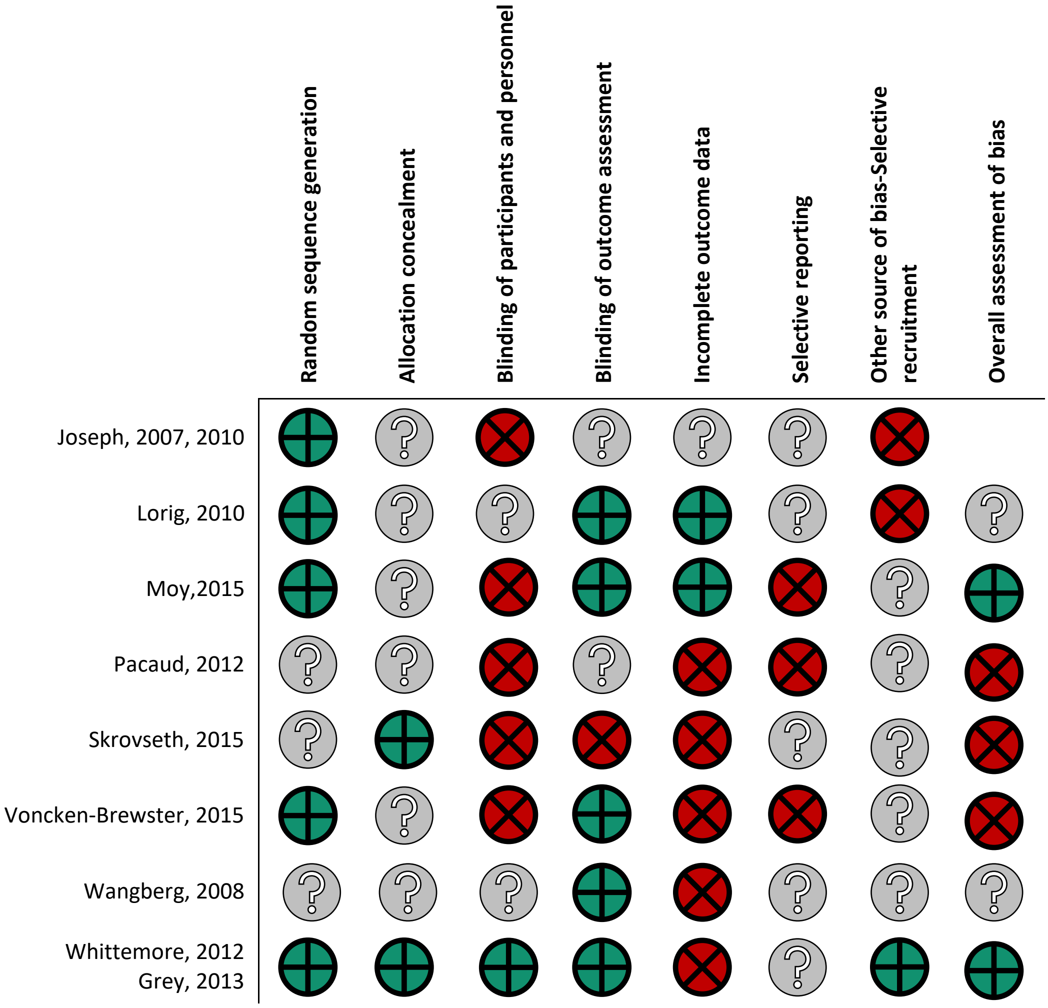
Eight of the RCTs had a high RoB for incomplete outcome data, four were low risk and two were unclear. High study attrition rates contributed towards the high risk with concerns about selective attrition,(Wangberg 2008, Istepanian, Sungoor et al. 2009, Glasgow, Kurz et al. 2012, Heinrich, de Nooijer et al. 2012, Pacaud, Kelley et al. 2012, Whittemore, Jaser et al. 2012, Grey 2013, Glasgow, Strycker et al. 2014, Skrovseth, Arsand et al. 2015, Voncken-Brewster, Tange et al. 2015) Those at low risk had low attrition and there was no evidence of selective attrition.(Edwards, Thomas et al. 2006, Lorig, Ritter et al. 2010, Holmen, Torbjornsen et al. 2014, Torbjornsen 2014, Moy, Collins et al. 2015) In 10 of the studies selective reporting was of unclear risk, three were of high risk and one was low. In the studies where the risk of selective reporting was unclear, protocols were not available. It was therefore not possible to establish whether the interaction analysis and were made a priori. In the three papers that were considered to be at high risk of selective reporting, there were discrepancies between what the study teams stated they would do in the methods (Pacaud, Kelley et al. 2012) or protocol(Moy, Collins et al. 2015, Voncken-Brewster, Tange et al. 2015) and the analysis or outcomes they published in the paper. For the study that was a low RoB the protocol was published and the analysis was outlined in the publication.(Holmen, Torbjornsen et al. 2014, Torbjornsen 2014)

Much of the Cochrane RoB assessment is focussed on ensuring there is balance in the samples in the two arms of the study. However, potential for selective recruitment is also important to ensure the sample is representative of the population with the condition. Here selection bias was assessed under the ‘other’ category. Seven studies were classified as unclear risk of bias if the inclusion criteria potentially excluded people who experience greater health inequity (no access to the internet, not having the skills to use it, language barriers) and there was no discussion of the study population being representative of those with the condition.(Wangberg 2008, Glasgow, Kurz et al. 2012, Pacaud, Kelley et al. 2012, Glasgow, Strycker et al. 2014, Holmen, Torbjornsen et al. 2014, Moy, Collins et al. 2015, Skrovseth, Arsand et al. 2015, Voncken-Brewster, Tange et al. 2015) Two further studies were rated as having unclear RoB for selective recruitment because they did not use any criteria that would exclude already disadvantaged groups from entering the study, but did not discuss whether the sample was representative.(Heinrich, de Nooijer et al. 2012, Huang, Terrones et al. 2014) Two studies were classified as low risk, one because the authors reported the sample was representative of the population with the condition,(Istepanian, Sungoor et al. 2009) and the other because the authors specified participants needed access to the internet, but supported them to access the internet on site if they did not have access at home.(Whittemore, Jaser et al. 2012) Three studies were classified as high risk were they provided evidence that there were biases in the sample who entered the study.(Edwards, Thomas et al. 2006, Joseph 2010, Lorig, Ritter et al. 2010, Glasgow, Kurz et al. 2012)



	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other source of bias-Selective recruitment	Overall assessment of bias
Edwards, 2006	?	?	?	?	⊕	?	⊗	?
Glasgow, 2012, 2014	⊕	⊕	⊗	⊗	⊗	?	⊗	⊗
Heinrich,2012	?	?	⊗	?	⊗	?	?	?
Holmen, 2014 Torbjornsen, 2014	⊕	⊕	⊗	⊗	⊕	⊕	?	⊕
Huang, 2014	⊕	?	⊗	⊕	?	?	?	?
Istepanian, 2009	⊕	?	⊗	?	⊗	?	⊕	⊗
								?

Key	
⊕	Low risk
⊗	High risk
?	Unclear risk



	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other source of bias-Selective recruitment	Overall assessment of bias
Joseph, 2007, 2010	⊕	?	⊗	?	?	?	⊗	
Lorig, 2010	⊕	?	?	⊕	⊕	?	⊗	?
Moy,2015	⊕	?	⊗	⊕	⊕	⊗	?	⊕
Pacaud, 2012	?	?	⊗	?	⊗	⊗	?	⊗
Skrovseth, 2015	?	⊕	⊗	⊗	⊗	?	?	⊗
Voncken-Brewster, 2015	⊕	?	⊗	⊕	⊗	⊗	?	⊗
Wangberg, 2008	?	?	?	⊕	⊗	?	?	?
Whittemore, 2012 Grey, 2013	⊕	⊕	⊕	⊕	⊗	?	⊕	⊕

Figure 14: Risk of bias table for RCTs

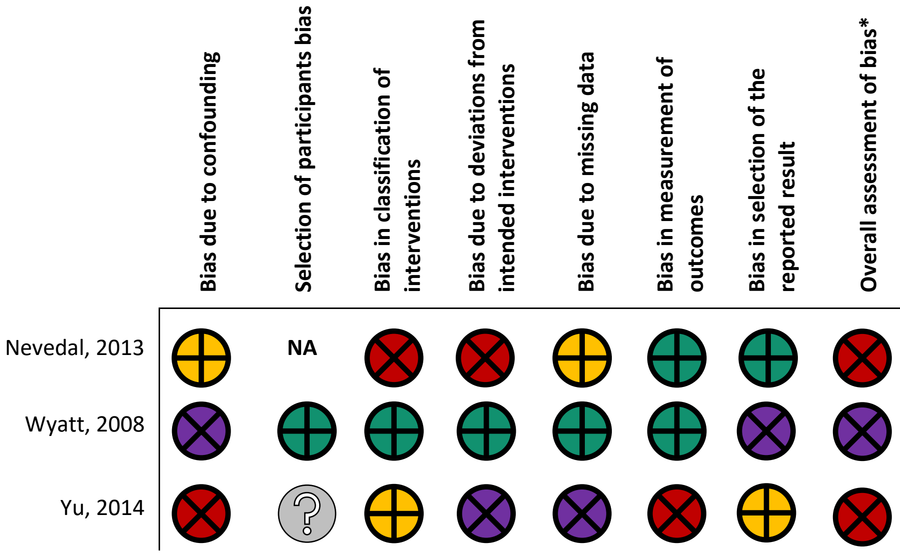
Non-RCT studies

Using RoBINs-I, two of the three included non-RCT studies were considered to have critical RoB(Nevedal, Wang et al. 2013, Yu, Parsons et al. 2014) and one had serious risk.(Wyatt and Hauenstein 2008) Bias due to confounding was of moderate RoB in one study, serious in one and critical in the other. For the study that was moderate risk, there were some issues with confounding that the study team did make some efforts to manage with analysis but they were not sufficient.(Nevedal, Wang et al. 2013) The study that was at serious and critical risk of confounding identified confounding factors but did not control for them.(Wyatt and Hauenstein 2008, Yu, Parsons et al. 2014) Selection of participants was low in one study, there was not enough information in one and not applicable in the other. In the study that was low risk there was no evidence selection of participants was based on characteristics observed after the start of the intervention and start of follow-up and start of the intervention coincided for participants,(Wyatt and Hauenstein 2008) One study there was not enough information to understand drop out at each point in the study.(Yu, Parsons et al. 2014) In the other study the intervention group was not differentiated so the question did not apply.(Nevedal, Wang et al. 2013)

Of the three non-RCT studies the bias in classification of interventions was judged to be low in one study, moderate in another and critical in the third. The study that was low risk, had only one intervention group that was predefined.(Wyatt and Hauenstein 2008) The study at moderate risk divided participants into frequent users and non-frequent users, and there was potential risk that those with worse outcomes were less likely to use the intervention. Although a the majority of the participants were infrequent users so the risk was potentially mitigated.(Yu, Parsons et al. 2014) The study that was judged to be critical in the study that distinguished benefiters and non-benefiters of the intervention that were determined during analysis.(Nevedal, Wang et al. 2013) Bias due to deviations from intended interventions was low in one study, serious in one and critical in the other. The study where bias was considered to be low the intervention was delivered as intended.(Wyatt and Hauenstein 2008) In the study with serious risk of bias the intended dose was not specified, but very few people used the intervention frequently.(Yu, Parsons et al. 2014) In the study where it was critical, intervention participation was not well defined so it was not possible to establish deviation in intended use.(Nevedal, Wang et al. 2013)

Bias due to missing data was judged to be low in one study, moderate in one and serious in the other. In the study where the risk was low, there was low study dropout rate.(Wyatt and Hauenstein 2008) For the study that was moderate risk, the baseline characteristics of participants that were not included in analysis were not described.(Nevedal, Wang et al. 2013) In the study where the risk of bias was considered to be serious there were discrepancies in the descriptions of the missing data.(Yu, Parsons et al. 2014) For bias in the measurement of outcomes two studies classified as low risk and one critical risk. In the low risk studies, outcomes were self-assessed and collected through an online system,(Nevedal, Wang et al. 2013) and the intervention was a one off session and outcome measures were unlikely to be influenced by the intervention received.(Wyatt and Hauenstein 2008) The study that was judged critical risk, it was not possible to ascertain whether there were issues with underreporting by participants.(Yu, Parsons et al. 2014)

For bias in selective reporting the studies were judged low in one study, moderate in one study and serious in the other. In the study that was low risk the reported outcome estimates were not likely to be based on the results.(Nevedal, Wang et al. 2013) The study that was considered to be moderate risk of bias did not specify how many times outcomes were assessed for each participant.(Yu, Parsons et al. 2014) The study that was serious risk selectively reported findings in the text.(Wyatt and Hauenstein 2008)



	Bias due to confounding	**Selection of participants bias**	**Bias in classification of interventions**	**Bias due to deviations from intended interventions**	**Bias due to missing data**	**Bias in measurement of outcomes**	**Bias in selection of the reported result**	**Overall assessment of bias***
Nevedal, 2013	🟨	**NA**	🟥	🟥	🟨	🟩	🟩	🟥
Wyatt, 2008	🟪	🟩	🟩	🟩	🟩	🟩	🟪	🟪
Yu, 2014	🟥	?	🟨	🟪	🟪	🟥	🟨	🟥

***Overall risk of bias: equal to the most severe level of bias found in any domain**

Figure 15: Risk of bias assessment for the non-RCT studies

Key:	
🟩	Low risk-comparable to a well performed RCT
🟨	Moderate risk-sound for a non-RCT but not comparable to a rigourous RCT
🟪	Serious risk- presence of important problems
🟥	Critical risk- too problematic to provide any useful evidence of the effects of the intervention
?	Unclear risk
NA	**Not Applicable**

4.2.3. Overview of evidence for a difference in intervention effectiveness by PP characteristics

This review identified some evidence that some PP groups: i) can predict different outcomes in study contexts when intervention group assignment is considered, and; ii) benefit more from exposure to web-based interventions than others. Here evidence will first be presented for i), followed by data from studies that have provided evidence ii) on difference in intervention effectiveness. Descriptive findings and estimates are presented where available.

4.2.4. Predictive value of PP categories on study outcomes

Eight of the 17 studies included explored whether PP categories predicted outcomes in studies of asthma, COPD and diabetes. There was some evidence that being employed, from a majority ethnic group and having higher levels of income predicted greater improvements in study outcomes. Gender and age showed different relationships with outcomes in different studies. There was no evidence that education or Medicaid enrolment (indicator of low income) had any predictive value for study outcomes. A summary of the associations are shown in Table 8 and described in the text below.

Table 8: Association of PP categories with outcomes

Outcome	Age (increasing)	Gender (male)	Ethnicity (minority ethnic group)	Education (lower level)	Employment (employed)	Income (higher)	Medicaid enrolment (vs not enrolled)	Health literacy
Asthma								
Health	0 Number of symptom free days in the last 2 weeks 9th through 11th graders in majority (98%) African American school. (Joseph, Peterson et al. 2007)	0 Number of symptom free days in the last 2 weeks 9th through 11th graders in majority (98%) African American school. (Joseph, Peterson et al. 2007)				0 Number of symptom free days in the last 2 weeks 9th through 11th graders in majority (98%) African American school. (Joseph, Peterson et al. 2007)	0 Number of symptom free days in the last 2 weeks 9th through 11th graders in majority (98%) African American school. (Joseph, Peterson et al. 2007)	
Behavioural	0 Medication adherence in students 9th through 11th graders in majority (98%) African American school. (Joseph, Peterson et al. 2007)	0 Medication adherence in students 9th through 11th graders in majority (98%) African American school. (Joseph, Peterson et al. 2007)				0 Medication adherence in students 9th through 11th graders in majority (98%) African American school. (Joseph, Peterson et al. 2007)	0 Medication adherence in students 9th through 11th graders in majority (98%) African American school. (Joseph, Peterson et al. 2007)	
Knowledge		-Asthma knowledge, boys acquisition was lower than the girls in a group of school children ages of 8 and 11 years (Wyatt and Hauenstein 2008)						
Psychosocial		+ Positive attitude towards illness, boys						

		improved more than girls in a group of school children ages of 8 and 11 years (Wyatt and Hauenstein 2008)						
COPD								
Health	0 Dyspnea Status in adults aged between 40–70 years of age(Voncken-Brewster, Tange et al. 2015)	0 Dyspnea Status in adults aged between 40–70 years of age(Voncken-Brewster, Tange et al. 2015)		0 Dyspnea Status in adults aged between 40–70 years of age(Voncken-Brewster, Tange et al. 2015)	0 Dyspnea Status in adults aged between 40–70 years of age(Voncken-Brewster, Tange et al. 2015)			
Behavioural								
Knowledge								
Psychosocial	0 Intention to increase physical activity in adults aged between 40–70 years of age(Voncken-Brewster, Tange et al. 2015)	0 Intention to increase physical activity in adults aged between 40–70 years of age(Voncken-Brewster, Tange et al. 2015)		+ Intention to increase activity (low score higher intention): Employed people had greater improvements than those who were not employed (t=-2.40 p=0.02, estimate -0.22) in adults aged between 40–70 years (Voncken-Brewster, Tange et al. 2015)	0 Intention to increase physical activity in adults aged between 40–70 years of age(Voncken-Brewster, Tange et al. 2015)			
Diabetes								
Health	0 HbA1c in adults with T1D (Skrovseth, Arsand et al. 2015) or	0 HbA1c in adults with T1D (Skrovseth, Arsand et al. 2015) or T2D (Torbjornsen	0 HbA1c: in youth with T1D(Grey 2013)	0 HbA1c in adults with T2D (Torbjornsen 2014)		+ HbA1c: increasing income was associated with an decrease		

	T2D (Torbjornsen 2014) - HbA1c: increasing age was associated with an increase in HbA1c (worse health outcome) at follow-up (p=0.02, estimate 0.14 (se 0.06), t value 2.34) in youth with T1D(Grey 2013)	2014) or in youth with T1D(Grey 2013)				in HbA1c (improved health outcome) at follow-up ((p=0.018, (<$40,000 least mean squares estimate 8.70(se 0.17) t-value 47.98, $40,000-79,999 LSE 8.71(se 0.17) t value 51.00, $80,000+ LSE 8.28(SE 0.16) t value 51.00) in youth with T1D(Grey 2013)		
Behavioural	+ Physical activity: A one standard deviation increase in age, lead to a 1.1 increase in physical activity in adults with T2D (Torbjornsen 2014)	0 Physical activity in adults with T2D (Torbjornsen 2014) + Self-care: men showed greater improvements in self-care than women (F(1,25) = 4.78, p =0 .038, ηp2 = 0.16) in people with T1 and T2D between 17 and 67 years (Wangberg 2008)		0 Physical activity in adults with T2D (Torbjornsen 2014)				
Knowledge	-Diabetes knowledge: Older participants had a lower post-test knowledge score than younger participants in adults with T2D	0 Diabetes knowledge: in adults with T2D aged 40-70 (Heinrich, de Nooijer et al. 2012)		0 Diabetes knowledge: in adults with T2D aged 40-70 (Heinrich, de Nooijer et al. 2012)				

	aged 40-70 (Heinrich, de Nooijer et al. 2012)							
Psychosocial	0 Conflict/uncertainty about control of diabetes conducted online with people with T1D and T2D (no estimates provided) (Edwards, Thomas et al. 2006) and depressive symptoms in adults with T2D (Torbjornsen 2014) + Self-efficacy: increase in age by a year was associated improvement in self-efficacy (lower scores indicate higher self-efficacy)(p=0.005, estimate -1.07 (se 0.38), t value -2.79) in youth with T1D(Grey 2013)	0 Conflict/uncertainty about control of diabetes conducted online with people with T1D and T2D (no estimates provided) (Edwards, Thomas et al. 2006) 0 Depressive symptoms in adults with T2D (Torbjornsen 2014) - Self-efficacy: boys had a less improvement in self-efficacy than girls (female reference group p=0.005, mean difference -2.72 (se 0.82), t value -3.30) in youth with T1D(Grey 2013)	0 Conflict/uncertainty about control of diabetes conducted online with people with T1D and T2D (no estimates provided) (Edwards, Thomas et al. 2006) - Self-efficacy: minority ethnic groups showed a less improvement in self-efficacy than in the majority ethnic group (white not Hispanic or Latino reference group) (p=0.009: black mean difference 3.82 (se 1.95) t-value 1.96, more than one race mean difference 5.23 (se 1.68) t-value 3.10, other mean difference -2.72 (se 3.22) t-value -0.84, white Hispanic/Latino estimate 1.36 (se 1.24) t-value 1.11, youth with T1D(Grey 2013)	0 Depressive symptoms in adults with T2D (Torbjornsen 2014)		+ Self-efficacy: youth with T1D from households with higher incomes had greater improvements in self-efficacy than those from lower incomes (p=0.0004: <40,000 reference group : 40,000-79,999 mean difference -2.8716 (se 1.30) t-value -2.20, $80,000+ mean difference -5.10 (se 1.31) t-value -3.91(Grey 2013)		

0 – no evidence of an effect for PP group, + evidence of a positive effect, -- evidence of a negative effect

Age

Of the six studies that reported whether age predicted study outcomes, three indicated there was a difference. The three studies focussed on people with diabetes. There was a mixed picture of the influence of age: with two studies finding increasing age was associated with lower levels of improvement, one study reporting the opposite effect. For the outcome HbA1c, increasing age was associated with lower levels of improvement in people with T1D,(Grey 2013) diabetes knowledge in people with T2D(Heinrich, de Nooijer et al. 2012) and self-efficacy in youth with T1D.(Grey 2013) Conversely, the study that reported changes in physical exercise found increasing age was associated with greater improvements in people with T2D. (Torbjornsen 2014) There was no evidence age predicted study outcomes in a study of people with T1D and T2D,(Edwards, Thomas et al. 2006) a study of 14-17 year olds with asthma in majority (98%) African American school.(Joseph, Peterson et al. 2007, Joseph 2010) or in adults with COPD aged between 40–70.(Voncken-Brewster, Tange et al. 2015)

Gender

Three of seven studies that explored the association between gender and outcome found evidence of an effect. Although the direction of the effect was mixed between the studies and within one study. Wangberg et al.(2008) found men enrolled in the studies showed greater improvements than women on a behavioural outcome (self-care in people with T1 or T2 diabetes).(Wangberg 2008) Female participants benefitted more than male participants on the psychosocial outcome of self-efficacy in youth with T1D.(Grey 2013) A pilot asthma study found evidence gender predicted a change in outcome, the direction of the association was mixed on two different outcomes. Boys improved more than girls on an attitude measure, while girls showed greater improvement on a knowledge outcome.(Wyatt and Hauenstein 2008) Four diabetes studies, an asthma study and a COPD study did not find any differences in any of outcomes by gender.(Edwards, Thomas et al. 2006, Heinrich, de Nooijer et al. 2012, Torbjornsen 2014, Skrovseth, Arsand et al. 2015) (Joseph, Peterson et al. 2007, Joseph 2010) (Voncken-Brewster, Tange et al. 2015)

Ethnicity

One of the two diabetes studies reporting on differences by ethnicity found evidence of a predictive effect. The study found that people from a majority ethnic group (white not Hispanic or Latino) showed greater improvements in self-efficacy after participation in the study but not in HbA1c.(Grey 2013) The other study did not find evidence of difference in uncertainty about control of diabetes for people with T1 and T2 diabetes of different ethnicities.(Edwards, Thomas et al. 2006)

Income and Medicaid enrolment

Two studies reported whether income predicted study outcomes. In diabetes study higher incomes predicted greater improvements in mean HbA1c and self-efficacy in people with T1D.(Grey 2013) In an asthma study there was no evidence household income or Medicaid enrolment predicted outcomes in 14-17 year olds with asthma in majority (98%) African American school.(Joseph, Peterson et al. 2007, Joseph 2010)

Education

There was no evidence education predicted outcomes in two diabetes studies,(Torbjornsen 2014){Heinrich, 2012) and one COPD study.(Voncken-Brewster, Tange et al. 2015)

Employment

A study found employed people improved their intention to increase their level of exercise more than unemployed people, but found no effect on dyspnea status in people with COPD aged between 40–70.(Voncken-Brewster, Tange et al. 2015)

4.2.5. Modification of intervention effectiveness by PP groups

Eight of the 11 studies that explored the modification of intervention effectiveness by PP categories, reported evidence of differences. There was some evidence that people were more likely to benefit from the intervention if they were: male, from a minority ethnic group and had higher health literacy. The findings for age were mixed. There was no evidence of an interaction with education, income, employment, or numeracy. Available evidence is summarised in Appendix 4.3 and 4.4, further details including estimates (where provided) are presented where interactions were found. Study data and ID numbers for the figures are available in Appendix 4.4.

Age

COPD

One of the two COPD studies found evidence that older participants benefitted less from the intervention than younger people on the behavioural outcome (Figure 16). The higher quality evidence came from Study 1 that indicated increasing age was negatively associated with intervention effectiveness. The evidence for no effect came from Study 2 (high RoB but larger sample). Study 1 also found no effect of modification of intervention effectiveness by age on the health QoL outcome. Study 1 focussed on USA army veterans ≥ 40 years old, a 1-year increase in age was associated with a 33-point decrease in change in daily step count, but found no association with the health QoL outcome.(Moy, Collins et al. 2015) Study 2 did not find any evidence of a difference in intervention effectiveness on the behavioural change outcome by age adults aged 40-70 years.(Voncken-Brewster, Tange et al. 2015)

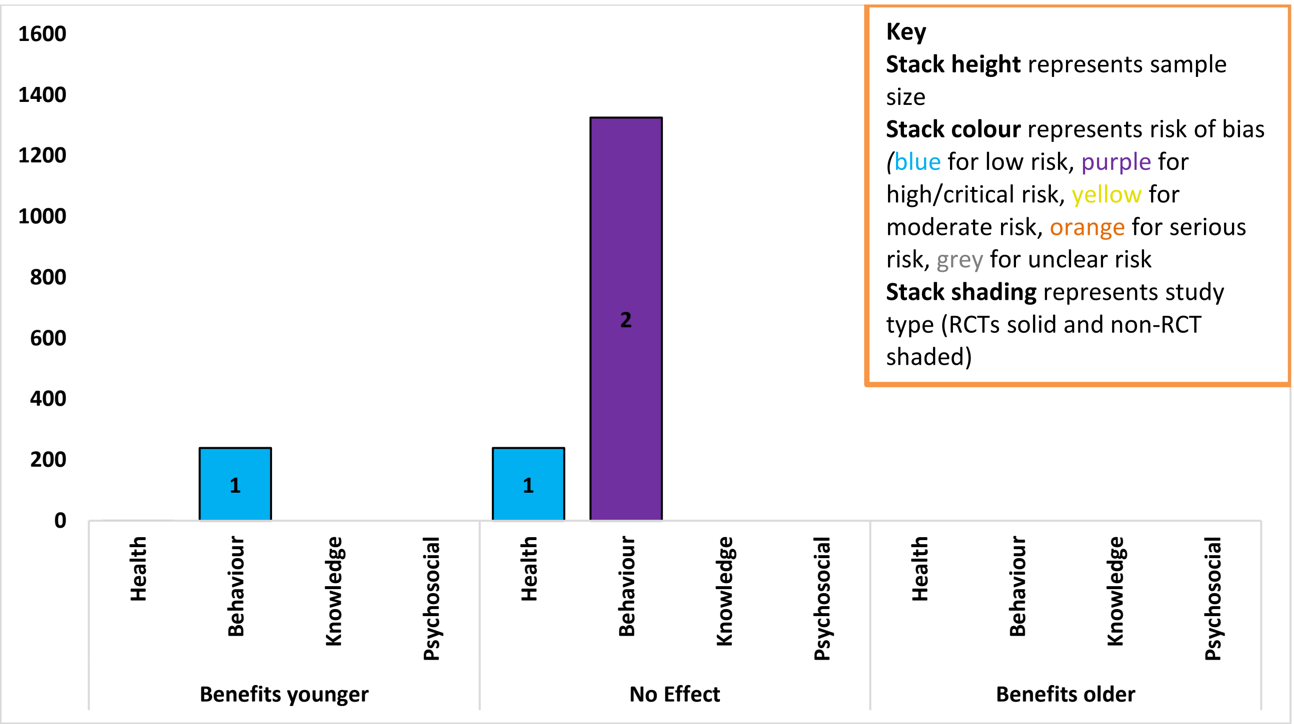


Figure 16: Summary of evidence for the modification of intervention effect by increasing age for COPD studies

Diabetes

Of the five diabetes studies that reported the modification of intervention effectiveness by age, only one study indicated there was a difference (Figure 17). The strongest evidence came from study 9, that found no evidence of an effect for the health and psychosocial outcomes and had a low RoB and a sample size of 320 participants. A much smaller study (ID 10, n=81) that had a high RoB, found evidence older people benefitted more from an intervention than younger people on behavioural and psychosocial outcomes. The evidence across the studies that found there was no effect for the behavioural change outcome had a combined sample of n=544 with a high and unclear RoB,(Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014, Huang, Terrones et al. 2014) and n=864 and low, high and unclear RoB for the psychosocial outcomes.(Glasgow, Kurz et al. 2012, Whittemore, Jaser et al. 2012, Huang, Terrones et al. 2014) There was no evidence of interaction effect with age across the health outcomes (Glasgow, Kurz et al. 2012, Whittemore, Jaser et al. 2012) or with diabetes knowledge.(Heinrich, de Nooijer et al. 2012, Huang, Terrones et al. 2014)

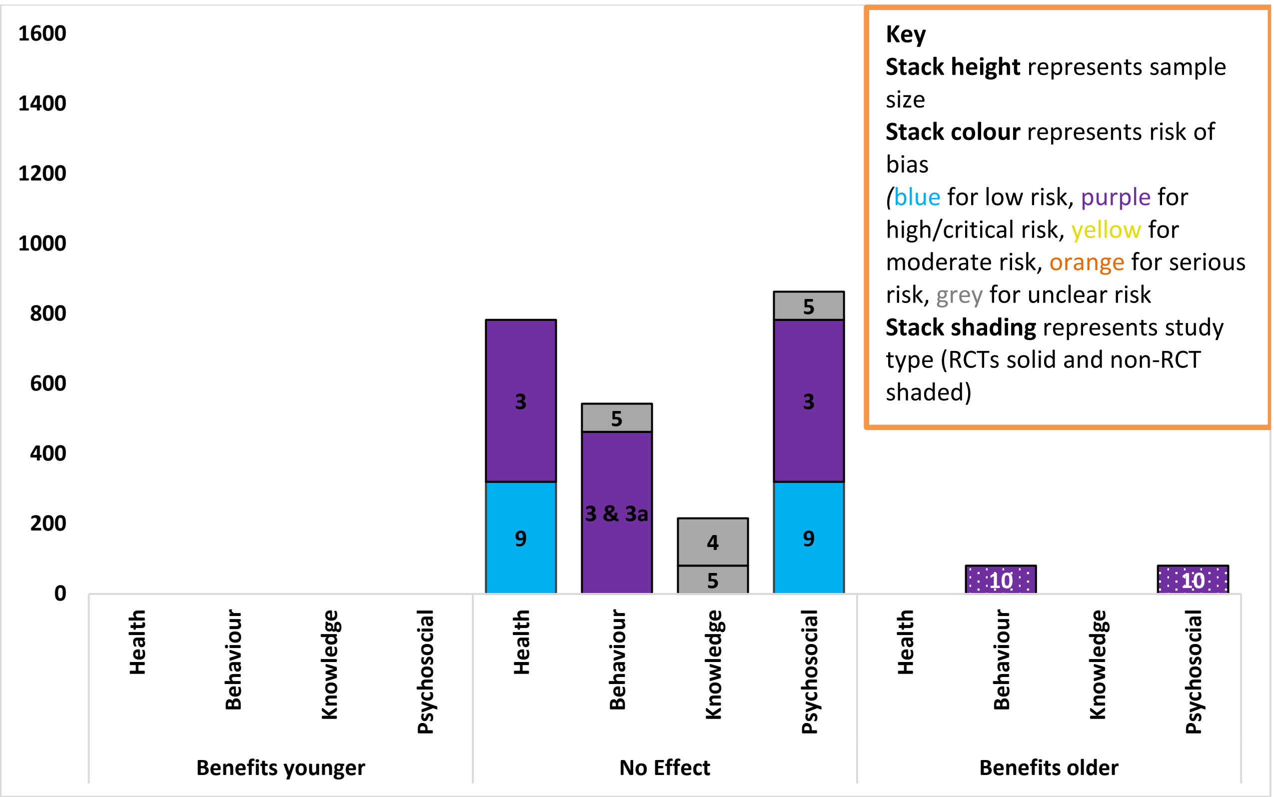


Figure 17: Summary of evidence for increasing age modifying intervention effect across the outcomes in the diabetes studies

In study 10, age interacted with intervention effectiveness on two outcomes, self-care and diabetes distress in participants aged ≥ 25 years with T2D. They found that older people benefitted more from the intervention than younger people on the outcome diabetes distress (estimate -0.34, SE 0.15, 95%CI -0.64 to -0.05, p=0.01) and on self-care age (0.04/year, 95% CI 0.02 to 0.06, p <0.001).(Yu, Parsons et al. 2014)

Osteoarthritis

In a study of working age adults with osteoarthritis, there was no evidence of a difference in those who did or did not respond to a web-based pain management programme in terms of age. Treatment responders were categorised as those whose pain composite of pain intensity and unpleasantness reduced to a clinically meaningful level (average pain reduction ≥ 30%) at the time point compared to baseline.(Nevedal, Wang et al. 2013)

Gender

COPD

Study 2 also explored modification of intervention effectiveness on change in physical activity by gender with no evidence of an effect. (Voncken-Brewster, Tange et al. 2015) Study 1 did not investigate any further participant characteristics with the health or behavioural outcome.(Moy, Collins et al. 2015)

Diabetes

There was some evidence that male participants benefitted more (3/5 studies) from diabetes interventions than female participants(Figure 18). The strongest evidence came from study 9, an RCT with a low RoB and a sample of 320, which indicated that men befitted more on the psychosocial outcome but they did not find an interaction with the health outcome.(Whittemore, Jaser et al. 2012) Two other studies agreed that male participants benefitted more from the interventions on health,(Pacaud, Kelley et al. 2012)and psychosocial outcomes.(Yu, Parsons et al. 2014) The evidence for the influence of gender on the psychosocial outcomes came from two studies with a combined sample of n=401: a larger RCT (n=320) with a low RoB,(Whittemore, Jaser et al. 2012) and the smaller non-RCT (ID 10, n=81) with a high RoB(Yu, Parsons et al. 2014) and whilst the RCTs that found no evidence of an effect, had a combined sample of 542 and a high or unclear RoB(Figure 18).(Glasgow, Kurz et al. 2012, Pacaud, Kelley et al. 2012) The evidence for male participants benefitting more on the health outcome was from a single small RCT (ID 8, n=79) with a high RoB,(Pacaud, Kelley et al. 2012) while the combined sample from the studies where there was no effect was n=783 with study 9 (n=320) having a low RoB(Whittemore, Jaser et al. 2012) and study 3 having a high RoB (n=463)(Figure 17).(Glasgow, Kurz et al. 2012) There was no evidence of the intervention effect being modified by gender for the behavioural or knowledge outcomes.(Glasgow, Kurz et al. 2012, Heinrich, de Nooijer et al. 2012, Pacaud, Kelley et al. 2012, Glasgow, Strycker et al. 2014, Yu, Parsons et al. 2014)

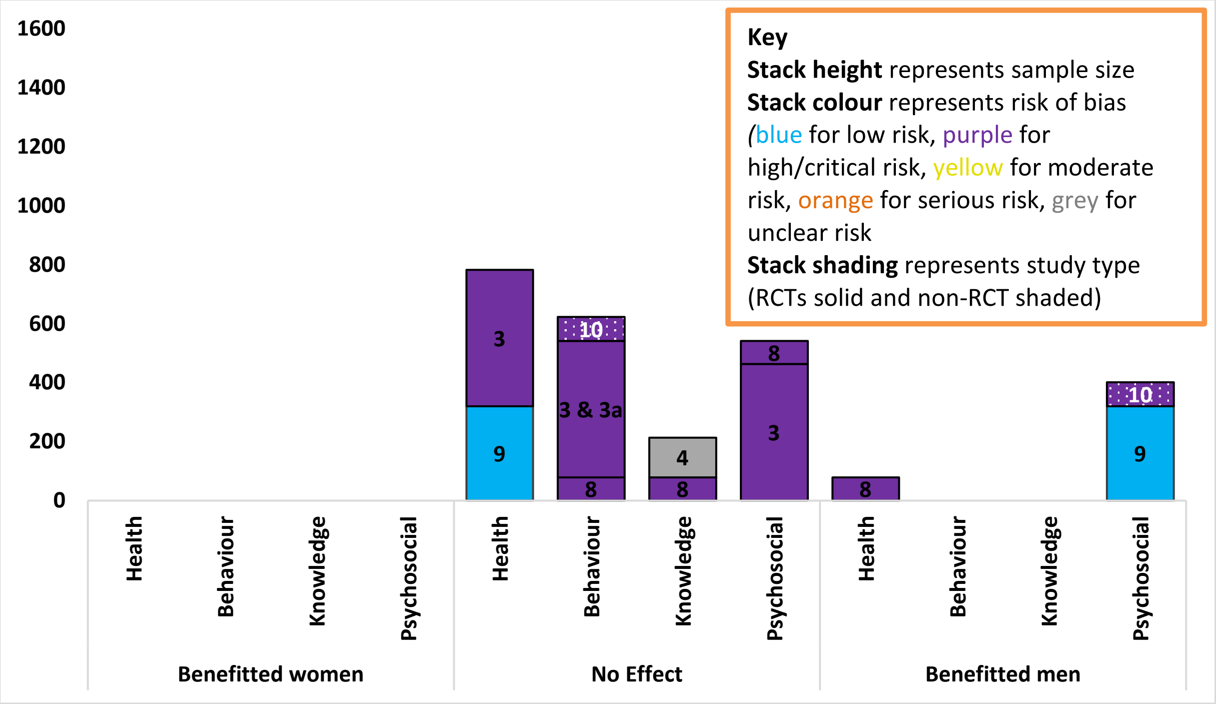


Figure 18: Summary of evidence for male gender modifying intervention effect across the outcomes in the diabetes studies

Of the studies that found male participants benefitted more than female particiapants, the strongest evidence came from study 9: a parallel group RCT that found the intervention effect on diabetes QoL in a group of youth with T1D was moderated by gender. Specifically, boys in the Managing Diabetes program had greater improvements in diabetes QoL compared with TEENCOPE participants (4.19 ± 1.01 vs. 1.03 ± 0.89; p = 0.019). The study team did not find evidence of an interaction between gender on the outcome HbA1c.(Whittemore, Jaser et al. 2012) Study 10 found that the improvement in diabetes distress following use of the intervention was greater in male participants in comparison to males in a single-arm pre-post cohort study of T2D aged ≥ 25 years.(Yu, Parsons et al. 2014) Study 8 reported a trend for a group by time by gender interaction for change in HbA1c from baseline to the final visit, although the findings did not reach the prespecified significance threshold of $p<0.05$ (F[2, 62]=2.76, p=0.071). Male participants in the two intervention groups tended to record a drop in HbA1c by the final visit, but males in the control group showed a slight increase in HbA1c from the first to final visit (F[2, 29]=3.05, p=0.063). They did not find any evidence of an interaction for female participants. There was no evidence that gender moderated the intervention effect on the other three study outcomes of self-care, diabetes knowledge and self-efficacy.(Pacaud, Kelley et al. 2012)

Osteoarthritis

There was no evidence of a gender difference in those who did or did not respond to a web-based pain management programme in adults with osteoarthritis.(Nevedal, Wang et al. 2013)

Education

COPD and diabetes

There was no evidence people with different levels of education benefitted more or less from using web-based interventions in one COPD study,(Voncken-Brewster, Tange et al. 2015) or three diabetes studies(Figure 19).(Glasgow, Kurz et al. 2012, Heinrich, de Nooijer et al. 2012, Glasgow, Strycker et al. 2014, Yu, Parsons et al. 2014)

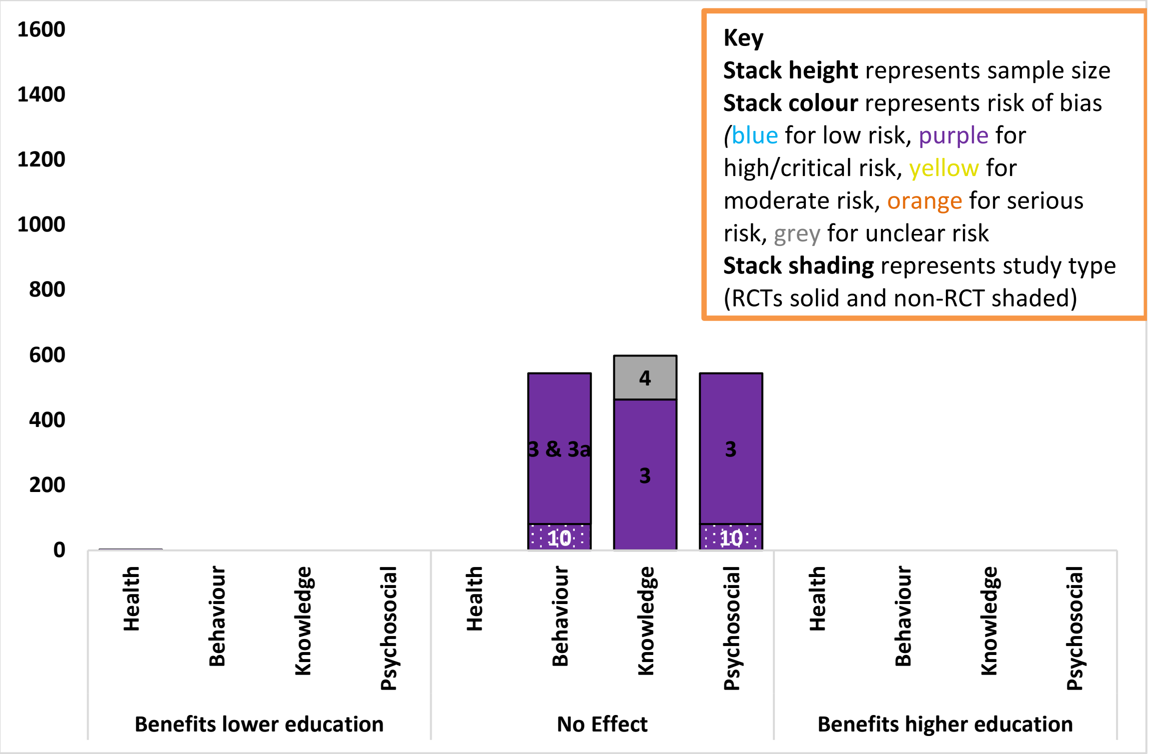


Figure 19: Summary of evidence for higher education modifying intervention effect across the outcomes in the diabetes studies

Ethnicity

Diabetes

There was evidence that minority ethnic groups benefitted more from the intervention than majority ethnic groups in three of the five diabetes studies that explored this interaction (Figure 20). The strongest evidence came from study 9, an RCT with a low RoB and a sample of 320, which indicated that there was no evidence of a difference by ethnicity on the health and psychosocial outcomes.(Whittemore, Jaser et al. 2012) The combined sample for the evidence people from minority ethnic groups benefitted more on the health outcome was n=597 and the two studies both had high RoB. (Istepanian, Sungoor et al. 2009, Glasgow, Kurz et al. 2012) Study 9 that found no effect on the health outcome had a sample of 320 and a low RoB.(Whittemore, Jaser et al. 2012) The evidence people from minority ethnic groups had greater improvements in the behavioural outcome after using the intervention, came from a large RCT (n=761) with an unclear RoB, (Lorig, Ritter et al. 2010) and the evidence of no effect came from two studies with a combined sample of 544 both of which had a high RoB.(Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014, Yu, Parsons et al. 2014) There was no evidence that ethnicity modified the intervention effect in psychosocial outcomes in the four studies that investigated this interaction.(Lorig, Ritter et al. 2010, Glasgow, Kurz et al. 2012, Whittemore, Jaser et al. 2012, Yu, Parsons et al. 2014)

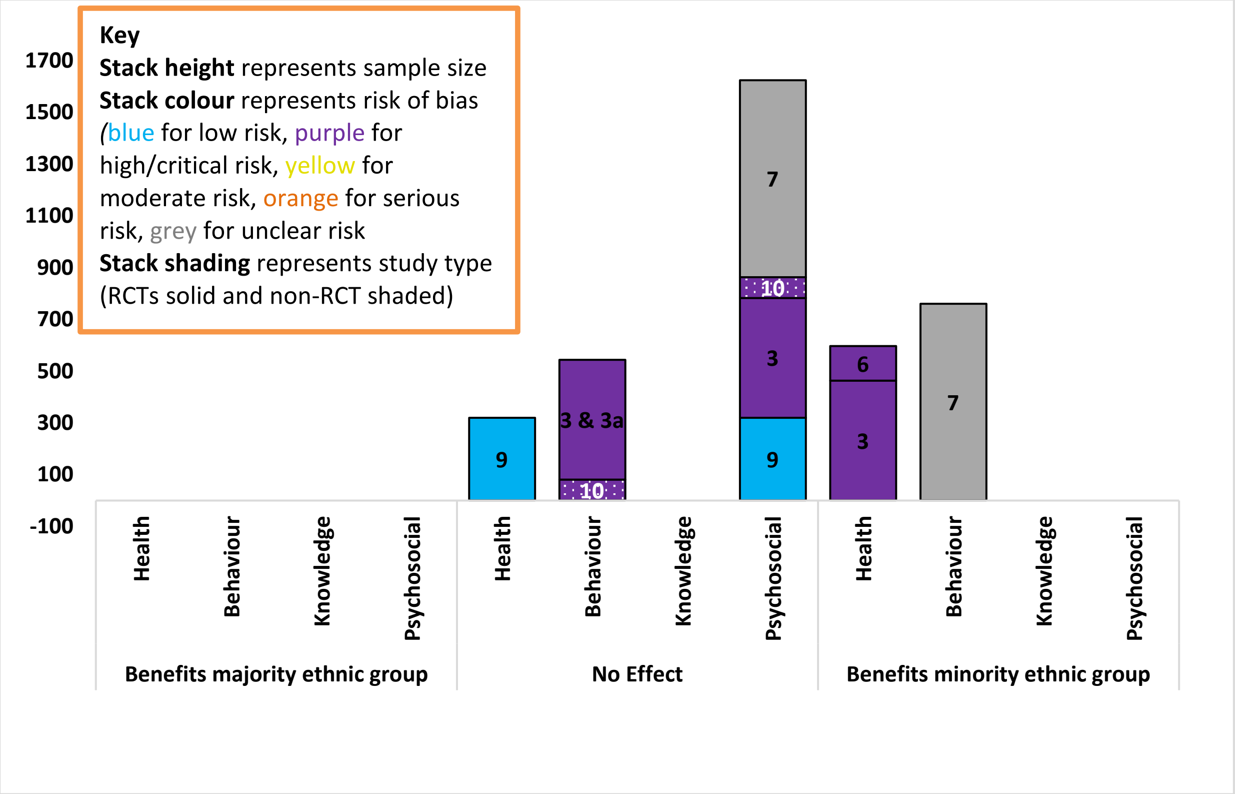


Figure 20: Summary of evidence for minority ethnic group modifying intervention effect across the outcomes in the diabetes studies

The strongest evidence that ethnicity modified intervention effect came from study 7: a large RCT that found evidence of an American Indian/Alaska Native versus non- American Indian/Alaska Native interactions with randomisation were significant in predicting 6-month activity limitation (no estimates provided). The American Indians/Alaska Natives program participants were found to have greater improvements with activity limitations in comparison to the non-American Indians/Alaska Natives. No evidence of interaction effects were found between ethnicity and the intervention effect on HbA1c or self-efficacy.(Lorig, Ritter et al. 2010)

Where there was evidence that ethnicity modified intervention effectiveness on the health outcome: Study 3 found Latinos showed a greater reduction in blood pressure than non-Latinos at 12 months only, in the intervention arm and the inverse relationship in the control arm with Latinos having less reduction than non-Latinos (p=0.006, no estimates provided).(Glasgow, Kurz et al. 2012) They did not find any interactions between ethnicity and intervention effect on change in behaviour or self-efficacy.(Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014) Study 6 explored the intervention effect on the blood pressure outcome, and found the reduction was greatest in the patients of African-Caribbean and Indo-Asian heritage in the intervention arm (no estimates provided).(Istepanian, Sungoor et al. 2009)

Osteoarthritis

There was no evidence of a difference in those who did or did not respond to a web-based pain management programme in terms of ethnicity in adults with osteoarthritis.(Nevedal, Wang et al. 2013)

Employment

COPD and diabetes

There was no evidence that employment was a moderator of intervention effectiveness in one COPD study,(Voncken-Brewster, Tange et al. 2015) and one diabetes study.(Yu, Parsons et al. 2014)

Health literacy

Diabetes

There was some evidence people with higher literacy levels benefitted more from the intervention on the diabetes knowledge outcome(Figure 21). Only one study (ID 5) explored the interaction with the knowledge outcome, the sample was small(n=81) and the RoB was unclear.(Huang, Terrones et al. 2014) There was no evidence health literacy modified intervention effect on a health outcome in one study,(Glasgow, Kurz et al. 2012) behaviour change outcome in three studies,(Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014, Huang, Terrones et al. 2014, Yu, Parsons et al. 2014) or the psychosocial outcome in three studies.(Glasgow, Kurz et al. 2012, Huang, Terrones et al. 2014, Yu, Parsons et al. 2014)

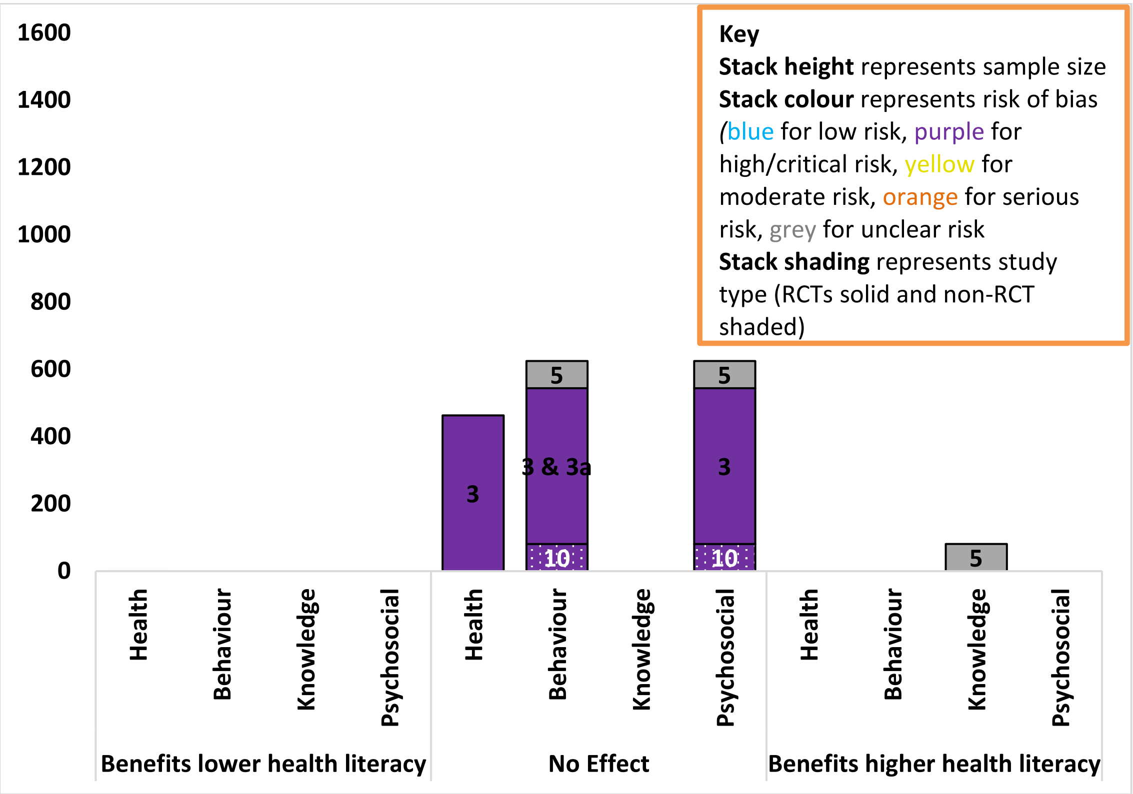


Figure 21: Summary of evidence for higher health literacy modifying intervention effect across the outcomes in the diabetes studies

Study 5 explored the effectiveness of an online intervention for chronic illness (including T1D) found adolescent participants in the intervention arm demonstrated greater improvements in disease management knowledge when they had ‘adequate literacy levels’ (score ≥60 of 100), but did not find evidence of a modification effect on either of the other study outcomes patient-initiated communication with clinician or self-efficacy.(Huang, Terrones et al. 2014)

Income, employment, numeracy, number of people living in the household

Diabetes

There was no evidence that the following characteristics modified intervention effectiveness in any of the diabetes studies: income in two, (Whittemore, Jaser et al. 2012, Yu, Parsons et al. 2014) employment in one,(Yu, Parsons et al. 2014) and numeracy in one.(Glasgow, Kurz et al. 2012)

Osteoarthritis

there was no evidence the number of people living in the household modified response to a web-based pain management programme in adults with osteoarthritis. (Nevedal, Wang et al. 2013)

4.2.6. Potential reasons for the differences in effectiveness

Application of theory to intervention development

Theory was explicitly referenced in seven of the 11 studies that explored modification of intervention effectiveness by PP groups(Table 17 Appendix 4.5, Table 18 Appendix 4.6). Four studies did not refer to any theory.(Istepanian, Sungoor et al. 2009, Lorig, Ritter et al. 2010, Heinrich, de Nooijer et al. 2012, Pacaud, Kelley et al. 2012) All seven of the studies that did apply theory, used it for intervention development. One study also drew on socio-ecological theory to guide the decision to maximise recruitment from minority ethnic groups(Latinos).(Glasgow, Kurz et al. 2012) Study teams generally provided details on how they used theory to guide the development of the intervention or to select mechanisms for change.

Of the seven studies citing the use of theory, four referenced a single theory,(Whittemore, Jaser et al. 2012, Huang, Terrones et al. 2014, Yu, Parsons et al. 2014, Moy, Collins et al. 2015) and three applied multiple theories.(Glasgow, Kurz et al. 2012, Nevedal, Wang et al. 2013, Voncken-Brewster, Tange et al. 2015) No associations could be made between the application of single or multiple theories to intervention design and the evidence of differences in effectiveness for different PP groups (Appendix 4.6, Table 18). All four of the studies that applied a single theory found evidence of a difference on one or more of their outcomes on the characteristic of age in two studies, (Moy, Collins et al. 2015) (Yu, Parsons et al. 2014) gender in two studies (Yu, Parsons et al. 2014) (Whittemore, Jaser et al. 2012)and health literacy in one study. (Huang, Terrones et al. 2014) Equally, the three studies that did not apply theory found evidence of differences by ethnicity (Istepanian, Sungoor et al. 2009) (Lorig, Ritter et al. 2010) or gender.(Pacaud, Kelley et al. 2012) One of the three studies that applied multiple theories found evidence of a difference by ethnicity,(Glasgow, Kurz et al. 2012) and the study that referred to the intervention as evidence-based but did not reference a theory did not find evidence of a difference in study effectiveness.(Heinrich, de Nooijer et al. 2012)

Five of the seven studies that applied theory to intervention development used a theory that considered the influence of the social environment rather than individual behaviour change in isolation (Appendix 4.6).(Glasgow, Kurz et al. 2012, Whittemore, Jaser et al. 2012, Nevedal, Wang et al. 2013, Huang, Terrones et al. 2014, Voncken-Brewster, Tange et al. 2015) There was no clear indication that applying theories that consider the social context reduced unequal benefits for advantaged groups or increased benefits in disadvantaged groups. Studies that had applied theories that consider the social context found no evidence of a difference in two studies,(Nevedal, Wang et al. 2013, Voncken-Brewster, Tange et al. 2015) evidence of greater benefits for a disadvantaged group in one study,(Glasgow, Kurz et al. 2012) and evidence of a disequalising effect in two studies.(Whittemore, Jaser et al. 2012, Huang, Terrones et al. 2014) The study that found ethnic minority groups benefitted more from the intervention also used socio-ecological theory to guide the decision to recruit a larger sample of people from minority ethnic groups.(Glasgow, Kurz et al. 2012) Both studies that applied a theory that considered behavioural change of the individual without considering the social context found evidence that some PP groups (age, gender) benefitted less from the intervention than others.(Yu, Parsons et al. 2014, Moy, Collins et al. 2015)

Application of behavioural change techniques

BCTs were described in the 11 studies that explored modification of intervention effect by participant characteristics. Using the highest category of the BCT taxonomy(Michie, Richardson et al. 2013) the BCTs most commonly applied were: feedback and monitoring (10/11 studies), followed by shaping knowledge (9/11 studies), goals and planning (7/11 studies), comparison of behaviour, social support and self-belief (5/11 studies) and reward and threat in one study(Table 9).

In the absence of systematic methods for linking BCTs to mechanisms of action of intervention,(Michie, Carey et al. 2016) we mapped presence or absence of a modification of intervention effect against BCTs present (Table 9). There was no apparent association between the BCTs applied and finding of evidence of modification of intervention effect by PP categories (Table 9). The same BCTs were applied in interventions that did not find differences in benefits by social groups and also in interventions were differences were found.

Table 9: BCTs categorised into the top-level hierarchies from the BCT Taxonomy v1 and interactions

Michie's Higher level BCT categories	**Outcomes**			
	Health	**Behavioural**	**Knowledge**	**Psychosocial**
1. Goals and Planning	0 (Whittemore, Jaser et al. 2012) 0 (Nevedal, Wang et al. 2013) + Ethnicity(minority group)(Lorig, Ritter et al. 2010) + Ethnicity(minority group)(Glasgow 2012)	0(Glasgow 2012) 0 (Voncken-Brewster, Tange et al. 2015) - Age(favours older) (Moy, Collins et al. 2015) + Ethnicity(favours minority groups) (Lorig, Ritter et al. 2010)	0 (Heinrich, de Nooijer et al. 2012)	0 (Glasgow 2012) 0 (Lorig, Ritter et al. 2010) + Gender(male) (Whittemore, Jaser et al. 2012)
2. Feedback & monitoring	0 (Moy, Collins et al. 2015) 0 (Whittemore, Jaser et al. 2012) 0 (Nevedal, Wang et al. 2013) + Gender(male)(Pacaud, Kelley et al. 2012) + Ethnicity(minority group) (Lorig, Ritter et al. 2010) + Ethnicity(minority group)(Glasgow 2012) + Ethnicity(minority group) (Istepanian 2009)	0 (Huang, Terrones et al. 2014) 0 Glasgow 2012) 0 (Pacaud, Kelley et al. 2012) 0 (Voncken-Brewster, Tange et al. 2015) - Age(increasing) (Moy, Collins et al. 2015) + Ethnicity(minority group) (Lorig, Ritter et al. 2010) +Age (increasing) (Yu, Parsons et al. 2014)	0 (Pacaud, Kelley et al. 2012) + Health Literacy(high) (Huang, Terrones et al. 2014)	0 (Huang, Terrones et al. 2014) 0 (Glasgow 2012) 0 (Lorig, Ritter et al. 2010) 0 (Pacaud, Kelley et al. 2012) + Gender(male) (Whittemore, Jaser et al. 2012) + age (increasing) & gender (male) (Yu, Parsons et al. 2014)
3. Social support	0 (Moy, Collins et al. 2015) 0 (Whittemore, Jaser et al. 2012) + Gender(male) (Pacaud, Kelley et al. 2012) + Ethnicity(minority group) (Lorig, Ritter et al. 2010) + Ethnicity(minority group) (Glasgow 2012)	0 (Glasgow 2012) 0 (Pacaud, Kelley et al. 2012) - Age(increasing) (Moy, Collins et al. 2015) + Ethnicity(minority group) (Lorig, Ritter et al. 2010)	0 (Pacaud, Kelley et al. 2012)	0 (Glasgow 2012) 0 (Lorig, Ritter et al. 2010) 0 (Pacaud, Kelley et al. 2012) + Gender(male) (Whittemore, Jaser et al. 2012)
4. Shaping knowledge	0 (Moy, Collins et al. 2015) 0 (Whittemore, Jaser et al. 2012) 0 (Nevedal, Wang et al. 2013) + Gender(male)(Pacaud, Kelley et al. 2012) + Ethnicity(minority group)(Lorig, Ritter et al. 2010) + Ethnicity(minority group) (Glasgow 2012)	0 (Huang, Terrones et al. 2014) 0 (Glasgow 2012) 0 (Pacaud, Kelley et al. 2012) - Age(increasing) (Moy, Collins et al. 2015) +age(increasing)(Yu, Parsons et al. 2014) + Ethnicity(minority group) (Lorig, Ritter et al. 2010)	0 (Heinrich, de Nooijer et al. 2012) 0 (Pacaud, Kelley et al. 2012) + Health Literacy(high (Huang, Terrones et al. 2014)	0 (Huang, Terrones et al. 2014) 0 (Glasgow 2012) 0 (Lorig, Ritter et al. 2010) + age (increasing) &gender (male) (Yu, Parsons et al. 2014) + Gender(male) (Whittemore, Jaser et al. 2012)
6. Comparison of behaviours	0 Study ID 9 (Whittemore, Jaser et al. 2012)	0 Glasgow 2012) 0 (Voncken-Brewster, Tange et al. 2015)		0 (Glasgow 2012) 0 (Lorig, Ritter et al. 2010)

	+ Ethnicity(minority group)(Lorig, Ritter et al. 2010) + Ethnicity(minority group) (Glasgow 2012)	+ Ethnicity(minority group) (Lorig, Ritter et al. 2010)		+ Gender(male) (Whittemore, Jaser et al. 2012)
10. Reward and threat	+ Ethnicity(minority group)(Glasgow 2012)	0 Glasgow 2012)		0 (Glasgow 2012)
15. Self-belief	0 (Whittemore, Jaser et al. 2012) 0 (Nevedal, Wang et al. 2013) + Ethnicity(minority group) (Glasgow 2012)	0 (Huang, Terrones et al. 2014) 0 (Glasgow 2012) - Age(increasing) (Moy, Collins et al. 2015)	+ Health Literacy(high) (Huang, Terrones et al. 2014)	0 (Huang, Terrones et al. 2014) 0 (Glasgow 2012) + Gender(male) (Whittemore, Jaser et al. 2012)
+Positive -Negative 0 No effect found				

Intervention use

Only six of the 11 studies that reported modification of intervention effectiveness by participant characteristics also reported modification of use by these characteristics. It was therefore difficult to draw a conclusion about the relationship. However, there was no clear evidence of a connection between the two, where both types of analysis were reported. There were four studies where participant characteristics modified both intervention effectiveness and use, however, the characteristics were not common (Appendix 4.6, Table 19).(Glasgow, Kurz et al. 2012, Pacaud, Kelley et al. 2012, Whittemore, Jaser et al. 2013, Huang, Terrones et al. 2014) One diabetes study found no evidence of an interaction between PP categories and either intervention effect or use.(Heinrich, de Nooijer et al. 2012) In one study, a sample of 633 was included for the effectiveness analysis and a subset of 45 was selected to explore differences in use in a secondary study. Therefore, it was not possible to compare the findings from the two types of analysis.(Case, Jernigan V Fau - Gardner et al. 2009, Lorig, Ritter et al. 2010)

4.3. Discussion

4.3.1. Summary of main findings

There was some evidence that study outcomes were predicted by differences in participant characteristics. Larger improvements in study outcomes from baseline to follow-up were found to be influenced by being: employed, from a majority ethnic group and having a higher household income. There were mixed findings for gender and age. For the diabetes studies one study indicated male participants showed more improvement and another study found female participants showed greater improvements overall. An asthma study reported larger improvements for psychosocial outcome among boys than girls, while girls' knowledge showed greater improvement. For age, two diabetes studies found younger participants were advantaged and one diabetes study reported the opposite effect. There was no evidence that education or Medicaid enrolment had any predictive value for study outcomes. As these analyses could not provide insight into social characteristics that modified intervention effectiveness, the source of these differences was not investigated further.

There was also some evidence that intervention effectiveness was modified by participant characteristics. Across the diabetes studies, there was some evidence that people were more likely to benefit from the intervention if they were: male, from a minority ethnic group and had higher health literacy. However, these findings should be treated with caution as most of the evidence came from a small number of low-quality studies. The findings for age were mixed across the COPD and diabetes studies. Older people were found to benefit less from the intervention in a high-quality COPD study, and they were found to benefit more in a low-quality diabetes study. There was no evidence of an interaction with education, income, employment, or numeracy. Strength of evidence across the studies could not be assessed through meta-analysis as not all studies provided estimates and the outcomes were heterogeneous. Therefore, strength of the evidence was explored through study size, RoB and estimates where possible. The studies reviewed were seldom judged to be of high quality, with the majority of the evidence coming from studies with high and uncertain RoB.

Except for mixed findings for age, there were no common associations between the participant characteristics that predicted study outcomes, and those that modified the intervention effectiveness.

There was no clear evidence that the difference in intervention effectiveness was caused by different application of BCTs or theories to study design. Of the studies that reported modification of intervention effectiveness by PP categories, just over half also reported differences in intervention use. But there was no clear association between differences in use by PP characteristics and differences in effectiveness by PP characteristics in these studies. This author could not find any further literature investigating why the difference in effectiveness by PP were occurring. The study team that found differences in effectiveness by health literacy suggested the intervention would need additional modules to ensure those with lower health literacy could benefit from the intervention as much as those with higher levels of health literacy.(Huang, Terrones et al. 2014) The interventions found to be more beneficial for people from minority ethnic groups was most likely to be the result of study design. All three studies where ethnicity modified the intervention effect to the benefit of minority groups made efforts to maximise recruitment of minority ethnic groups. None of the studies adapted the intervention for the populations they targeted, although the study that targeted recruitment of Latino people had the intervention available in Spanish and English.(Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014) One of the three studies provided an interpretation of the difference: the study that targeted American Indians/Alaskan Natives (AI/AN) suggested that the relative success of the intervention in this subgroup was because of the design of the study and a selection bias. They reported that a high proportion of the participants who entered the study were actively seeking information about diabetes when they found the study website. All control participants were offered the intervention at the end of the study. The AI/AN participants were only involved in the study for 6 months, whereas the non-AI/AN participants continued for 18 months. They suggest that could have contributed to the intervention being more successful in the AI/AN group than the non-AI/AN group as the non-AI/AN control group may have sought other interventions rather than waiting 18 months. (Lorig, Ritter et al. 2010) The two other studies that found minority ethnic groups benefitted more and the studies that found male participants benefitted more did not did not offer an interpretation of the modification of intervention effectiveness.(Istepanian, Sungoor et al. 2009, Glasgow, Kurz et al. 2012, Pacaud, Kelley et al. 2012, Whittemore, Jaser et al. 2012, Yu, Parsons et al. 2014)

4.3.2. Strengths and weaknesses

The methodology was common with the systematic review described in Chapter 3. Detailed discussion of the strengths and weaknesses in this methodology and limitations in the evidence-base were discussed in Chapter 3. Therefore, only issues specific to this systematic review will be discussed in here.

To this author’s knowledge, this is the only systematic review that has investigated whether there are equal benefits of web-based self-care interventions for people with different characteristics. This review was also the first to establish whether different application of BCTs and theory contributed to modification of intervention effect by participant characteristics in the field of digital interventions. Four health conditions were included, providing systematic evidence across the conditions. Four study outcomes were included to explore modification of effectiveness of the different elements that can contribute towards behavioural change.

There were limitations to the methodology of this review associated with the mapping of BCTs and theory to modification of intervention effect. For the mapping of BCTs, the use of Michie’s Taxonomy of BCTs was explored, but it did not provide any further clarity in this instance.(Michie, Richardson et al. 2013) As yet there is no agreed methodology for analysis using these newly emerging standardised descriptions of BCTs. Therefore, a pragmatic approach was taken to enable comparison across studies, where single BCTs were mapped to the finding of a modification of effect and no evidence of an effect. There were limitations in this approach as it could not represent specific combinations of BCTs or theory applied.

There were also limitations in the methodology and data reported by the studies included in the review. It was not possible to conduct meta-analysis because the outcomes were heterogeneous, and essential data were not reported. A high proportion of the included studies found that intervention effect was modified by at least one participant characteristic on at least one outcome. This suggests that teams may be more likely to publish these analyses when they find evidence of a difference in effect.(Dwan, Gamble et al. 2013) It was difficult to draw a firm conclusion about the association between BCTs or theory applied, or difference in use and modification of intervention effect as the use of BCTs and theory in intervention development were inconsistently reported.

4.3.3. In the context of previous literature

There is no previous systematic evidence comparing the health equity effects of web-based self-care interventions for people with different social characteristics. This review agrees with previous evidence from single studies that found web-based self-care interventions can benefit underserviced and disadvantaged groups.(Gustafson, Hawkins et al. 2002, Murray, Burns et al. 2005, Muller, Rowsell et al. 2017) However, the studies that had previously found disadvantaged groups benefitted from the intervention, designed the intervention specifically for those from underserved and disadvantaged groups.(Gustafson, Hawkins et al. 2002, Murray, Burns et al. 2005, Muller, Rowsell et al. 2017) None of the studies included in this review had adapted the intervention for the study population, with the exception of one study that was targeting Latinos and had the intervention available in Spanish.(Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014) It is possible that the minority ethnic group may have benefitted more because they had less exposure to health care support prior to using the digital intervention so benefitted more from it. The majority ethnic group may have received more non-digital support prior to entering the study, which may have resulted in lower levels of relative gains. There has been previous evidence that those from ethnic minority groups and those with lower SES face greater challenges accessing health care services and support.(Buchan and Richardson 1973, Cartwright and O'Brien 1976, Appleby and Deeming 2001)

Alternatively, the findings that ethnic minority groups benefitted more than majority groups may have been related to sampling strategy. The three studies that made efforts to maximise recruitment of minority ethnic group and found evidence minority groups benefitted more, had a high representation of people from these groups in the study sample.(Istepanian, Sungoor et al. 2009, Lorig, Ritter et al. 2010, Glasgow, Kurz et al. 2012, Glasgow, Strycker et al. 2014) This have resulted in the sample being powered to detect a differences, where in other samples the minority ethnic group are not sufficiently represented to detect differences. Webb et al.(2010) similarly found that recruitment sampling was an important predictor of effectiveness of an intervention.(Webb, Joseph et al. 2010) They found that when theory or predictors were used to select recipients for the intervention, had the greatest improvements in behaviours.(Webb, Joseph et al. 2010) For one of the studies in this review that found minority ethnic groups benefitted more, the decision to recruit a larger sample of people from minority ethnic groups was guided by the social ecological model.(Glasgow, Kurz et al. 2012, Sallis, Owen et al. 2015) The other two studies cited evidence of unequal access to healthcare for minority ethnic groups, being a motivation to target recruitment of people from those groups.(Istepanian, Sungoor et al. 2009, Lorig 2010) Therefore, consideration of the sample where the intervention was evaluated appears to be important in addition to considering the needs of the target population. Issues with selection bias in the studies included in the systematic reviews and the potential to mask true differences in effectiveness by social groups was discussed in Chapter 3, section 3.3.3.

Interventions designed without considering the needs of the users can exclude social groups, and this is the likely cause of the difference in effectiveness found by gender, health literacy and age. Van Dijk's theory of the digital divide proposed that if the content of the technology only fulfils the needs of the dominant group (e.g. men, high education) or is challenging to use, those users from the less dominant group will benefit less from the use of the technology.(Van Dijk 2012) This supposition has been supported by findings that design of online health information can limit the usability of digital interventions for people of lower SES and older age.(Berland, Elliott et al. 2001, Rogers 2003, Gilmour 2007, van Deursen and van Dijk 2010) Evidence from this systematic review indicated women and those with lower health literacy benefitted less from the interventions. It is possible that the intervention content was less relevant to the women than the men, and was written in such an way that it was less accessible to those with lower health literacy.(Van Dijk 2012) The mixed findings for age may be associated with whether the interventions were designed with the needs of older or younger people in mind. It may also be related to the other characteristics of the participants classified as older or younger people. As educational attainment has been found to be the strongest predictor of internet competence, this is an important consideration.(van Deursen and van Dijk 2010) In the studies where older people were found to benefit more from the intervention, they may have had higher level of education and consequently digital skills relative to their younger counterparts. The converse may be true in the studies where younger participants benefitted more from the intervention. Indeed, a systematic review that found web-based self-care interventions led to improvements in outcomes for older adults with chronic conditions, reported the samples in the included studies mostly consisted of highly educated, white patients.(Stellefson, Chaney et al. 2013) Therefore, the relative benefit found for older participants may have been related to study design, or the educational level of the older people in the study sample. The limitations of conducting analysis comparing individual groups and the need to consider how characteristics intersect was discussed in Chapter 3, section 3.3.2.

In this SR it was not possible to comment on whether theory or BCTs were more or less effective. Study teams generally did not discuss how they used theory to guide the development of the intervention or to select mechanisms for change. This was similar to the findings from Michie et al.'s (2009) review that explored whether the application of theory and BCTs influenced the effectiveness of non-web behavioural-change interventions targeted at low income groups.(Michie, Jochelson et al. 2009) These authors also suggest that the absence of associations may be explained by the absence of detail of how theory was applied in designing the intervention.(Michie, Jochelson et al. 2009)

4.3.4. Recommendations specific to systematic reviews

Recommendations specific to the systematic reviews were covered in detail in Chapter 3 but include: careful consideration of the population of people teams wish to target with the intervention and any barriers these groups may face in using these interventions or entering research studies. Using theory to select PP groups that may be disadvantaged by the digital interventions, routine reporting of differences in benefits obtained by people across PP groups(specified a *priori,* reported with estimates).

4.3.5. Conclusions

There was some evidence that greater improvements in study outcomes from baseline to follow-up were predicted by being; employed, from a majority ethnic group and having higher levels of income. The findings were unclear for gender and age. There was also evidence that PP modified intervention effectiveness. In the diabetes studies, there was some evidence that people were more likely to benefit from the web-based intervention if they were: male, from a minority ethnic group and had higher health literacy. However, these findings should be treated with caution as most of the evidence came from a small number of low-quality studies. The findings for age were mixed across the COPD and diabetes studies. There was no evidence of an interaction between intervention effect and education, income, employment or numeracy. Except for mixed findings for age, there were no common associations between the participant characteristics that predicted study outcomes, and those that modified the intervention effectiveness. There was no clear association between modification of intervention effectiveness by participant characteristics and the application of BCTs or theory to intervention design, or differences in use. Major methodological limitations in the included studies limited the analysis possible and the strength of the evidence. This author concludes that, there do appear to be interaction effects which warrant analysis in future research and recommends *a priori* consideration of predicted interaction effects.

CHAPTER 5. QUALITATIVE STUDY LITERATURE REVIEW AND METHODS

5.1. Chapter overview

This chapter presents the literature review and methods for the qualitative study including the rationale for selecting type 2 diabetes as the focus of the study. Of the research questions outlined in Chapter 1 (Section 1.5), this review was designed to address the following primary research question: How and why people with type 2 diabetes use web-based self-care technology and how their experiences vary.

Therefore, the review focuses on literature relevant to the lived experience of chronic conditions, the influence of social inequalities and how this relates to digital self-care interventions. This chapter considers literature around the experience of living with all chronic conditions, with a focus on T2D which was the target condition in the primary research.

5.2. Literature review

5.2.1. Introduction

Digital self-care interventions have the potential to reduce health inequities by increasing access to healthcare and through tailoring of intervention content to the needs of the users (See Chapter 2, section 2.1.4). However, the findings from the systematic review (Chapters 3 and 4) indicated these interventions may increase inequity, through lower use and usability in disadvantaged groups. The simple relationships between social or cultural group, health status and healthcare considered in much intervention literature may not sufficiently consider the lived experience and social identities of people living with chronic disease (see sections 5.2.2 and 5.2.3 below). This chapter considers literature around the experience of living with all chronic conditions, with a focus on Type 2 Diabetes (T2D) which is the target condition in the primary research. A breadth of theories will be presented as a way of understanding the illness experience. This author recognises that there are tensions between the theories and is not attempting to argue that they are compatible, but rather to explore some of the different ways the theories have been considered in the literature as pertains to T2D.

5.2.2. The experience of living with chronic illness

This literature review will present relevant theoretical frameworks and evidence from studies that have explored the experiences of living with a chronic illness. Differences in internal and external resources available to an individual and how they influence a person's ability to adapt to their diagnosis and to engage with self-care will be discussed. This includes web-based interventions as an external resource.

Chronic illness as an assault on personal identities

A diagnosis of a chronic illness results in widespread changes in the life of the person with the condition and their family. Social science perspectives on chronic illness have suggested that being diagnosed with a chronic illness can be experienced as a disruptive life event, or an assault on a person's 'personal identity' or sense of self.(Bury 1982, Goldman and Maclean 1998) It has been argued that the chronic illness challenges a person's sense of self and requires a shift to a new identity, which incorporates the chronic illness and the associated changes into their life. (Goldman and Maclean 1998, Broom and Whittaker 2004) The social theory of identity proposes that a person's sense of self operates in a social context, and is influenced by group memberships, social positions, interpersonal relationships and status.(Mead 1934, Adams, Pill et al. 1997) The person with the chronic condition will construct their illness and will interpret and negotiate their new social identity in the context of their pre-existing social identities.(Adams, Pill et al. 1997) Each person will adapt differently, for some the diagnosis may present a sense of the 'diminished self' if they are unable to reconcile the illness identity with other identities.(Charmaz 1995, Adams, Pill et al. 1997) People who are able to successfully incorporate their illness identity with their other social identities, describe the illness as 'just a part' of them and are found not to experience a 'diminished self'.(pg. 199 (Hewett 1994, Adams, Pill et al. 1997) Acceptance of the illness identity and assimilation into the personal identity has been associated with greater engagement with management of chronic conditions. (Goldman and Maclean 1998, Gomersall, Madill et al. 2011)

Stigma

The individual with chronic illness is not only negotiating the disruption to their lives and sense of self, but are also confronted with shifts in the way that society views them.(Broom and Whittaker 2004) Chronic illnesses such as Type 2 Diabetes (T2D), epilepsy, HIV and multiple sclerosis are associated with social stigma.(Goffman 2009) People with chronic conditions describe experiencing discrimination in work, their social lives and in interactions with healthcare services.(Chapple, Ziebland et al. 2004, West, Dye et al. 2006, Sayles, Ryan et al. 2007, Puhl and Heuer 2010, Browne, Ventura et al. 2013, Browne, Ventura et al. 2014) Two types of stigma are defined in the literature, enacted stigma(experienced from others) and felt stigma (self-maintained). (Scambler and Hopkins 1986) Some chronic conditions such as paraplegia are visible, others such as diabetes are invisible, and others are both visible and invisible as with multiple sclerosis. (Joachim and Acorn 2001) The person with an invisible stigmatising condition has the choice of a variety of strategies to cope with stigma.(Joachim and Acorn 2001) These include the decision of whether to disclose the condition, which might mean they get needed support but they may also suffer further stigma. (Joachim and Acorn 2001) Alternatively, they can try to conceal the condition, thereby avoiding identifying or being identified with the stigmatised identity. (Adams, Pill et al. 1997, Joachim and Acorn 2001)

Conducting self-care behaviours can make visible an otherwise invisible stigmatised illness. An example of this is in people with T2D, who report feeling fearful that conducting activities involved with self-care of the condition will result in them being judged or rejected socially. (Schabert, Browne et al. 2013) Activities such as taking medication, monitoring blood glucose, injecting insulin and making different dietary choices contribute to the feeling of being ‘other than the norm’.(Rayman and Ellison 2004) People with T2D have expressed ‘feeling different’ from how they felt prior to diagnosis and different to people without diabetes.(Rayman and Ellison 2004) A well-documented example of stigma-induced identity threat is the “diabetic junkie”, where a person with diabetes is concerned that injecting insulin in public could potentially harm their social identity by people mistaking them for illicit drug users.(Tak-Ying Shiu, Kwan et al. 2003, Broom and Whittaker 2004, Major and O'Brien 2005, Browne, Ventura et al. 2014) There is also a risk to the person with chronic conditions that in rejecting culturally and societally governed behaviours, they may become isolated from their support networks, which can result in psychological issues and poorer health outcomes.(Wellard, Rennie et al. 2008, Hinder and Greenhalgh 2012)

Performance of identity in illness narratives

Goffman (1959) proposed that through discourse, individuals stage performances of their most desirable selves or identities in order to ‘save face’ in difficult situations, such as a stigmatising chronic disease.(Goffman 1959, James 2000, Luttrell 2003) Using a theatrical metaphor, Goffman (1959) explained that identities are presented with an audience in mind.(Goffman 1959, James 2000) He asserted that someone cannot be a ‘self’ by themselves, instead identities must be accomplished in ‘shows’ to persuade an audience.(Goffman 1959, James 2000) Both in medical history taking in primary care and in social science an illness narrative is elicited from the patient or participant.(Bury 2001, Riessman 2003) Through the telling of illness narratives a patient has a platform to explain and provide context to their disrupted lives and to conduct identity work.(Bury 1982, Charmaz 1995, Riessman 2003) Illness narratives do not reveal a 'true' identity, but rather a preferred identity or identities, that are selected from multiple personas that people switch between throughout their everyday lives.(Harre and van Langenhove 1999, Riessman 2002)(Riessman 2003; Bury 1982a; Charmaz 1995)

Self-determination, control and the moral component of self-care

Personal accountability and self-determination are central to the self-care model of chronic conditions, where a person is expected to take control of their condition.(Ellis, Boger et al. 2017) Qualitative investigation of the meaning of control in the management of chronic conditions, have found that when people talked about 'control' they were simultaneously referencing two meanings.(Charmaz 1995) First the meaning employed in biomedicine in the discourse of HCPs and diabetes educators, and second about the desire to assert a positive identity and power in the management of their condition.(Charmaz 1995) People with chronic conditions often position themselves as having agency over their condition in their illness narrative.(Riessman 2003) This provides a sense of their sick body being more predictable and manageable, which can help the person feel they have regained lost control over their lives and bodies.(Riessman 2003) Consequently providing more cohesion between the altered body and the self.(Riessman 2003)

'Being in control' is highly prized in western culture and denotes agency and power.(Charmaz 1995) In contrast, being 'out of control' is indicative of chaos and moral failing.(Charmaz 1995, Broom and Whittaker 2004, Gomersall, Madill et al. 2011, Ellis, Boger et al. 2017) This message can be internalised by people with chronic illness, who feel morally responsible for their condition.(Broom and Whittaker 2004) The focus for people with chronic conditions is often engaging in the 'right' or 'wrong' behaviours.(Balcou-Debussche & Debussche, 2009; Moser et al., 2008; Moser et al., 2006) The ability for a person to control their chronic condition can provide a looming threat to their sense of 'self'.(Broom and Whittaker 2004) Where there is a feeling of moral victory when they are 'in control' and of moral failing when they are not.(Broom and Whittaker 2004)

Issues with the positioning of control in the management of chronic conditions, and associated implications of morality is well illustrated in the literature describing experiences of people living with T2D. The modern portrayal of T2D is that it is a condition brought on by an individual's unhealthy lifestyle, which is often attributed to a lack of self-control.(Broom and Whittaker 2004) As such, people with T2D often feel like they are blamed for failing to responsibly manage their health resulting in stigmatisation of the condition.(Broom and Whittaker 2004) This is reflected in the qualitative literature where people with diabetes report feeling that others blame them for their condition, and describe a sense of self-blame in respect to lapses in self-management.(Peel, Parry et al. 2005) (Tak-Ying Shiu, Kwan et al. 2003, Chun and Chesla 2004) People with type 1 diabetes(T1D) have described a need to distance themselves from the public perception of people with T2D as they believe that they only experienced stigma due to misplaced negative judgments about T2D.(Browne, Ventura et al. 2014) However, focus on the role of the individual and lack of acknowledgement of the role of external influences can result in loss of self-esteem, feeling of powerlessness and disengagement from the self-care of their condition.(Broom and Whittaker 2004)

5.2.3. The influence of the socio-economic context on how people adapt to a chronic illness diagnosis and their ability to self-care for their condition

Social structures of inequality and the resources available to the person both constrains their lives and the possibility of narrating them.(Riessman 2003) Here the influence of the Socio-Economic (SE) context on adaption to the illness identity and the control people have to manage their condition will be discussed.

Influence of the socio-cultural context on control over illness narratives and performance of identity

The individual's ability to successfully adapt to changes in identity is influenced by the significance the individual places on the illness (such as negative associations), internal resources and resource or assets in the social environment.(Adams, Pill et al. 1997, Goldman and Maclean 1998, Gomersall, Madill et al. 2011) In terms of internal resources, the degree to which a person is impacted by the illness identity is dependent on their sense of self before diagnosis and their temperament.(Goldman and Maclean 1998, Gomersall, Madill et al. 2011) The external resources in the social environment, include; family and friends, work, financial capital, the healthcare system, and; social definitions of illness.(Goldman and Maclean 1998) Social characteristics such as gender and SES impact how people are able to make sense of their changing identities, and whether they are able to adapt positively to the threat to their sense of self when faced with chronic illness.(Riessman 2003)

Influence of the social structures of inequalities on self-care

Unequal access to resources to control their condition means that not everyone has the equal opportunity to become a 'good' self-manager.(Ellis, Boger et al. 2017) The degree of control, power and autonomy a person has over their life has been found to exist on a social gradient.(Marmot 2004) Those with lower SES have less control over their lives, as they are more reliant on state provision (which may be limited), are more likely to live in neighbourhoods with fewer resources and their choices are often limited.(Marmot 2004) This lack of control affects health, wellbeing and social participation.(Marmot 2004) Indeed it has been proposed that 'control over destiny' is a social determinant of health in itself. (Sen 1999, Whitehead, Pennington et al. 2016) The theory of fundamental causes (covered in detail in Chapter 2, section 2.2.4) Link and Phelan (1995)suggests that the social gradient to control is caused by disparities in the array of resources available to individuals, which are used to avoid risk and to adopt protective strategies.(Link and Phelan 1995, Phelan, Link et al. 2004, Phelan, Link et al. 2010) These included: power, advantageous social connections, money, knowledge and status.(Link and Phelan 1995, Phelan, Link et al. 2004, Phelan, Link et al. 2010) In the theory they propose that there is a social gradient to these key resources, where people in more privileged social positions gain a health advantage.(Link and Phelan 1995, Phelan, Link et al. 2004, Phelan, Link et al. 2010) Therefore, those with a lower SES have less power over their lives and are less likely to be able to have good control over their health.(Link and Phelan 1995, Phelan, Link et al. 2004, Phelan, Link et al. 2010) This can mean people with lower SES become classified as ‘bad’ self-managers, resulting in stigmatised and categorisation as the undeserving sick.(Broom and Whittaker 2004, Ellis, Boger et al. 2017) This may subsequently affect the resources and support they are offered from health services, friends, family and other people with diabetes.(Broom and Whittaker 2004, Ellis, Boger et al. 2017)

Influence of the social structures of inequalities on access and use of digital self-care tools

Digital self-care interventions are an additional external resource that can be leveraged to improve health. Participants in studies exploring the use of web-based self-care interventions generally report that the interventions increase their knowledge of their chronic conditions, as well as their motivation and confidence to self-manage.(Fairbrother, Pinnock et al. 2013, Fairbrother, Ure et al. 2014, Williams, Price et al. 2014, Hallberg, Ranerup et al. 2016) Participants have also described feeling more aware of their condition, better cared for, better informed to make decisions and that they could engage with the HCPs as an equal in consultations.(Morton, Dennison et al. 2017) In a study conducted in Norway, 12 adult participants with T2D used the Few Touch app (described in Chapters 3 and 4) for a year. (Tatara, Arsand et al. 2013) Participants described benefits in terms of being able to instantly confirm how their self-management activities influenced their blood glucose levels.(Tatara, Arsand et al. 2013) They also talked about the low effort needed for keeping on top of self-management activities, and the mobility and pervasiveness of smartphones playing an important role in the integration of app into their everyday lives.(Tatara, Arsand et al. 2013) This demonstrates how technology like the Few Touch app provided an additional external resource that supported people with T2D to manage their condition, reducing barriers to accessing support and offering more choice to the users.

However, there is some evidence (Chapter 3) that people from lower SES groups with fewer resources are less likely to access and use digital self-care interventions.(van Dijk 2005, Yu 2006) In qualitative studies, participants have described barriers to accessing web-based self-care interventions, such as: issues with internet connection or lack of access to the internet at home; not feeling comfortable using devices or the internet; lack of confidence to understand and use the information provided; having competing priorities and not having time to use interventions.(Kerr, Murray et al. 2010, Yardley, Morrison et al. 2010, Kuijpers, Groen et al. 2013, Carolan and de Visser 2018) These issues have the potential to disproportionately affect some social groups over others. Older people, those from minority ethnic groups, with lower SES and living in remote geographical regions have lower access to the internet.(Gibbons 2005, Hardiker and Grant 2011) Challenges with accessibility in design of online health information and issues with digital skills have found to create issues with the usability of digital interventions for older people and those people of lower SES.(Berland, Elliott et al. 2001, Rogers 2003, Gilmour 2007, van Deursen and van Dijk 2010) Web-based health information has been found to be variable in quality, hard to navigate and has mostly been developed to be used for people with higher school or greater reading ability.(Berland, Elliott et al. 2001, Gilmour 2007) Living in poverty can create precarious and unpredictable living conditions, where people are unable to buy their way out of problems which creates challenges with finding the space to focus on self-care.(Broom and Whittaker 2004, Ellis, Boger et al. 2017) For example, working parents may not be able to afford childcare support, which limits the time they have for themselves to conduct self-care activities.(Siddiqui, Khan et al. 2013)

A study based in Australia used focus groups to probe the impact of digital technology (not health specific) on the social determinants of health in people from low SE backgrounds.(Baum, Newman et al. 2014) The authors found that lower levels of economic, cultural and social capital made access and use of digital technology more challenging for people from lower SE groups, which in turn affected their access to a range of social determinants of health.(Baum, Newman et al. 2014) Participants with lower SES could not afford to purchase new technology (economic capital), lower levels of education (cultural capital) meant technology was challenging to use, and they did not have the social connections (social capital) to support the use of the technology.(Baum, Newman et al. 2014) Baum et al.’s (2014) study provides a more sophisticated approach to the digital divide and social inequalities than considered in much intervention literature, but did not explore the impact of digital health interventions the experience of living with and self-managing chronic conditions.

5.2.4. Rationale for the selection of type 2 diabetes as target for the study

The rationale for the selection of the four high burden health conditions as a focus of this research is available in Chapter 2 section 2.1.6. Of these T2D was selected as the high burden physical condition to explore further in the qualitative study. This decision was influenced by the findings from the systematic review and a review of the available web-based interventions in the public domain. As the study was focussing on the use of web-based interventions in people’s everyday lives, it was essential that people were able to access these interventions. The systematic review described in Chapters 2-4 revealed that there were many web-based interventions for diabetes but few for the three other targeted high burden physical health conditions. A review of available health apps in android and apple stores indicated there were many interventions for diabetes and asthma already in the public domain and few for COPD or osteoarthritis conditions. Diabetes was selected over asthma to allow for synthesis of findings between the qualitative study and evidence from the systematic reviews which was predominantly around diabetes. T2D was selected to be the focus rather than exploring both T1D and T2D because although the management activities in the two conditions are similar, the lived experience of the conditions is different, including different identities and experiences of stigma (see section 5.2.2)

5.2.5. Present NHS policy for providing technology to people with T2D

Present guidelines of NHS England for the prescription of technology for people with T2D only includes references to blood glucose monitors. NICE guidelines specifies blood glucose monitors should only be offered to people with T2D if they are on insulin, having hypoglycaemic episodes, on medication that increases their risk of hypoglycaemia while driving, or they are pregnant or planning to become pregnant.(NICE 2016)

5.2.6. Summary and gaps in evidence and research questions

A diagnosis of T2D results in widespread changes in the lives of the person with the condition as well as their families, and can be experienced as an assault person's sense of self.(Bury 1982, Goldman and Maclean 1998) The internal and external resources available to an individual influence how they can adapt to the new diabetic identity and subsequently engage in self-care.(Adams, Pill et al. 1997, Goldman and Maclean 1998, Gomersall, Madill et al. 2011) Digital interventions can be viewed as an external resource people can draw on to improve health outcomes. However, there is an indication that some groups are excluded from digital technologies due to issues with access and usability, which may exacerbate health inequity. To this author's knowledge there has been no investigation in to how social inequalities may impact use of digital health interventions to support the self-care of T2D where people have freely chosen the interventions they wished to use. Of the research questions outlined in Chapter 1 (Section 1.5), this review was designed to address the following primary research question: How and why people with T2D use web-based self-care technology and how their experiences vary. This review has explored a range of theories that consider the illness experience. This author is not attempting to argue that these theories are compatible. Rather these theories have been presented to demonstrate how different theories have been considered in the literature that is relevant to the experience of having T2D.

5.3. Methods

The methodological orientation underpinning the study was an inductive approach drawing on aspects of grounded theory.(Strauss and Corbin 1997, Thomas 2003) It has been noted that the inductive approach can be almost indistinguishable from grounded theory.(Thomas 2003) However, the inductive approach places less focus on technical methodology, such as 'open' and 'axial' coding.(Thomas 2003) The inductive approach has been described as a systematic procedure for analysing qualitative data, where the analysis is guided by specific research questions or objectives.(Thomas 2003) Here this author was seeking to understand the specific research question of how and why people with type 2 diabetes use web-based self-care technology.

5.3.1. Ethical approval and informed Consent

Ethical approval was granted on the 27th of April 2017 from the University of Bristol Faculty of Health Sciences Research Ethics Committee (Application and favourable opinion letter available in Appendix 5.1).

The participants received both written and verbal information. The participant received the Participant Information Sheet (PIS) in advance of the study session via email along with a link to the online consent form. They were offered paper versions of the consent form as an alternative, which a few of the participants who selected a face-to-face interview selected. The consent form assured the participant of the confidentiality of the data collected and asked for permission for interviews to be audio recorded and to publish anonymised quotations from the study. There was no time restriction on how long participants had to respond. Therefore, participants were given sufficient time to read the information, consider any implications, and raise any questions with the author prior to deciding to participate. At the beginning of the interview session the author checked that the participant had read the PIS and the participant was given an opportunity to ask the author questions. The author also provided a verbal explanation of the study to the participant which covered all the elements specified in the written information provided for the participant. The participants were informed of the aims, methods and participation requirements of the study. For those who had completed the consent form online verbal consent was then obtained. For those who had opted for a paper consent form, written consent was then obtained. Participants were informed that they are free to withdraw at any time.

5.3.2. Data protection and confidentiality

The study author consulted with the University of Bristol Data protection and IT Governance services about the best procedure for the collection and storage of online data. Consent forms and questionnaires were both created in the University of Bristol Online Survey (BOS) system. The two forms had different IDs and the linkage was kept in a password protected document so the data could not be paired by looking at the completed data forms on the BOS system.

Recordings were made on encrypted audio-recorders and transferred to the University of Bristol secure servers where they were kept in accordance with the Data Protection Act (2018). Paper versions of consent forms were digitised and kept on the secure server and paper originals were stored in locked filing cabinets. Once the audio recordings were transcribed, they were anonymised (all names or other identifying material removed). Only anonymised quotes were reported. The anonymised transcriptions were kept separately from the identifiable information on the consent forms, so they could not be linked.

5.3.3. Participant identification and recruitment

Purposive sampling was undertaken to obtain a sample of people who were diagnosed with T2D, spoke and understood English and were currently using or had previously used a web-based intervention to help them self-care for their condition. Particular efforts were made to ensure people who are under-represented in research were included in this sample. Gatekeepers for groups or services supporting people with lower SES and Black, Asian and Minority Ethnic (BAME) people were approached. This author acknowledges that the language restriction may have acted as a barrier to study entry for people from BAME groups. This decision was taken because there were no resources to contract an interpreting service, as well as in response to the methodological challenges of cross-language qualitative research.(Squires 2009) People were recruited from:

- local and national diabetes UK groups;
- support groups for BAME people in the Bristol area;
- Bristol-based community centres that served BAME people and people from lower income groups; (Barton Hill Settlement and Easton Family Centre);
- Support groups for BAME people with diabetes, and;
- Through connections with diabetes researchers and research groups (Bristol and Leicester) that have had success recruiting people from the British South Asian population.

Each source was contacted to establish the best way to communicate the study details to the potential participants. Where possible the researcher attended meetings in person to discuss the study. A sign-up sheet was taken to the meetings to take the contact details of interested participants when attending meetings in person. Where study details were communicated via email, potential participants were asked to express their interest via email or phone. Once a participant expressed an interest in being involved in the study, they were contacted to discuss the study and to answer any questions before they decide whether to take part. The author (Sophie Turnbull) checked that the participant had a diagnosis of T2D, spoke and understood English, and that they were currently using or had previously used a web-based intervention to help them self-care for their condition. Following this, the participant was either sent a link to an online participant information sheet, consent form and screening questionnaire or paper copies of these were posted depending on preference, after completion the participant was contacted to arrange to arrange an interview. The questionnaire approved by the Ethics committee is available in Appendix 5.1. The purpose of the screening questionnaire was primarily to support purposive sampling and to maximise diversity in terms of: the type of intervention that they have used and socio-demographic characteristics (age, gender, ethnicity, education, religion, income, IMD). Recruitment continued until data saturation was reached.

5.3.4. Data collection and interview conduct

The interviews were conducted in a location convenient to the participant. The interviews were semi-structured and conducted by this author. The duration of the interviews ranged from 35 minutes to two hours 13 minutes. To ensure the study was accessible to as many people as possible from different regions and with different requirements, phone interviews were offered as an alternative to a face-to-face meeting. Video calling was offered but was not taken up by any of the participants. Therefore, interviews were conducted by telephone, in participants' homes and in a diabetes unit in Leicester hospital.

In one interview, the first 10 minutes of a telephone interview was lost because the recording device did not pick up the audio. There were no further issues with lost data. On three of the phone interviews it was apparent that family members (including children and partners) were around the person being interviewed, which may have affected the content of the interview. In one interview the male participant asked his wife about dietary changes following his T2D diagnosis. In another interview the participant appeared to be distracted by an infant and also seemed to become less talkative when it became apparent her husband was in the room, this was particularly around questions about her partner's contribution towards dietary changes. This was not the case for the face-to-face interviews. The face-to-face interviews had the benefit of bodily social cues, it was easier to encourage conversation using facial responses rather than using "um", which can disrupt the flow of the interview.(Vogl 2013) The transcripts were not returned to the participants for comment.

The topic guide was developed using theory and evidence of the lived experience of chronic conditions, self-care and the digital divide (Appendix 5.3.). There were three iterations of the topic guide, with minor changes from the first to the third edition, around challenges of conducting self-care activities in the context of social gatherings. In the early iteration more focus was placed on cultural practices associated with social events (including religious ceremonies). However, issues around events did not appear to be important to participants, they tended to refer more to situations where they were out of their normal routine (such as holidays). Therefore, the third iteration of the topic guide explored social gatherings in a less specific way. Field notes were taken during and after interviews to describe the environment the interview was undertaken in, and to record reflections on how the interview went and how it felt to undertake them.

The interviews were audio recorded and the transcribed verbatim, anonymised (discussed in section 5.3.2), and the script were checked for accuracy. The first interview was transcribed by the author and the subsequent interviews were transcribed by "UK Transcription", which is one of the Bristol University recommended transcription services. The transcripts were checked against the audio by this author, errors were corrected, and omissions were added. The transcribed interviews were imported into NVivo for analysis.

5.3.5. Data analysis

Analysis was ongoing and iterative and began soon after data collection had started. Insights from analysis informed subsequent data collection and the topic guide was revised to reflect emerging themes from the analysis. Interview topic guides (version 1.0 and the final version 1.3) are available in Appendix 5.3. The data were analysed using the Thematic approach: patterns (or themes) were identified that were prominent in the interviews, both within individual interviews and across participants.(Braun and Clarke 2006) Coding of the data was conducted in NVivo. Three transcripts were coded by the author and were independently coded by two members of the supervisory team. The lists of codes were reviewed in a meeting and discussed and the team reached a consensus on the list of themes. New themes emerging in subsequent transcripts were discussed in regular meetings with the team and the coding structure was further refined. The coding tree is available in Appendix 5.4. Participants have not provided feedback on the findings.

Some major themes were derived from theory prior to coding and further themes were derived from the data as they emerged. During analysis the results were divided into two broad groups with common themes within them. The groups were: i) experiences of accessing and using web-based intervention, and; ii) the role of technology in the construction of illness identities and narratives. Chapter 6 provides the sample description, an overview of the digital interventions used and the results and discussion for the group i) and Chapter 7 covers the results and discussion for ii).

5.3.6. Reflexivity

Personal characteristics

Participants interviewed in person would be aware that the author was a white woman, in her thirties, who is relatively affluent, with no visible disabilities and a healthy weight, who appears relatively fit. Several of those interviewed by phone made a reference to the author being younger even though they were not able to see this physically. All would have known that the author was a student researcher at the University of Bristol. These factors had some influence on the dynamic in the interviews by shifting the way in which people chose to present themselves for someone with the aforementioned characteristics. Some participants were quite informal quickly and talked about having daughters of a similar age. Others demonstrated their scientific knowledge of diabetes and technology and it is quite possible that this was in response to the author's position at the University. Others grouped the author in with HCPs and there was a sense of a performance of the 'good diabetic' in the interview. In these situations where there seemed to be power dynamic, the author played the role of the 'naïve researcher' to shift the balance towards the participant as the expert in the scenario.(Råheim, Magnussen et al. 2016)

The author is positively disposed towards technology solutions to healthcare issues. The position taken by the author is that digital interventions have the potential to be beneficial for people with chronic conditions and there are likely to be socio-cultural differences in the way people access and use technology. These positions may have affected the data, as experiences indicating differences in access were actively sought and probed in the interviews and the analysis. Comments from the participants that did not reflect this view may not have been pursued as far as those that did reflect this perspective.

The majority of the training and experience undertaken by the author is in quantitative methods and this too is likely to have a bearing on the conduct and the interpretation of the interviews. This author transitioned from thinking in quantitative terms, where the responses from the participants were taken as an objective reality. To an understanding that the interviews were a presentation of a subjective reality, that was being performed to the author. This became key theme in the research, where technology was used to avoid the stigmatised diabetic identity and enact preferred identities.

Relationship with participants

There was no prior relationship with the study participants before the study commenced, except for in one case where the participant had agreed to the author attending her local Diabetes UK group to advertise the study. Following a conversation at that meeting she had disclosed she used technology to support the self-management of her diabetes and she was invited into the study. The participants knew that the study was about the use of technology to support the self-management of T2D but did not know the author was exploring differences by SE and cultural groups.

In most of the interviews a good rapport was developed with the participant. In a few interviews the participants seemed quite closed, and it was challenging to get them to provide detailed responses to questions. For some people, the limited responses were just to a few questions, for others it was during the whole interview. One person was also caring for a baby while conducting the interview on the phone and seemed very distracted. In some interviews the participants had partners present in the room, which appeared to influence how they responded to questions. For example, in one interview when asked about his diet he referred to his wife for an answer.

CHAPTER 6. QUALITATIVE STUDY RESULTS AND DISCUSSION: EXPERIENCES OF ACCESSING AND USING WEB-BASED INTERVENTIONS FOR TYPE 2 DIABETES

6.1. Chapter overview

The qualitative study was designed to answer the primary research question: How and why people with type 2 diabetes use web-based self-care technology and how their experiences vary. The methods were described in Chapter 5 (pages 164-168). Two broad groups of themes emerged from the interviews. The first group of themes described participants experiences of accessing and using web-based interventions. The second group of themes covers the role of technology in the construction of illness identities. This chapter provides the sample description, an overview of the digital interventions used and the results and discussion for the first group of themes and Chapter 7 covers the results and discussion for the second.

6.2. Results

6.2.1. Sample description

Twenty-seven people with T2D were eligible to enter the study, and data saturation was reached after 21 interviews. Data saturation was established when no further information was emerging in relation to the key themes of accessing technology (learning about and acquiring), use of technology to understand the diabetic body, stigma, control, and use of technology in interactions with Health Care Practitioners (HCP). Around 18 interviews were conducted when it began to feel that there was no new information related to these themes. Three further interviews were conducted after this interview with participants with similar socio-cultural characteristics and digital interventions. Towards the end, the only new information that was emerging was differences in what participants liked and did not like about the technology they used. Use of technology in identity work continued to produce new information throughout the interviews, as each participant used the technology to present a slightly different identity. However, data saturation was reached in the central concept in this theme, where participants used technology to enact and confirm positive identities and avoid the stigmatised identity. The decision not to interview the six further participants was made because they did not represent any greater diversity in terms of socio-cultural characteristics or in the digital interventions they had used. If it was possible to recruit more participants from BAME groups, more interviews would have been conducted, as it is likely that saturation had not been reached for experiences of people from these groups. One person expressed an interest in the study but chose not to proceed because they did not feel comfortable with the University standard procedure of data storage.

Of the 21 interviewed participants, the majority responded to a circulated email to local level Diabetes UK groups (n=7) (https://www.diabetes.org.uk) or to an advert circulated in an established diabetes research group in Leicester (n=6). People were also recruited through adverts with Diabetes UK nationally on their website and newsletter (n=3), word of mouth/snowballing (n=3), attending local community groups in Bristol (n=1) and through a Facebook advert (n=1). The sample was diverse in terms or age (median 60 years, range 29-74, gender (52% men), socioeconomic situation (SES) and household income (Table 10). All participants had completed intermediate education between secondary level and university (Low Ed), and two thirds (62%) had a High Education (High Ed) with a University degree or equivalent. Most of the participants identified as White British (81%) and were of Christian religion (57 %). The intention was to recruit a maximum diversity sample in terms of: the type of intervention that participants used and socio-demographic characteristics (age, gender, ethnicity, education, religion, income, IMD). Diversity was achieved for type of intervention, age, gender, education, income and IMD. Targeted efforts were made to approach groups that supported people from BAME groups, however the uptake was lower than was hoped. As such the thematic analysis may not capture the range of experiences of those from minority ethnic groups.

The sample was self-selecting for those who were interested in using technology to support the management of their condition. However, not all people in the sample were technophiles, and the sample ranged from people who used multiple digital interventions, to those who used one, and in one case the participant had tried digital interventions but had stopped using them because they were not helpful for her (ID 24).

Table 10: Participant characteristics

Participant characteristics	**Male** **N=11**	**Female** **N=10**
Age		
21-30	0	1
31-40	1	0
41-50	1	1
51-60	3	4
61-70	4	3
71-80	2	1
Socioeconomic situation (SES)$^{\alpha}$		
1 Lowest SES	1	2
2 Lower SES	2	1
3 Mid-SES	3	1
4 Higher SES	1	2
5 Highest SES	4	3
Not available	0	1
Education		
Left school before 16 years of age	0	0
Secondary school or equivalent	1	0
Intermediate between secondary level and university (e.g. NVQ3-5, diploma, apprenticeship) (Low Ed)	5	2
University degree or equivalent (High Ed)	5	8
Ethnicity		
White-British	9	8
Asian/Asian British-Indian	2	1
Black or Black British	0	0
Mixed	0	0
Chinese	0	0
Other-White European, with mixed racial ancestry	0	1
Religion		
No religion	2	3
Christian	6	6
Muslim	1	0
Jewish	0	0
Sikh	0	1
Hindu	1	0
Buddhist	0	
Prefer not to say	1	
Estimated household income last year (before tax and not including benefits)		
<£16,000 and/or eligible for means tested benefits	3	0
£16,000-£24,999	1	4

£25,000-£34,999	3	0
£35,000-£44,999	0	2
>£45,000	2	2
Prefer not to say	2	2
Use of digital interventions		
Lighter (≤2 interventions)	7	5
Heavier (>2 interventions)	4	5
α- Indices of multiple deprivation score for home post code of each participant was used to determine relative deprivation within England and the quintile is given		

6.2.2. Digital interventions used

The type of digital interventions that people used fell into four main categories. All interventions were either web-based or had smartphone app connectivity:

1) Tools to support and personalise care:
    - Blood Glucose Monitors (BGMs) with accompanying app: Dario meter, Freestyle Libre, Trueyou mini
    - Blood pressure monitors with accompanying app
    - Apps to support healthy eating and increase exercise: Carbs and Cals, MyFitnessPal, Health app by Samsung and Apple, pedometer apps, Diabetes Diary, Change4Life, Couch 2 5k, Water app, Slimming world app, Diabetes UK app, Tap and Track, Habits, IBG star (BGM app)
    - Wearable technology/sports trackers: Fitbit, Apple watch, Microsoft band, generic pedometer band, Garmin, cycling computer
2) Information from official sources and experts- this included:
    - Forums and websites: Health Unlocked NHS, Diabetes.co.uk, DiabetesUK, NHS choices, NHS local websites
    - YouTube- lectures from experts in the field
3) Social networking and information from other diabetics:
    - Personal networks: Facebook, WhatsApp
    - Online forums: Health Unlocked NHS, DiabetesUK, Diabetes.co.uk
4) Improving or managing the relationship with HCPs or people working in practices:
    - Access to medical records
    - Apps and websites for booking and managing appointments: GP practice app, NHS choices

Most people did not use interventions designed specifically for people with diabetes, but rather used technology designed to support healthy living and social connectivity. The diabetes specific interventions were the BGMs (Dario meter, Freestyle Libre, Trueyou mini) used by ten participants, and three different apps (Diabetes diary, IBG star app and Habits) each used by one participant. Habits was an app developed specifically for South Asians with diabetes. Of the ten people who used BGMs, five were supplied BGMs by their HCP and five purchased them privately. Fitness trackers (used by 16 participants) and apps that tracked nutrition or fitness (used by 11 participants) were used by the most participants. The median number of different interventions trialled by the participants was two (range 1-7), 12 participants were light users (≤2 intervention) and nine were heavier users (>2 interventions) of digital technology.

6.2.3. How people learned about digital interventions

Participants described learning about digital interventions that might support their self-management through searching the internet, social networks, support groups and online communities and forums. Participants talked about researching online, navigating apps stores and products and seeking out expert advice.

> *I just googled, or, or sort of had, had a browse through the Apple Store. And thought, "What might be, er, what might be usable?" (ID 29, heavier user of technology, Male, 64yrs, White, High Ed, highest SES)*

Many participants initially found out about technology through friends and family. They described friends and family letting them know about technology that supported health and fitness.

> *my son put me onto it [MyFitnessPal]. He, he's a big fitness freak. And, erm, he, he said, "Try this app, mum," and he set it all up for me, and it went from there, and I really, I still use it, I still like it. (ID 40, lighter user, Female, 72yrs, White, High Ed, higher SES)*

Group membership influenced the type of technology people heard about. Participants who were involved in community-based diabetes support groups and diabetes research groups described finding out about technology themselves from magazine articles, talks and conferences and hearing about them from other group members. Online communities and forums fulfilled a similar purpose to physical support groups in spreading information about innovations in technology.

> *We had a talk at the local diabetes group (…) it was a professional from Abbott-- actually, on the FreeStyle Libre. Erm, within the diabetes group we, erm, go to Health Melas, and that type of thing, as part of Diabetes UK. And we have stalls with all our literature and what have you, and we talk to people (ID 42, heavier user, Male, 72yrs, White, High Ed, Mid SES)*

> *I'm sort of active in the diabetes online world, of course, there are always people there talking about new innovations and things that are coming up and people will be on trials and all sorts. (ID 33, heavier user, Female, 60yrs, White, High Ed, highest SES)*

Participants took advice from those whose opinions they trusted and valued, because they were friends, were perceived to have higher status, or because they appeared to have professional knowledge.

> *I do quite a lot of work, with, er, the Diabetic Research Centre, (…) one of the lads on - who does the Research Village as well - he's on quite a few of their focus groups. Well, he said about it [Change4Life app]. And I'd never heard of it. (ID 28, lighter user, Male, 66yrs, White, low ed, mid SES)*

Later in the same interview. The participant elaborated further:

> *He's very, very, very knowledgeable. And there's also a lady, er, on there [Research group], as well. Erm, and I think she has got a medical background. Er,*

> *and she’s an enormous, erm - an absolute wealth of information (…) them two are absolutely fantastic. And they’re incredible people to have on the focus groups. Because whereas you’ve got your normal, like run-of-the-mill Joe Bloggs meeting, when we’re talking about things - they have a much more in-depth, er, er, understanding of things. And they present more problems, and ask more questions, and say things that we wouldn’t dream of saying. (ID 28, lighter user, Male, 66yrs, White, Low Ed, Mid-SES)*

Participants did not generally describe learning about digital interventions from HCPs, and most felt that HCPs had limited knowledge of technology that could support their diabetes self-care. They talked about educating HCPs about technology available to the public and their benefits. Only one person mentioned that technology had been recommended to them by an HPC.

> *Doctor T don’t get the technology. So when I go in there, yeah, he’s really interesting, he’s so sweet, but he says, “So what is this Fitbit? Are you still wearing it?” (ID 10, lighter user, Female, 61yrs, White, Low Ed, lowest SES)*

> *That [Food Smart app] was recommended on the first [NHS] health visit that I had from this wellbeing thing. They said, “Look, we’ve got this, this would help you in actually seeing the makeup of what you eat.” (ID 22, lighter user, Male, 67yrs, White, Low Ed, Highest SES)*

6.2.4. How people acquire technology

In context with health services

Many participants felt that limited resources in the NHS prevented them from accessing technology to support their diabetes self-care. This came across particularly strongly in the context of BGMs. Some participants described being provided BGMs while others were not. Those who were not supplied monitors felt that the NHS was limiting availability of BGMs to people with T2D because of budgetary restraints or perceived need.

> *if I had a choice, I’d have a meter. But they refused to give me a meter (…) I respect her [diabetic nurse] judgment but equally there’s a cynical side of me thinks; “Is this down to cost or is it down to medical decisions? I don’t know.” (ID 27, lighter user, Male, 58yrs, White, Low Ed, highest SES)*

> *it’s disgraceful really that these technologies, the quite basic technologies, are so blinking expensive that people feel they have to be cut. You know, things that help people self-manage. Because as soon as you self-management and, and you get better educated and self-managed things improve, but, you know, we live in a time when that doesn’t count really. (ID 37, heavier user, female, 68yrs, White, High Ed, higher SES)*

There was a sense that people with T2D had different digital resources available to them than those with Type 1 Diabetes (T1D). Participants described encounters with HCPs where they had been told regular blood glucose monitoring was only needed for people with T1D. There was a feeling from several of the participants that people with T2D were provided with less services and resources than people with T1D generally and in the context of health technology.

> *I told her [nurse] that I had tested my own blood glucose, and she looked at me in horror and said (…) "Only test- you shouldn't be testing. Type 1 diabetics test, Type 2's don't need to." "What readings have you been getting?" (…) So I told her, and she said, "Oh. Oh right, well, if you ever go above 12, come back and see us immediately." (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *you don't need anything else [wearable to activity tracker]. I mean a Type 1 does but a Type Two doesn't. I mean my doctor and my diabetic nurse have said, "You don't need to test [blood glucose levels] on a daily basis, erm, because you are Type Two." (…) They're, they're saying Type Twos who are non-insulin dependent don't need it. (ID 34 male, lighter user, 55yrs, white, Low Ed, Lowest SES)*

> *I get the feeling (…) that they [Diabetes UK] tend to be more interested in the Type Ones than the Type Twos. Er, the reason being that Type Twos can get on with it and just, you know, leave them to it. They forget that some of us, you know, are actually on insulin (…) diabetes is a real, you know, we all get affected the same way. We all have, you know, amputations. We all have, er, highs and lows. (ID 38, heavier user, Male, 65yrs, White, High Ed, High SES)*

The provision of BGMs appeared to be particularly important to the participants because many people attributed using this technology (privately bought or NHS supplied) to having greater control over their blood glucose levels or diabetes in general.

> *if I hadn't got my blood glucose meter, and then, the Libre. I mean the Libre is ridiculously expensive to self-fund. I can't do it all the time (…) then I use the prick testing the rest of the time. Erm, but without those two things, I wouldn't be in control of my blood glucose. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

Some participants privately bought technology because it was not supplied by their HCP or because they felt that the equipment provided was not adequate for their needs. Participants talked about purchasing BGMs themselves and additional test strips to use with them. They also described purchasing BGMs because they felt the information provided by HCP was not useful and they wanted to more personalised information about their body.

> *I belong to a forum called, Diabetes.co.uk. Erm, and, erm, I learnt most of what I know about diabetes on there. Erm, and, there were people talking about how to fund your own blood glucose testing by using cheap meters and whatever. And pay for them privately rather than have a prescription. And I'd done that. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *They supply me with, erm, one box of 50, erm, a month (…) I do buy my own strips as well, erm, because I'm very conscious that, sometimes you have to test – or I, I have, I test – when perhaps it's not absolutely necessary, but I need to know where I am. Er, sometimes I feel low, and, erm, I'm not. So, I really don't want to start taking food, but I can understand that, er, it's perhaps not necessary, er, clinically. (ID 42, heavier user, Male, 72yrs, White, High Ed, Mid SES)*

> *I was pretty stunned when they [GP] gave it [diet leaflet] to me and I scanned down it. I thought, "I, I, I'll read, I'll read it better, surely it can't be this bad. I'll read it better." And then I went outside, stood outside and read it, and binned it. (…) in other appointments [with HCP], have said, "Well, the way I controlled, the reason I've got, I've lowered my HbA1c is because I got myself a blood glucose meter, and I started testing after meals, and I found what foods sent my blood glucose high. And as a result I no longer eat bread, rice, potato, pasta, and so on." And they, sort of, blank it and carry on with whatever they were saying. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

Participants described having negative reactions from HCPs about their use of BGMs they had self-purchased rather than being prescribed. However, other technology (such as digital dietary and activity aids) used to support self-care behaviours appeared to elicit more positive reactions. One participant described not being provided with a BGM because the HCPs felt having access to a BGM may be unhelpful for people with health anxiety.

> *Respondent: …if that carried on for three weeks to a month, I'd be off to the doctors. Who would probably not take the evidence of my Libre as anything, because when I did discuss the Libre with the doctor he said, "Yes, it doesn't meet with any approval in this neck of the woods." But that was over a year ago. He might have changed his tune now.*
>
> *Interviewer: So what, what did he mean by that?*
>
> *Respondent: I've no idea. I didn't pursue it. I thought, "You arrogant sod," and changed the subject (Laughter). I, I pick my battles. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *I showed them [Diabetes Diary app] to a doctor (…) because he was talking about the blood test and HbAs and I said I do keep a check and I…bought my phone out and showed him the graph (…) He'd never seen it before and he thought it was an excellent idea. (ID 20, lighter user, Male, 74yrs, White, Low Ed, Lower SES)*

> *if I had a choice, I'd have a meter. But they refused to give me a meter. (…) The nurse is confident that I've got it under control. If I was really honest with you, I would, I would much prefer to understand the diet more, by having a period of*

> *metering. But I think it was a combination of, in the early days, she recognised the issues I'd got psychologically. And she thought that I'd end up in an even deeper hole if I was on a meter. (ID 27, lighter user, Male, 58yrs, White, Low Ed, Highest SES)*

Barriers and facilitators to access

Participants described how access to technology was facilitated by people in their personal networks. They talked about having access to technology through gifting and through perks from work. Participants also described personal trainers using technology with them.

> *my husband gave me an Apple Watch, as a very generous gift. And I am in love with it (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *you can put all your details in of, you know, your medical details and everything [Health app iPhones], but I've not gone that far, 'cause it is actually a company phone, it's not my phone. Although I'm free to use it (ID 22, lighter user, Male, 67yrs, White, Low Ed, Highest SES)*

> *My Fitness Pal we used when, again, when I was, she [personal trainer] was really training me up for this half marathon. I've done a few half marathons now, and she really wanted to keep a track of what I was eating, you know, before, after and how it affected me and everything. So, really my personal trainer G has helped me to really understand the diabetes more, you know, by doing all that. (ID 37, heavier user, Female, 68yrs, White, High Ed, Higher SES)*

Group membership provided benefits which included access to digital technologies. Those who were members of diabetes support groups talked about receiving discounts off expensive digital interventions and being offered free samples.

> *One or two of the, the people within the group have availed themselves of it [Freestyle Libre], because we did get some, erm, free vouchers from the rep, and these were distributed within the group. (ID 42, heavier user, Male, 72yrs, White, High Ed, Mid SES)*

> *quite often you would get a monitor by, you'd be given it by, erm, er, the companies, you know when, because being part of Diabetes UK. And in the support group, and then I sort of became secretary, and then I became chair. Erm, you'd go to stuff, and they'd say, "Here, have this" (ID 11, heavier user, Female, 59yrs, White, High Ed, Highest SES)*

Social status seemed to help some participants be able to gain better access to technology. One person was able to negotiate getting replacement technology when his failed because he felt confident with technology companies because of previous work with them. Another person gained pre-launch access to a culturally sensitive app for himself and his South Asian support group through contacting the company directly as the lead of the support group.

> *being a Microsoft partner-Er, you get a lot of, things sent to you. You know, I, well bought one, er...actually, I went through three of them. Er, battery failures or whatever but, er, each time they got replaced. Then, eventually, said, "Well, we're not gonna bother replacing, we'll just give you your money back." (ID 36, heavier user, Male, 57yrs, White, High Ed, Higher SES)*

> *it hadn't reached the iPhone yet. Then contacted the company who were making it. I said to the company, "Well let's, erm, you're going to launch it, let's pilot it within our groups, to see…" The effectiveness, to see how, what people think. (ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Low Ed, lower SES)*

The cost of digital interventions was prohibitive for some participants. The participants differed in how much they were willing and able to spend on self-care supporting technology. Participants talked about considering buying technology but could not being able justify the cost. Some used expensive technology but adapted its use to limit expense. Others described using digital interventions that were free to download onto their smartphones.

> *they're very expensive [Freestyle Libre]. So, that, that one is a no-go at the minute. (ID 40, lighter user, Female, 72yrs, White, High Ed, Higher SES)*

> *Interviewer: Erm, so is there anything about your Fitbit you don't like? (…)*
>
> *Respondent: Maybe a bit more affordable. This one was £60, that's the cheapest. Now they've gone up to about £90 I think. (ID 10, lighter user, Female, 61yrs, White, Low Ed, Lowest SES)*

> *because of the expense, because it's [Freestyle Libre] about £50 for every two weeks, erm, I stopped using it as frequently, and came more on to a regime where, when things were going to be changing, erm, I would use it. (ID 42, heavier user, Male, 72yrs, White, High Ed, Mid SES)*

> *A free app. And a, it's kind of coach, so behind the app-You've got diabetes coaches. (ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Low Ed, Lower SES)*

Not everyone felt they had the skills to navigate technology, but people drew on social support to help them negotiate issues with usability. Some people were self-confessed early adopters and technophiles, while other people felt less able to navigate new innovations. There was a suggestion that these limitations in the individual's knowledge of technology could be overcome by support from people in their social network; where people with technology knowledge and skills could act as 'tech buddies' to help the participants overcome issues with usability.

> *now I couldn't load it, and luckily I've got a daughter and a wife who is sort of techie, you know. I'm a bit of a technophobe, even though I, I input data on a second job. (ID 10, lighter user, Female, 61yrs, White, Low Ed, Lowest SES)*

> *What we say to our support group members is, those who are not so smart, for phone, kind of geeks, just go and tell you family members to help you. (ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Low Ed, Lower SES)*

For some people their access to digital interventions was limited by the type and capacity of their phones. These were issues situated in the technological environment, which were outside of their control and something they could not always resolve by drawing on their assets. One participant reflected that not everyone had access to a smartphone, limiting their access to interventions based in that technological environment. Some interventions were not supported by their brand of smartphone and others stopped being supported when phone operating systems were upgraded. Participants also talked about how phone reception could limit their ability to rely on phone-based management tools to support their diabetes.

> *some people who have got, er, iPhones [in the support group] or, erm, Android phones…Have used, bits and pieces. But they haven't, er, and they haven't really used in the same way. And, erm, some of the people don't have a sm-, don't have smart phones. (ID 29, heavier user, Male, 64yrs, White, High Ed, Highest SES)*

> *it doesn't work with every smartphone. I've just changed mine, unfortunately. It worked very well with the Apple, erm, devices. (ID 40, lighter user, Female, 72yrs, White, High Ed, Higher SES)*

> *Because sometimes we're in…we're regularly in northern France…reception is not very good and my mobile is not that that useful. So this thing [counter for insulin pen] is kind of a...err backup (ID 20, Male, 74yrs, White, Low Ed, Lower SES)*

6.2.5. Why people select and use technology

For those that did not face barriers to accessing technology, selection of technology was influenced by what participants liked and valued, what they do not like and find challenging, and social characteristics.

What people like and value

Some participants talked about getting technology because it was fashionable, or because people in their social network had one.

> *I don't use it[Fitbit], that's it. It's just, it's just gone out of fashion. It's just like something that, it's like we're waiting for something fresh now. (ID 24, lighter user, Female, 29yrs, Asian/Asian British-Indian, High Ed, Lower SES)*

Many participants felt that the personalised information provided by digital interventions was more beneficial than 'one size fits all' guidelines issued by HCPs and in structured education courses. There was a common feeling that producing guidelines to all people with T2D and treating them as one group was problematic. Participants talked about turning to digital interventions and forums because they offered tailoring to different culturally specific needs, personal diet preferences and learning styles that were not catered for by community-based education courses. Others felt that physical and digital interventions were complementary, with the courses providing broader information and technology providing the detail.

> *I think everybody's different. For a variety of reasons, and people have, er, succumbed to type II for a variety of reasons. And I think to try one fits all scenarios is quite dangerous. So, I can eat things that other people can't eat. (ID 27, lighter user, Male, 58yrs, White, Low Ed, Highest SES)*

> *how appropriate that style or level of learning is for any of those people [in the DESMOND course], never mind all of them, it's gonna but suboptimal because, you know, if you've got six people in the room, then those people aren't gonna get the same things out of it. Some will get m-much more than others and, you know. (ID 33, heavier user, Female, 60yrs, White, High Ed, Highest SES)*

> *I've been engaging with Habits [South Asian specific diabetes app] and the doctor [in India]. (…) when I saw it I thought, "Wow this is something I've been looking for, for a while." And it's now here, so we have to take advantage (…) I think in the absence of nothing, you've got something that you've got to go in and see if it's going to help you to manage your condition.(ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Hindu, High Ed, Lower SES)*

> *when I was diagnosed diabetic, I wasn't offered a course and I didn't push for it. Because I have, I had heard feedback from other people on the forum who had gone on said course…and found it absolutely useless, because it just pushed carbs. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

There was a sense that technology was beneficial because it could be accessed at a time and pace that suited the user and could be used around other time commitments. One participant felt they got the same benefit from an app as a community course, but the course took many hours and the app was much quicker to use and relayed the same information. Another participant, who moderated a private messaging group (WhatsApp) alongside a support group felt that the social platform increased access to support for people who could not make the physical meetings.

> *it's [Change4life app] telling me exactly what I need to know. In a way that I can understand. So, although it's only a tiny little app. And the other was, er, hours and hours, and hours - they both achieved the same end. That they told me what I needed to know, in a way that I could understand. (ID 28, lighter user, Male, 66yrs, White, Low Ed, Mid SES)*

> *There's people who don't attend the support group, but they value just that WhatsApp group. (…) then they get to, they get information via email, or, or through the WhatsApp and they find that valuable as well, because it keeps them,*

> *keeps them connected. (ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Low Ed, Lower SES)*

Perceived limitations in accuracy of the feedback from digital interventions did not stop participants from using technology. Many participants acknowledged limitations in the accuracy of the data but felt that having an indication of how they were doing was enough to support their self-management. There was a feeling that the drawback of the technology not being completely accurate was outweighed by the benefit of having access to technological innovations.

> *it comes down to this question of precision, 'How precise do you need to be, or how precise am I?" But as long as I think it's sort of -ish, then probably it's 80, 80 anyway – if it's sort of 80 or 90% accurate, it's probably okay. (ID 29, heavier user, Male, 64yrs, White, High Ed, Highest SES)*

> *it's not very accurate for telling you what your precise number is. Your blood sugar reading. So, differed sensors read differently, and you have to get to accept this (…) But, you can always tell whether you're going up or down, running steady, about to have a hypo. So, erm, invaluable, but it comes with, erm, with problems. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

There were mixed views about whether digital forums facilitated greater social support than physical courses and support groups. Some participants talked about how people would miss out on learning from other people with diabetes and emotional support if they only used apps to support their care. Participants described bonding with people over health and fitness, sharing ideas about preferred technology and health achievements. Several participants were satisfied they received all the support they needed from online forums. However, others were quite scathing about the social element of some digital social platforms.

> *when I, attended a course, or tutored a course – you learn things from other people. You learn things from talking to people. Erm, and that interaction, is something that you can't, well, which an app doesn't replicate (ID 29, heavier user, Male, 64yrs, White, High Ed, Highest SES)*

> *you can have little competitions as well. So I've got Fitbit friends. Erm, and you, you, er, do challenges, like who will do the most steps in a week. And, er, and the Fitbit seems somehow to, you know – it likes you all together, and, erm, er, yeah. Er, so it's, it makes you quite competitive. (ID 35, lighter user, Female, 63yrs, White, High Ed, Mid SES)*

> *From Diabetes.co.uk, or I've made quite a few friends on there, erm, and we, we interact separately from the forum. (…) They have a local group [Diabetes UK], but I have a very low opinion on their website and forum. So I have never shown any interest in their Diabetes UK organisation locally. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *the idea of sort of going onto, er, onto a sort of social website, to say that, you know, "I'm feeling great today, or not sort of great today. "And then waiting for somebody else, to comment on it, that, that's, that seems just pretty futile, and narcissistic. But obviously, if it helps some people, that, that's fine. (ID 29, heavier user, Male, 64yrs, White, High Ed, Highest SES)*

Participants liked technology that was 'user friendly' and were put off technology that was intrusive.

> *I think it's [Fitbit] really user friendly, and er, it's not difficult to use. It doesn't take over your life, like some aids do. (ID 27, lighter user, Male, 58yrs, White, Low Ed, Highest SES)*

> *The one that was a complete pain in the bum that I deleted, was the water app, because that kept popping up, "Drink water, have you drunk water?" And I was like, "I'm fed up with this. (ID 31, lighter user, Female, 58yrs, White, Low Ed, Highest SES)*

What participants do not like and find difficult

Participants appeared to be cautious about trusting information that they received through web-based social platforms, such as online forums and messenger services. They talked about not taking the information at face value, and fact checking information that was shared. One person talked about challenges with moderating the information shared on these social platforms.

> *I've always used Diabetes.co.uk as a springboard. I'll go and I'll read somebody's opinion and I'll either agree or disagree. And then I'll go and look up what they were talking about. (…) if my information that I have researched contradicts it, then I'll disagree. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *I say, "Don't use America, but also be very, very cautious about what you see on the internet." (ID 10, lighter user, Female, 61yrs, White, No religion, Low Ed, Lowest SES)*

> *I've read the blogs, I don't read them anymore. There's people on there that are part-time doctors that tell you advice. And you know, I posted 'What alcohol should I drink?' And you get some ridiculous answers. (ID 27, lighter user, Male, 58yrs, White, Low Ed, Highest SES)*

> *we get so many people posting on our, on our WhatsApp group. All these different kind of, you know, YouTubes, you know, 'Use this herb' or this and that. So, we've tried to, erm, ask people not to post anything, post it to me first. And then I'll post it to somebody who's got a bit more knowledge of kind of- then say "Between us we'll see whether it's worth sharing or not". (ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Low Ed, lower SES)*

There was a perception from some participants that technology could not always replace current effective non-digital interventions. One man talked about physical prompts he used that could not be easily replaced by technology, (e.g. medicine dosset boxes) but found apps helpful for tracking their intake of insulin where no physical prompts were available. A few of the interviewees talked about the benefits in a physical course of having someone to do activity with them or demonstrate what they should be doing

> *it's [apps] of no benefit if you are just taking medicine, because it doesn't record…the way you take your metformin because the dosset box you can see when they have popped (…) So, so taking insulin was a driver to get an app that would thoroughly keep a record of when I had two, or done something… (ID 20, lighter user, Male, 74yrs, White, Low Ed, Lower SES)*

> *we're now talking about having a meeting just on, you know, finding a venue where there's a kitchen and where there are people who have got teach- some recipes to share. They will show people how to make it. (ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Low Ed, Lower SES)*

There was some discussion around challenges using web-based interventions when there is no internet signal. One participant described how he used a non-digital intervention as back-up for when his phone had no internet reception.

> *sometimes, isn't really practical [App], if you're in a place which hasn't got a good signal. (ID 29, heavier user, Male, 64yrs, White, High Ed, Highest SES)*

Influence of age and gender

Technology was constructed (by the older participants) as something that young people use and older people resist. For some participants, differences in use of technology between older and younger people had been observed as well as perceived. Some felt that older people refused to engage in the shift in culture to healthcare being more technologically lead. There was also the view that younger people had a better understanding of technology and some of the digital interventions were better suited to the way younger people interact with technology.

> *I don't think it's any point trying to tell an 85-year-old about Fitbits. But someone who's sort of, has an understanding, try it, see if it works for you. (ID 27, lighter user, Male, 58yrs, White, Low Ed, Highest SES)*

> *the young people I know with Type 1 and stuff, they- it's all chat... You know, they have these, erm, chat, er, forums and things like that. They, they use them a lot, I think. (ID 37, heavier user, Female, 68yrs, White, High Ed, Highest SES)*

In contrast the younger people in the sample (female aged 29 and male aged 31 years old) talked about the benefits of physical interventions over digital. The younger woman highlighted the value of having sessions where they did physical exercise and did not value the digital interventions as a support for her diabetes. The younger man highlighted the importance of a non-digital interventions allowing him to make social connections. The young woman did express the feeling that she had different requirements than others on the diabetes support course because they were much older.

> *apps are not very good in compared to that kind of stuff [LEAP/Weightwatchers]. 'Cause the whole point is you got to be physical......I think and you've got to do it. (…) The app, the apps are good for people that, that are independent in their own exercise. (ID 24, lighter user, Female, 29yrs, Asian/Asian British-Indian, High Ed, Lower SES)*

> *I would like to do a course [Man vs Fat], and that would sort of encourage me to meet other people, but also, to share my a-, hopefully, er, speak to other people, and then they can share ideas, on what works for them, and what's been quite useful, and then sort of pick up some things that way. (ID 23, lighter user, Male, 31yrs, Asian/Asian British-Indian, High Ed, Mid SES)*

> *I found it really good but I was like the youngest one there. So everyone else was like, quite sedentary. And I found it really easy to lose weight and, erm, and they all just like, hmm. (ID 24, lighter user, Female, 29yrs, Asian/Asian British-Indian, High Ed, Lower SES)*

The younger woman was the only participant that felt that none of the different types of technology she had tried had been helpful for the management of diabetes.

> *I haven't used it for a while [Change4Life] because I just, erm, it, kind of, like, I did use the Fitbit for a couple of days but I just found, erm, yeah. I just wanted to see what the, what fuss is all about, so I got one. But there's nothing really that can help you. (ID 24, lighter user, Female, 29yrs, Asian/Asian British-Indian, High Ed, Lower SES)*

Male and female participants emphasised different concerns about technology. Male participants consistently brought up concerns about data security of technology and how this influenced what they chose to use. Many of the men in the group had concerns with what companies were doing with their personal details or whether their information could be hacked and used maliciously. Male participants also talked about some technology feeling insidious, when it felt like all movements were watched by online companies. One male participant felt that companies followed ethics codes so would not exploit their information. Some of the female participants spoke about challenges with establishing which online sites were credible sources of information but did not bring up issues about security.

> *…you're leaking data all over the place, er, for nasty people to, if they wanted to, hacking. (ID 36, heavier user, Male, 57yrs, White, High Ed, Higher SES)*

> *if you've been Googling something, or I find it quite disturbing that if you're looking at something else and then an advert comes up on what you've been looking at. So, it all seems to be linked in certain ways, and you think, "Oh crikey,"*

you know, “it’s like you are being watched.” (ID 22, lighter user, Male, 67yrs, White, Low Ed, Highest SES)

there’s ethical, there’s ethics and codes of practice that the company has to follow anyway, which...So, I can’t see that they’re going to be selling our information… (ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Low Ed, Lower SES)

6.3. Discussion

6.3.1. Summary of main findings

Participants described how they: learnt about, acquired, and used technology to support the self-management of their T2D. Participants talked about learning about digital interventions through searching on the internet and through social networks (in person and online). Participants took advice on technology from those whose opinions they trusted and valued, because they were friends, perceived to have higher status, or because they appeared to have professional knowledge. Participants did not generally describe learning about digital interventions from HCPs, and most felt that HCPs had limited knowledge of technology that could support them.

In terms of how participants acquired technology, there was a belief that the NHS was limiting availability of digital interventions (particularity BGMs) to people with T2D because of budgetary restraints or perceived need. There was a feeling from the participants that people with T2D were provided with less services and resources than people with T1D generally and in the context of health technology. The provision of BGMs appeared to be particularly important to the participants, as many people attributed using this technology (privately bought or NHS supplied) to having greater control over their blood glucose levels or their diabetes in general. Some participants purchased technology because they felt that the information or equipment provided by the HCP was not adequate for their needs. Participants described having negative reactions from HCPs when they spoke about their use of BGMs they had self-purchased, but digital dietary and activity aids appeared to elicit more positive reactions. There was a perception that HCPs thought having access to a BGM may be unhelpful for people with health anxiety.

Participants talked about how they accessed technology through personal networks (gifting, work perks, use with personal trainer) and group membership (discounts and free samples). Some participants described using their social status to gain better access to replacement technology when theirs broke and access to technology before it had been released to the general public. Some participants also described how cost, type and capacity of phones and skills navigating technology were limitations to the use of some technology. But participants described how issues with skills using interventions could be overcome by drawing on support from ‘tech buddies’ from their social network.

For those who did not face barriers to accessing technology, participants described intervention choice being influenced by what they liked and valued and what they did not like and found challenging. Some participants perceived the selection and use of technology was influenced by age, and there was an indication of a gender difference in concerns about technology. Perceived benefits included the personalisation of digital interventions and being able to access the intervention at a time and pace that suited the user. Many participants acknowledged limitations in the accuracy of the data from the digital interventions, but this was not viewed as a major issue. There were mixed opinions on the role of digital interventions in social connectivity. Some participants felt digital interventions reduced opportunity for emotional support and learning from people face-to-face, while others felt well supported using online forums. Participants liked technology that was 'user friendly' and were put off technology that was intrusive. Perceived limitations discussed were knowing what sources of information were trustworthy online, digital interventions not always being able to replace effective non-digital interventions and situations where there was no internet signal. Technology was constructed (by the older participants) as something that young people use and older people resisted. However, the younger participants in the sample (female aged 29 and male aged 31 years old) preferred physical interventions to digital interventions. The younger woman was the only participant that described feeling that none of the different types of technology she had tried had been helpful for the management of diabetes. There were gender differences in concerns about technology. The men in the group consistently brought up worries about data security of technology and how this influenced what they chose to use. Some of the women in the group spoke about challenges with establishing which were credible sources of information but did not bring up issues about security.

6.3.2. Interpretation of findings

There was evidence that resources a participant had available to them, influenced whether they heard about, had material access to, and could benefit from digital self-care interventions. They described drawing on their digital skills, social connections, economic capital and status to facilitate access to technology. Some participants described using their advanced digital skills to learn about new innovations, and to navigate innovations. Although lower levels of digital skills were described as limiting access to technology, participants were able to draw on 'tech buddies' from their social networks to support them to navigate issues with usability. Social networks provided access to information about new digital innovations and to innovations themselves through gifting, work perks, use with personal trainer, discounts and free samples. Therefore, the type of technology participants were aware of and had access to depended on how well informed and connected their networks were. There was evidence that membership of diabetes support and research groups provided an opportunity to access a network of people with diabetes who may be more knowledgeable than those in their personal network. Online communities, served a similar purpose, connecting people on a much larger scale to a more diverse group of people with diabetes than in their immediate networks. This allowed for a greater diffusion of knowledge and ideas. Participants were able to draw on financial assets to access more expensive technology. They also used their status as leaders of diabetes groups or as technology experts to gain access to technology prior to general release, or to get replacements for faulty technology.

6.3.3. In the context of other literature

Previous evidence has indicated that people with fewer resources are less likely to access and use digital self-care interventions (Chapter 3).(van Dijk 2005, Yu 2006) This study has provided an insight into some of the mechanisms that contribute towards this inequity in access. The findings mirror those from a qualitative study based in Australia that used focus groups to understand the impact of access to digital technology (not health specific) on the social determinant of health in people from low SE backgrounds.(Baum, Newman et al. 2014) Baum et al.(2014) reported that those with fewer economic, educational and social resources encountered more challenges accessing and using digital technology, which in turn affected their access to a range of social determinants of health.(Baum, Newman et al. 2014) They found participants with lower SES faced challenges affording to purchase new technology.(Baum, Newman et al. 2014) They found that lower levels of literacy that resulted from a lack of educational opportunities acted as a barrier to accessing and confidence using technology.(Baum, Newman et al. 2014) As in this study, they found that social networks facilitated access to digital technology.(Baum, Newman et al. 2014) Baum et al. (2014) also found evidence of digital exclusion being amplified by social exclusion, however, there were no reported issues with social exclusion in this study.(Baum, Newman et al. 2014) This difference may have been the result of differences in the sizes and diversity of the samples; in Baum et al.'s(2014) study they had focus groups including a total of 55 people from lower SES areas, where in this study a diverse range of people were consulted across a range of SES. Therefore, their study included more experiences of people living in disadvantaged situations. In this study, those from lower SES groups were not socially isolated, talked about having supportive family members and being active in communities and support groups.

Previous studies have found that internet health information is variable in quality, challenging to navigate and mostly developed for those with higher school or greater reading ability.(Berland, Elliott et al. 2001, Gilmour 2007) Although there was discussion about challenges navigating digital technology none of the participants in this group talked about issues with understanding the health information. This may be because in the real-world setting (as in this study) people are less likely to select and use technology that is not easy to understand. Alternatively, this may have been because all of the participants had completed intermediate education between secondary level and university and this is sufficient to understand the information provided in the digital interventions. In this study there were some references to having access to internet signal acting as a barrier to access of digital intervention, but no participants described having issues accessing the internet as in previous studies.((Kerr, Murray et al. 2010, Yardley, Morrison et al. 2010, Kuijpers, Groen et al. 2013, Carolan and de Visser 2018) This again is likely to be due to the purposive sampling in this study, where people were sought who had experience of using a digital intervention. Those who had issues with accessing the internet are less likely to have used digital interventions and would therefore have not been invited to interview.

The findings related to barriers and facilitators to intervention use where there were no issues with access, do agree with previous studies that have investigated usability and acceptability of a single web-based intervention. In common with these studies, participants described the benefits of digital interventions being that they could be accessed at a time and place that suits.(Kerr, Murray et al. 2010, Yardley, Morrison et al. 2010, Kuijpers, Groen et al. 2013, Carolan and de Visser 2018) Similarities in perceived barriers to using the interventions were: missing out on human contact, lack of confidence with technology, and technical issues such as concerns with security.(Kerr, Murray et al. 2010, Yardley, Morrison et al. 2010, Kuijpers, Groen et al. 2013, Carolan and de Visser 2018)

The findings in this study that difference in resources influenced how people learnt about relevant technology and access it supports theories of health inequalities. Including the theory of fundamental causes and social capital theory. The theory of fundamental causes suggests that there is a social gradient in the control people have over their lives that it is mediated by disparities in the array of resources available to them.(Link and Phelan 1995, Phelan, Link et al. 2004, Phelan, Link et al. 2010) The resources include: power, advantageous social connections, money, knowledge and prestige. (Link and Phelan 1995, Phelan, Link et al. 2004, Phelan, Link et al. 2010) This study demonstrated how people drew on knowledge, economic capital, status and social connections to access to technology to support the self-care of T2D.

The findings in this study that social groups influence access to technology supports social capital theory.(Portes 1998) Social capital theory addresses inequities at a community level, and proposes that there is a social hierarchy in ‘the ability of actors to secure benefits by virtue of membership in social networks and other social structures’.(Portes 1998) This theory suggests that belonging to a social network, provides access to resources and benefits that individuals would not have on their own.(Eriksson 2011) These resources include knowledge, status and capital.(Eriksson 2011) This study indicated that measures such as education, occupation and household income, were not sufficient to encapsulate the resources people had available to them. These categories ignored the importance of membership to social groups and how these influenced access to technology. There was evidence membership to social groups (e.g. diabetes groups, research groups and online forums) supported access to knowledge about technology and provided shortcuts to accessing new and helpful innovations

There was some evidence of ‘bridging social capital’ through memberships to these groups. Bridging social capital are the connections that link people across different networks or social groupings (such as ethnicity, occupational class, or religion), and are responsible for transmission of information and resources.(Portes 2000, Eriksson 2011, Putland, Baum et al. 2013, Claridge 2018) Bridging social capital differs from ‘bonding social capital’, which refers to within group connections that cultivate a sense of a shared identity, belonging and has found to buffer stress.(Macinko and Starfield 2001, Putland, Baum et al. 2013, Claridge 2018) Bridging often involves associations between people with different social identities, but shared interests or goals.(Pelling and High 2005) In the context of this study, the shared interest was diabetes and their goal is to increase their knowledge of their condition and find ways to manage it. Bridging occurred through diabetes support groups, involvement in research groups and online forums. A clear example of this is where a man from a traditional occupational working-class background with lower education learned about technology he had ‘never heard of’ through others who were ‘very knowledgeable’ in his research group. He may not have had the opportunity to learn about these innovations through his own personal network and gained access to the knowledge of people from different occupational and educational backgrounds.

6.3.4. In the context of policy

Many of the participants in this study reported challenges in accessing BGMs or sufficient strips for their needs from the NHS. The NICE guidelines at the time of the interviews specified that self-monitoring of blood glucose for adults with T2D should not be offered unless the person is on insulin, having hypoglycaemic episodes, on medication that increased their risk of hypoglycaemia while driving, or they are pregnant or planning to become pregnant. Although, perhaps paradoxically, the guidelines also stress that patients with T2D should be encouraged to achieve and maintain a HbA1c target agreed between the HCP and themselves. The focus of support in the guidelines is on structured education and medication.(NICE 2017) The accounts in this study where people talked about being supplied a BGM by the NHS, may be because they met one of the fore-mentioned exceptions, because they were issued a monitor before they were restricted, or because of a postcode lottery and differences in practice policy.(Goodwin, Curry et al. 2010)

The participants in this study felt that there were differences in the experiences of the T1D and T2D. They talked about how they felt more resources and support were directed at those with T1D, including the provision of BGMs. This was confirmed by the NICE guidelines, where BGMs are not recommended routinely for those with T2D, while the guidelines for those with T1D were to provide them and support their use.(NICE 2015, NICE 2017)

6.3.5. Strengths and limitations

To this author's knowledge, this is the first study to explore how people choose technology to support to the self-care of T2D (or any chronic illness) and their experiences using digital technology. Previous studies have qualitatively investigated usability and acceptability of single web-based interventions. But none has investigated actual usage in a real-world setting where the individual had the choice to use interventions that were publicly available.

The study was rigorously performed with supervision from a skilled qualitative researcher. Double coding of a subset of interviews by two members of the supervisory team and ongoing discussion about coding structure ensure the coding scheme was robust. Multiple views of the data promote confidence in the credibility of the findings.(Sandelowski 1995) A diverse range of experiences and opposing sides of arguments were identified and presented. Discussion of the influence of the personal characteristics of the interviewer were discussed in the reflexivity section of Chapter 5, section 5.5.6.

Some caution should be exercised in the generalisability of the findings. Recruitment generally was challenging, in terms of reaching people with a T2D diagnosis, who had used web-based interventions, were willing to engage in research, while achieving diversity in terms of SES and cultural characteristics. Diversity was achieved in the sample in terms of age, gender, SES, household income and IMD. However, despite efforts made to recruit a diverse sample in terms of ethnicity and religion most of the participants identified as White-British and were of Christian religion. The criteria that the participant needed to speak and understand the language restriction may have also acted as a barrier to study entry for people from minority ethnic groups. The decision was taken to have the language restriction because there were no resources to contract an interpreting service, and in response to the challenges with conducting cross-language qualitative research.(Squires 2009) Overall, the most successful route for recruitment was through contacting diabetes support groups servicing local communities across the UK. However, none of the BAME participants came from these groups. All three of the people who identified as Asian/ Asian- British were recruited through links with a Leicester University diabetes research group. This group had spent years and lots of resources fostering and maintaining links with the South Asian community in the area. Where recruitment was attempted at centres in Bristol that served BAME people, individuals (particularly women) talked about not using or having access to computers or the internet.

People who expressed an interest in the study were mostly adults >51 years who had taken an interest in technology and were engaged in the innovations. Several of the participants in the sample lead support groups and/or were involved in research groups so may have been particularly engaged in innovations in the field. However, the participants were not all technophiles. Those who had previously used technology but were no longer using technology were also actively sought and were present in the group, as were lighter users of technology. Although, those who had tried but did not like technology were probably less likely to volunteer for the study. Those who had never used technology were not included because the main aim of the study was to understand differences in experiences of using digital tools by people from different socio-cultural backgrounds. Therefore, interviewing people who had not used the tools would not help to answer this research question. However, this is likely to have excluded some groups of people who have historically been found to have lower access to the internet including; older people, those from minority ethnic groups, with lower SES and those living in remote geographical regions.(Gibbons 2005, Hardiker and Grant 2011)

6.3.6. Conclusions

There was evidence that resources a person had available to them, influenced whether they heard about, had material access to, and could benefit from digital self-care interventions. Participants used their digital skills, social connections, economic capital and status to access to technology to help them manage T2D. They used their digital skills to learn about new relevant technology online, and to navigate innovations. Some participants described how their digital skills limited access to technology. However, these participants were able to draw on 'tech buddies' from their social networks to support them to navigate issues with usability. In addition to providing technical support, social networks also provided access to information about new digital innovations and access to innovations themselves. Therefore, the type of technology participants were aware of and had access to was partly dependant on how well informed and connected their networks were. There was evidence of 'social bridging' where membership of diabetes support, research groups and online communities provided an opportunity to access a network of people with diabetes who may be more knowledgeable than those in their personal network. Participants were able to draw on financial assets to access more expensive technology. They also used their status as leaders of diabetes groups to access technology ahead of general release, or as technology experts to get replacements for faulty technology. Where access to the technology was not an issue, participants described their choice of technology being influenced by what they liked and valued and what they did not like and found challenging. Technology was constructed (by the older participants) as something that young people use and older people resisted. However, the younger participants talked about how they preferred physical interventions to digital interventions to support the management of their condition. There were gender differences in concerns about technology. Most of the men in the group brought up worries about data security of technology and how this influenced what they chose to use. Some of the women in the group talked about the challenges establishing what online information was credible, but did not talk about concerns about security. Implications for these findings will be discussed in Chapter 8.

CHAPTER 7. QUALITATIVE STUDY RESULTS AND DISCUSSION: TECHNOLOGY AND ILLNESS IDENTITIES IN PEOPLE WITH TYPE 2 DIABETES

7.1. Chapter overview

The qualitative study was designed to answer the primary question: How and why people with type 2 diabetes use web-based self-care technology and how their experiences vary. The methods were described in Chapter 5 (pages 164-168). Two broad groups of themes emerged from the interviews. The first group of themes described participants experiences of accessing and using web-based interventions. The second group of themes covers the role of technology in the construction of illness identities. Chapter 6 described the study sample, the results and discussion for the first group of themes. This chapter covers the results and discussion for the second group of themes.

7.2. Results

7.2.1. Sample description

The sample description was provided in detail in Chapter 6.

7.2.2. Understanding the diabetic body and establishing what self-care works

Digital interventions were used as a tool to help participants understand their diabetic bodies and to enable them to develop their self-care expertise. They used data from blood glucose monitors to provide concrete evidence about what was happening to their bodies; turning a relatively hidden illness into something visible and tangible. Participants described the experience of being diagnosed with diabetes feeling unreal, or talked about being in denial about their condition. There was a sense that the data from digital interventions allowed them to confront and accept their diagnosis and prompted them to engage in the self-care of their condition.

> *…I say, always make a point of saying now, to sort of newly diagnosed people, you know, "If you feel like that, it's not just you, there's a lot of people have trouble getting their head around being given the diagnosis and the changes they've got to make." (ID 31, lighter user, Female, 58yrs, White, Low Ed, Highest SES)*

> *the other thing that I, I did in defiance of my medical advisors was I put myself to test my own blood, finger prick testing. And you know, frankly based on that personal[ised] real time feedback you've nowhere to go. You know, you, you know, you can see in front of you where the problem is (…) that really for me was the, the keeping me on the straight and narrow because you have nowhere to hide from that evidence (ID 33, heavier user, Female, 60yrs, White, High Ed, highest SES)*

Technology allowed participants to conduct trial and error experiments to establish what diets worked best for them in managing their diabetes. Participant talked about using feedback from blood glucose monitors to establish how *their* diabetic "body works, how it reacts" (ID 33) to different food. One woman talked about using information she had found online and testing whether specific diets worked for her, using the output from monitors as evidence.

> *I knew how my diabetes, erm, responded to, erm, various foods, because I, I was taught how to use the, erm, glucose monitoring that we used at that time. But the Libre added another dimension. (ID 42, heavier user, Male, 72yrs, White, High Ed, Mid SES)*

> *I've changed my view based on other people's opinions and experiences [from online forums]. And I thought I'd give it a go myself. I'm an inveterate self-experimenter. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

Many of the participants believed that the feedback from digital interventions was an important motivator to stay engaged in self-care activities. The benefits of the interventions described by the participants included personalisation, a nudge to be more active and positive reinforcement through the feedback of their achievements. There was also a sense that wearable activity monitors broke down the belief people were not able to be more active.

> *I wouldn't be without my Fitbit, it drives me. It absolutely drives me, because I get panicky last week when I couldn't blooming recharge the thing…. I have to know what I'm doing. (ID 10, lighter user, Female, 61yrs, White, Low Ed, lowest SES)*

> *the bottom line now is if, whereas before I'd have jumped in the car to drive down the town (…) I walk (...) So, it's driven me to do things and change my lifestyle as a result of trying to get that 7000 steps. (ID 27, lighter user, Male, 58yrs, White, Low Ed, highest SES)*

> *one of the things with the apps like Fitbit and that is it gives you that reward, the monitoring gives me a reward. I don't perceive it as in any way coercive or anything (…) it is just an aid to help me celebrate my achievement… (ID 30, heavier user, Female, 56yrs, White, High Ed, SES NA)*

> *when you talk to somebody about exercise, they straight away, they think gyms and Lycra or something. Whereas, you know, actually if you say, "Actually you are quite active, when you think about it." Then they're not convinced, but if they've got this on there [Fitbit], and then they have a look at it, just after their normal day, "Oh, I've done 5,500 steps. Well actually, I didn't feel that I'd done that. So now I've done 5,500, I could maybe do 6,000 tomorrow." So, I think it's a very gentle way to encourage people. (ID 31, lighter user, Female, 58yrs, White, Low Ed, Highest SES)*

Participants talked about using data from digital interventions to help them identify any issues early and to prompt them to visit their HCP when they get some irregular readings.

> *you go and see the doctor if things were actually sort of…getting worse and nothing was working (…) so if the graph [in Diabetes Diary app] is getting high and staying high, you think right… I had better go see my diabetic nurse…you know…what should I do! (ID 20, lighter user, Male, 74yrs, White, Low Ed, Lower SES)*

In contrast, some of those without blood glucose monitors discussed the uncertainty around whether their management activities were keeping their blood glucose levels in range between check-ups with their HCPs.

> *between tests, it's six months. And, and I could, I could have gone completely up and down, and…Er, you know. And I, I, that's the one thing I don't know – is, is whether, if in between, er, erm, I'm doing any harm, or doing something that I shouldn't do. So, yeah, it would be kind of nice to have something that measured that. (ID 35, lighter user, Female, 63yrs, White, High Ed, Mid SES)*

7.2.3. Stigma

Many of the participants described experiencing stigma as a result of being diagnosed with diabetes. There was a sense that family, friends and the media blamed them for getting diabetes because they were overweight or (they presumed) they had an unhealthy lifestyle. Some talked about being given unsolicited advice on diet and exercise from people in their social circle and HCPs. One participant described being told to inject insulin in private, and talked about being stared at when she injected in a public place.

> *dad came out with a comment, "Oh it's because you're overweight that you got Type Two, er, diabetes." (...) occasionally you used to get the comment, "Oh you're too fat, you're too fat, you're too fat." (ID 34 male, lighter user, 55yrs, white, Low Ed, Lowest SES)*

> *I remember somebody saying to me, "Well, do you think it's 'cause you probably drank too much?" (ID 11, heavier user, Female, 59yrs, White, High Ed, Highest SES)*

> *all the publicity around type 2 is entirely negative, so people think A), that I must have brought it on myself, so you can see people, sort of, raising their eyebrows and then, sort of, wanting to give you a little talk about healthy eating (…) people assume that you're not exercising and they start lecturing you about that as well. (ID 30, heavier user, Female, 56yrs, White, High Ed, SES NA)*

> *people have sometimes said, you know, "Oh, if you really want a bit of privacy maybe you have to go to the toilet and do it [inject insulin]." And you're like, "No, I won't be doing that." (…) . I mean I've only ever once had an issue in a restaurant, and that, and this bloke was just like so drunk it was just ridiculous. Erm, and he kind of spotted it and kind of kept looking and looking and despite how I kind of turned or, you know, tried to move away… (ID 31, lighter user, Female, 58yrs, White, Low Ed, Highest SES)*

Participants described how people with T2D were judged in the media for bringing the condition on themselves, whilst people with T1D were given sympathy. One person felt that some of the worst judgements she had experienced came from people with type 1 diabetes.

> *If ever Type 2 is mentioned in the media, it seems to be (…) Type 1 is a disease that people normally get in childhood and they can't help it, and it's terrible. And Type 2 is for those fat slobs who have a bad lifestyle, and, erm, all they need to do is look after themselves better. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *I say probably some of the worst discrimination or judgements have been from other diabetics. Quite shameful really. (…) that would mainly be from Type Ones who think they have proper diabetes. And they have an autoimmune disease, so there's nothing that they can do about it. (…) there's the, the superiority of it. (ID 33, heavier user, Female, 60yrs, White, High Ed, highest SES)*

Some participants described not disclosing their diabetes diagnosis in fear of being labelled with the stigmatised diabetic identity. The two youngest (29 and 31 years) participants emphasised the challenges of being diagnosed young, and how that affected their wish to conceal their diagnosis due to fear of judgement. One woman talked about not wanting to be identified as the 'diabetic lady', as she felt it was reductive. A man spoke about people in the South Asian community concealing their diabetes diagnosis, for fear of the family being "tarnished" with the stigmatised label. He emphasised that this was a problem particularly women in the South Asian community.

> *I just got diagnosed at such a young age. Erm, I, I thought I told two people that I - no, I told my diabetes, er, the nurse at my foot check, I told her. She goes, "Oh God, it must be a bit depressing being diagnosed at such a young age." So she kind of rubbed it in, so I'm like if that's the, if that's the, you know, I'm gonna get, so I shan't tell anyone. Yeah, so I haven't really told anyone, yeah, yeah, so no one really knows(ID 24, lighter user, Female, 29yrs, Asian/Asian British-Indian, High Ed, Lower SES)*

> *they sort of judge you, and, er, because I've, I've thought, because I'm, er, quite big, erm, so they sort of…They, yeah, essentially because I don't want them to think it's my fault, because it partly is my fault, but also, erm, er, I don't know if I'm embarrassed, or ashamed of it, or not, I don't know. (ID 23, lighter user, Male, 31yrs, Asian/Asian British-Indian, High Ed, Mid SES)*

> *to me that just seems like, a kind of a pejorative label ['the diabetic lady'], it doesn't seem a, a very humane thing to call somebody. You know, okay, I hope they don't call me a nutter at 52 but, you know, you don't mind being the lady in the end house, you don't mind being so many things, but to be called the diabetic lady, it's just a bit, it just struck me as being a bit sad really. And wasn't a very personal thing, a very personal label for that person, who is a person who happens to be living with diabetes. But it hasn't changed her soul or her moral compass or anything like that. It just felt a bit inhumane. (ID 33, heavier user, Female, 60yrs, White, High Ed, highest SES)*

> *There is stigma, there is certainly, people will be dim- in denial or hidden. Erm, they don't want their family members being tarnished (…) Let's take an Asian female, it, by bringing the families have been kind of very protective, not wanting to get their female known who have diabetes to come out, because it could, er, it could be a barrier for her future kind of marriage proposal. (ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Low Ed, lower SES)*

Participants described finding ways to conduct self-management activities that allowed them to conceal their diabetic identity, this included using discrete blood glucose monitors. Participants talked about passing the diabetic diet as a common dietary restriction, so they did not need to disclose their diagnosis. One woman talked about using orange juice to prevent hypoglycaemia in social situations, as it was not as "obvious" as dextrose (ID 11). Several of the women in the group talked explicitly about the importance of blood glucose monitors being discrete. One woman talked about the blood glucose testing kits supplied by the NHS being "bulky", and the small monitor she purchased herself allowed her to be more "discrete" conducting self-care activities (ID 40). Those with less money available to them may not have had the ability to purchase these discrete monitors, to replace the bulky NHS ones. The younger woman described how using a blood glucose monitor exposed her diagnosis to family members, and how she wanted future technology to be 'a bit more discreet' (ID 24).

> *I have to say gluten free is fantastic get out card, people don't know what gluten is, people have no idea where you get gluten, so you can just about pass on anything for that. (ID 33, heavier user, Female, 60yrs, White, High Ed, highest SES)*

> *if I'm in a meeting that's running on. I'll think, I'll start to get a bit panicky. So, I'll keep orange juice, little cartons, or dextrose, or something with me. I prefer the orange juice, because it doesn't look so obvious (ID 11, heavier user, Female, 59yrs, White, High Ed, Highest SES)*

> *best bit is you can test yourself effortlessly, 30 times a day, if you like. It's relatively discreet. Nobody would know I was wearing one unless I had a sleeveless top on. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *I didn't tell anyone. No, it's this, erm, I didn't tell anyone until I think I was pregnant really 'cause then they noticed, erm, I had a machine given to me when I was pregnant. I never tested my blood sugars before then (…) No one knew, no one knew or I lied to them (ID 24, lighter user, Female, 29yrs, Asian/Asian British-Indian, High Ed, Lower SES)*

Later in the same interview

> *we're[family] waiting for something fresh now. (…) something a bit more heart rate monitor or a bit more discreet (ID 24)*

The older men did not explicitly mention that they wanted blood glucose monitors to be discrete. However, not all of the participants interviewed used blood glucose monitors, and some men in the group did describe being reluctant to disclose their diagnosis and injecting insulin in public. They talked about going to the ‘gents’ or somewhere ‘private’ to inject insulin (ID 20). Although one man had stated he was happy to ‘tell everyone’ about his diagnosis, he felt strongly that the behaviour of injecting was ‘not normal’ (ID 28).

> *[my] employer would know…and obviously immediate family would know, (…) anything that’s not obvious you don’t advertise (ID 22, lighter user, Male, 67yrs, White, Low Ed, Highest SES)*

> *Seeing, er, needles, er - are not an everyday thing. They’re not normal. And it’s not something that everyone does, that is acceptable. As normal. Er, it’s an unusual thing. You wouldn’t have the needle, unless you’d got a, a medical reason for having it. So you’re obviously slightly different to the majority of society. (…) You know - I think it’s a private, personal thing - that should be kept that way. Although, I’m not embarrassed about having it. I’m not a bit. If somebody wanted to watch me do it, I would willingly do it for them. (ID 28, lighter user, Male, 66yrs, White, Low Ed, Mid SES)*

7.2.4. Use of technology in identity work

Participants construction of their identities influenced their technology use. They used digital interventions to project, enact and confirm their preferred positive identities, and as a defence against a stigmatised diabetic identity. Through their use of technology participants presented themselves as someone who was more in control, younger, more skilled, higher status or with specialised knowledge. Some described how the technology they used required a level of understanding that not everyone had.

> *once you’ve got things under control, these are the sort of things that are going to help you, and it’s probably wrong to try and box people in, but I don’t think it’s any point trying to tell an 85-year-old about Fitbits. But someone who’s sort of, has an understanding, try it, see if it works for you. (…) but it’s worked for me, because I took control. And I suspect, there might be areas of the population that don’t take control. Rather, ignore it, hope it will go away. (ID 27, lighter user, Male, 58yrs, White, Low Ed, highest SES)*

> *I also would just mention that I did a mathematics Open University, er, foundation course. Erm, so I, I can use that information that I got from that [from the Freestyle Libre], the understanding, to understand a bit about the statistics (ID 42, heavier user, Male, 72yrs, White, High Ed, Mid SES)*

> *I would connect my meter, the scanner meter [Freestyle Libre], erm, each morning and download the data, have a little look at it. But, you know, I am data master, you know, I’m I am someone who likes data. (ID 33, heavier user, Female, 60yrs, White, High Ed, highest SES)*

Some participants had embraced the illness identity, and had developed new positive identities through leadership roles in the diabetes community and as expert patients. This seemed to be reflected in their drive to share with others their experiences of using technology to support their diabetes management. For example, a man who was part of a diabetes research group and was starting a local support group described how he told everyone about his diagnosis and about the app he used to support his diabetes management.

> *Interviewer: …do you tell many people that you're diabetic?*
>
> *Respondent: Everybody. (…) if we're in conversation - like, if we were at a party or we were having a, a drink somewhere, or…We were just in a social gathering, and we were talking away - I would come out with it, if it needed to be come out. But I wouldn't offer it up - like, I wouldn't brag about it. But I'm not shy about the fact.*

Later in the same interview

> *Told loads of people about it [Change4Life app], yeah. Even people who had diabetes, I've said, "You know, you want to get this app, because it's so good." You know, I think - and just to tell you how much sugar is in stuff. (ID 28, lighter user, Male, 66yrs, White, Low Ed, Mid SES)*

Participants used knowledge of technology to enact positive identities in social contexts. Some described taking pride in sharing their knowledge about new innovations to others in their social circles. Others talked about using technology that enhanced social integration, providing a way to be part of a group and to avoid feeling like an outsider.

> *we cascade the information from here [Diabetes research group], back into the group [Diabetes support group]. And occasionally, staff from here [Diabetes unit], go to the [Diabetes support] group and do presentations as well. (ID 27, lighter user, Male, 58yrs, White, Low Ed, highest SES)*

> *I've told people, in fact, it's so funny, because I'll erm, if I have a big one [Fitbit achievement badge], if I've like walked to India [on her Fitbit], I'll put that on Facebook. I'll then load up the picture, "Look where I've walked." And three of my friends have said, "We've bought Fitbits because of you." (ID 10, lighter user, Female, 61yrs, White, Low Ed, lowest SES)*

> *a lot of people use it [MyFitnessPal] and, erm, for example, er, I have spoken to people who are like kind of really trying to lose weight, or trying to get fit, and then, you sort of say, "What are you using?" Or, "What helps you, and what aids you?" And we're able to talk about it, and then you make some friends that way, as well." (ID 23)*

Participants described choosing diabetes apps, website and forums that helped form and confirm their identity. One man talked about followed the guidelines suggested by the NHS and the Diabetes UK website, while a woman talked about following Diabetes.co.uk which provided guidance outside of the medical model. There was a sense that one site was for the 'good diabetic' following the advice from their HCP and the other was for the rebel, frustrated with the current healthcare system.

> *I use Diabetes UK a lot, because I find that I trust Diabetes UK. I use the NHS, erm, website, because I trust it. I'm sceptical about the Diabetes.co.uk. Erm, they call them, erm, yeah, it, it's, erm, where people put on their, erm, blogs. It's not a blog, it, it's where people put on their thoughts about things. (ID 42, heavier user, Male, 72yrs, White, High Ed, Mid SES)*

> *So, the forum website that I belong to has got the red logo. And then there's Diabetes UK, which is the blue logo and the charity. They have a local group, but I have a very low opinion on their website and forum. So I have never shown any interest in their Diabetes UK organisation locally. Because they are funded largely by, erm, people who are invested in the status quo (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

Construction of gender identities shaped the way in which technology was used in one account. A man described how his wife as a 'proper woman' who 'looks after her husband'. He describes himself as a 'muppet' when it comes to shopping. He initially spoke about how he used the app but later revealed that his wife used a digital intervention on his behalf, because she did the food shopping and cooking. This gendered dynamic was present in other accounts, where people talked about their wives predominantly managing their diet. However, the person with diabetes used the technology rather than their female partner.

> *Interviewer: Erm, and so with the - the Change for Life app, like how often do you use it?*
>
> *Respondent: All the time. All the time, yeah - every time we do the shopping. Er, E [wife] will look at everything, everything. Er…*
>
> *Interviewer: So, so - do you use it? Is she, is she sort of shopping, and you use it?*
>
> *Respondent: Well, I don't really do shopping. I mean, I'm just a muppet. If I walk round, pushing the trolley, I find things to put in the trolley, that we don't need. Because I'm a bloke, aren't I? (ID 28, lighter user, Male, 66yrs, White, Low Ed, Mid SES)*

7.2.5. Control

A common thread through the participant's accounts was that digital interventions helped them feel more in control. Having more information about diabetes in general and personalised information, created a feeling of greater agency to affect their diabetic bodies, behaviour, and healthcare. For example, one woman spoke about how having remote online access to her medical records made her feel like she had more ownership over her healthcare.

> *just keep learning and keep kind of researching and hopefully that'll help to keep diabetes under control or managed better really…Because we're more informed (ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Low Ed, lower SES)*

> *without those two things [blood glucose meter and Freestyle Libre], I wouldn't be in control of my blood glucose. I would, I would be thinking, "Oh well, just one won't hurt, will it? This is a special dinner, I'll have pudding." Erm, and stuff like that. And, and my blood glucose would be much higher, and my HbA1c, would be up in the, in the, erm, diabetic range. There's no way I could keep this level of control (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *you're gonna have a lot to see [remote access to GP medical records], and it gives you a bit more control over your health, as opposed to, "Well the doctors are there, they can just do it and get on with it, it's not my responsibility." (…) it makes you feel part of it, and it's not something the doctor owns, they're your records, erm, these are your test results, erm, and I think it makes you a bit more focused to try and, you know, erm, get your levels better, get more under control (ID 31, lighter user, Female, 58yrs, White, Low Ed, Highest SES)*

Participants described technology they used as tools to regain control over their sick bodies and to support them in their goal to restore their former health. Many of the group did not see diabetes as a progressive illness and believed that is was possible to reverse or halt their diabetes. They had not surrendered to their 'sick self' and felt that their illness was something that they were still able to master. Participants described hearing stories of people 'reversing' their diabetes, which motivated them to go to the gym or seek out technology that could help them. One man presented contradictory beliefs that he cured himself of diabetes using technology, while also acknowledging that he will always have diabetes.

> *I read somewhere, you know, people lost weight and their diabetes actually went. Now whether that's sort of a mild form, or it does just go, I don't know… (ID 22, lighter user, Male, 67yrs, White, Low Ed, Highest SES)*

> *I've gone on the internet, and I read about this study, er, at Newcastle University… I've been going to the gym on a sort of regular basis (…) I'm trying to sort of, er, do what they did, really. Trying to reverse it. "(ID 23, lighter user, Male, 31yrs, Asian/Asian British-Indian, High Ed, Mid SES)*

> *[I] used various other apps, (…) well it seems, it seems to have worked (…) if I went to the doctors now, I would no longer be diagnosed as diabetic. But, erm, but, that I am diagnosed as diabetic, means that, you know, in a sense, once you've got it, er, you know, er, you, you, you've got it, as it were. (ID 29, heavier user, Male, 64yrs, White, High Ed, Highest SES)*

Digital interventions helped participants to feel more in control of their diabetes in situations where they were out of their normal routine. This included when people were in environments where they could not control what happens, such as holidays and when they had changed their management strategies. Participants spoke about how it was only necessary to use the technology for a short time, with it becoming redundant after they had gained the information they needed, or once they felt they had their diabetes under control.

> *I- mainly [use the Freestyle Libre] when I'm at most risk of going off, off, erm, the wagon. So Christmas, holidays, are, erm, trips away, er, if I have any work trips and I'm staying in a hotel, I'll slap one on, because that way, as I say, it gives me more self-control. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *the thing she[wife] said is, "You only need it [Change4Life app] for a few weeks", because you generally buy the similar type things, most of the time, don't you? (ID 28, lighter user, Male, 66yrs, White, Low Ed, Mid SES)*

> *In the early days I had this finger test, you know-…prick thing, I was doing that quite on a regular basis, but when it all came under control I sort of stopped doing it. (ID 22, lighter user, Male, 67yrs, White, Low Ed, Highest SES)*

One women expressed the idea that technology is only helpful in areas of management where people can exert some control. She highlighted how it was easy to feel good using technology when things are going well, but it can also feel negative when it is not.

> *If you're in a situation where there was something positive you could do and that was reinforcing it, then it's all well and good, but if all an app does- so, like, for example, when I first started taking my blood sugar (…) really, all the monitor was doing was telling me I was failing. Because, I was doing what I was told and I couldn't understand why that meant I got high results. But, then, when you know what you're doing and you're using your monitor and it's going, "Yay, you know, you've woken up and your bloods are really good today," that's a completely different kettle of fish. So, it depends very much on whether you can do something about something. (ID 30, heavier user, Female, 56yrs, White, High Ed, SES NA)*

Participants with more financial resources available to them were able to buy more expensive equipment, (such as the Freestyle Libre) to which the users attributed their success at keeping their diabetes under control. This feeling of being in control played a key part in coming to terms with the diabetes diagnosis and their changed body.

> *I'd encourage anybody who could afford it to get the Libre, even if they only ran it for a month. Because it would teach them so much about their diabetes, and their body, and how things were working (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)*

> *some of the successes that people have had [with the Freestyle Libre] in terms of reducing their HbA1Cs have been quite staggering. Just based on that additional feedback. (ID 33, heavier user, Female, 60yrs, White, High Ed, highest SES)*

> *it's [Freestyle Libre] just expensive. Very expensive. So, M, who's part of the group, she had one on trial. But I think if she bought it, you're talking, I think £100 a month. Some silly amount of money. Yeah. But the idea, I think being that more people use it and the cost will come down. But, she, her blood sugars are ridiculously low. Erm, but when she showed, showed us what it can do, that would be really useful (ID 27, lighter user, Male, 58yrs, White, Low Ed, highest SES)*

7.2.6. Use of technology to increase status with HCPs

Technology was used by participants to increase their sense of power or status in their interaction with HCPs. Some participants talked about using technology to resist treatment prescribed by clinicians or to modify their treatment regime. Others described how gaining knowledge of diabetes online enabled them to negotiate care, because they knew more about their condition and treatment choices. One woman had received additional interest from her HCP and had been spoken to by medical students because of her weight loss, which she attributed to her Fitbit. She was treated as an expert patient and she talked about not wanting to lose the diabetes diagnosis because she was enjoying sharing her journey.

> *Interviewer: …So you just, sort of, bought your own, erm, blood pressure-*
>
> *Respondent: I did, yes. Er, because obviously the GP didn't like me not taking any blood pressure tablets. Er, so I said, well, "Then, we'll keep an eye on it." "If it starts going up, I'll take the damn things." (ID 36, heavier user, Male, 57yrs, White, High Ed, Higher SES)*

> *because you're, you're slightly informed, so they can't just treat you as somebody who's, you know, like a naughty boy, "You've not done this or your weight it is going up." (ID 26, lighter user, Male, 48yrs, Asian/Asian British-Indian, Low Ed, lower SES)*

> *he has agreed not to discharge me. I know because I, I said to him, I braved him. Because I say to him, when he asked me to see these students (…) I said to him, "If I'm doing all this for you…" Erm, of course it's helping me, I'm enjoying telling people about my journey [losing weight with the Fitbit]. And it is successful so far…So don't get rid of me yet. (ID 10, lighter user, Female, 61yrs, White, Low Ed, lowest SES)*

7.2.7. Morality and technology use

There was a sense that technology influenced how moral judgements of behaviour were done. The feedback from digital interventions was used by participants as their ‘conscience’, and to show them when they had been ‘bad’. Participants were able to perform their identity of the ‘good diabetic’ through their technology. They described using the digital interventions to provide proof of their management activities to their HCP, to demonstrate their ‘good’ness and to avoid chastisement. Some used outputs and data to provide evidence of their self-care activity and to add legitimacy to their feedback on what they had been doing to manage their diabetes.

Interviewer: And what do you say to people when you recommend it [Libre and Fitbit] to them?

Respondent: It’s your conscience, there’s nowhere to run. (ID 33, heavier user, Female, 60yrs, White, High Ed, highest SES)

I don’t have the self-control. Unless I can see it listed on the meter that you, you did a bad thing. (ID 41, heavier user, Female, 50yrs, White, High Ed, Lowest SES)

my diabetes nurse here, she’s quite pleased with me. And she said (...)“Oh, I wish everybody would have one [Fitbit].” (ID 35, lighter user, Female, 63yrs, White, High Ed, Mid SES)

7.3. Discussion

7.3.1. Summary of main findings

Participants in this study used technology to help them confront and understand their diabetic body, to develop their expertise in self-care, support self-experimentation and to keep them engaged in the continuous management of their condition.

Digital interventions were used by participants to exert some control over the identity they project to others. Participants described concealing their diagnosis because they feared judgement or did not want to be associated with the stigmatised diabetic identity. Some women in the group talked about purchasing discrete blood glucose monitors to allow them to conduct self-care behaviours without revealing their diabetic identity. The men in the group did not bring this up as a concern but not all participants interviewed used blood glucose monitors, and some men did mention concealing their condition and finding ways to inject insulin in private. At present technology could not be leveraged to hide this behaviour, and therefore avoid the possibility of stigmatisation through being mistaken for illicit drug users.

Participants selected technology that allowed them to enact their preferred positive identities, other than that of the stigmatised diabetic identity. Ethnic, cultural and gender identities influenced the technology participants chose to use and how they used it. Most of the participants described using non-diabetes specific technology that encouraged social integration rather than highlighting differences and isolating them with a stigmatising disease. However, some participants, had established positive identities following their diagnosis, such as diabetes community leaders and expert patients. This seemed to translate to a drive to share their experiences of using technology to support their diabetes self-care with others.

Through the use of digital interventions participants felt like they had more control over their diabetes. Many participants believed that is was possible to 'reverse' their diabetes, and technology was used to support them in their goal to master their sick bodies and restore their former health. Participants with more financial resources available to them were able to buy more expensive equipment, to which the users attributed their success at keeping their diabetes under control.

Participants used technology to increase their sense of power or status in their interaction with HCPs. Some participants used technology to resist treatments prescribed by clinicians and to modify their treatment regime, or to negotiate support received. Others used digital interventions to provide proof of their management activities to their HCP, to demonstrate their 'good'ness and to avoid chastisement. There was a sense that technology was influencing how moral judgements of behaviour were undertaken. Participants used the feedback from technology to let them know when they had controlled their behaviour and had been 'good', or not controlled their behaviour and were 'bad' or failing.

7.3.2. Interpretation of findings in the context of health inequity

Chapter 6 presented the themes from the interviews that indicated resources a person had available to them influenced whether they heard about, had material access to, and could benefit from digital self-care interventions. This chapter presented themes from the interviews that indicated digital interventions themselves subsequently acted as a resource participant could draw on to come to terms with their diabetic identity, support self-care activities, and to influence how they are viewed by others. Participants described using digital interventions as tools to better understand their diabetic bodies, to support self-care behaviours, and to enable them to develop their self-care expertise. They used digital tools to confront and accept their diabetic identity, to project, enact and confirm their preferred positive identities, and as a defence against a stigmatised diabetic identity. Ethnic, cultural and gender identities influenced the technology participants sought out and how they engaged with it.

There was an indication that participants with more financial resources available to them were able to buy more expensive equipment, to which the users attributed their success at keeping their diabetes under control. Money could therefore buy greater control or a feeling of being in control which played a key part in a participant's ability to come to terms with the diabetes diagnosis and their changed body. There was also some indication that those who could afford to buy discreet blood glucose monitors could avoid stigma by allowing them to subtly perform behaviours that would identify them as being diabetic. Those who only had the option of the 'bulky' NHS kits would not have this choice.

7.3.3. Strengths and limitations

Strengths and limitations of this study were discussed in Chapter 6.

7.3.4. Interpretations in the context of existing literature

Most pertinent to the findings of this study are literature of illness identities, stigma, control and the moral implications of the control of diabetes, all within the context of social structures of inequalities.(Bury 1991, Charmaz 1995, Bury 2001, Catherine Kohler 2003, Broom and Whittaker 2004, Whitehead, Pennington et al. 2016) The diagnosis of a chronic condition such as T2D, has been described as an assault on the identity.(Bury 1982, Goldman and Maclean 1998) The person's sense of self is challenged and a shift is required to a new identity, which incorporates the T2D diagnosis and the wide-ranging changes to their lives.(Goldman and Maclean 1998, Broom and Whittaker 2004) Successful adaptation is dependent on acceptance of the change to the identity and lifestyle shifts, and is mitigated by available internal resources and those from the external environment.(Goldman and Maclean 1998, Riessman 2003, Gomersall, Madill et al. 2011) In this study, participants described using external resources (digital interventions) to support them to confront and come to terms with their diabetes diagnosis. Helping to make a largely invisible disease more tangible and to help them understand their changed diabetic body.

The experience of enacted and felt stigma following a chronic illness diagnosis has been well documented, and in this study stigma influenced the technology participants selected.(Broom and Whittaker 2004, Goffman 2009) According to Goffman's stigma theory, stigma occurs with chronic illness when people behave in a way that deviates from expectations of what is 'normal'.(Goffman 2009) He proposed that people conceal their true identities to fit in in the world of 'normals'.(Goffman 2009) As T2D is a relatively invisible illness, people with the condition can choose to disclose their condition which might mean they get support but might experience stigma.(Adams, Pill et al. 1997, Joachim and Acorn 2001) Alternatively, they can conceal the condition in order to avoid identifying or being identified with the stigmatised identity.(Adams, Pill et al. 1997, Joachim and Acorn 2001) If people choose to conceal their condition, they risk being outed when they perform some self-management behaviours, such as taking blood glucose readings.(Joachim and Acorn 2001) Some of the participants in this study described disclosing their diagnosis and consequently experiencing stigma. Others described concealing their diagnosis and finding ways to conduct self-care activities without having to identify themselves as diabetic. Some women talked about purchasing 'discrete' blood glucose monitors. One woman described how the blood glucose 'machine' provided by the NHS revealed her diagnosis to her family, even though she had chosen not to tell them. She subsequently wanted something 'more discrete'.

The men in the group did not talk explicitly about blood glucose monitors needing to be discrete, but some did express concerns about disclosure of their diagnosis and described finding ways to hide their insulin injections. The performance of masculine identities in the narratives may have also influenced how the men presented their concerns and motivations around using technology. Qualitative research into the experience of chronic illness for men has indicated that the diagnosis can create a threat to the masculine identity.(Riessman 2003) In several accounts the men presented themselves as someone who was not interested in others' opinions, and yet they hid the diabetic self-care behaviour because it was "not normal". The open discussion of the need for discrete technology, would therefore not fit with this presentation of themselves. There is also the possibility that for the men in this group, the main concern was concealing injecting behaviour in fear of being mistaken for an illicit drug user. This is an example of the 'diabetic junkie' stigma-induced identity threat, documented in previous qualitative literature.(Major and O'Brien 2005; Broom and Whittaker 2004a; Browne et al. 2014; Tak-Ying Shiu, Kwan, and Wong 2003) At present technology could not support the concealment of injecting behaviour, which may be why the importance of technology being discrete was not explicitly mentioned by these men.

The majority of participants used technology to express other preferred identities and to resist giving the diabetic identity master status. James (2000) and Luttrell (2003) proposed that people tell stories that allow them to present their more desirable selves, in challenging situations such as the diagnosis of a stigmatising disease.(James 2000, Luttrell 2003) This was reflected in this study, where participants used technology to present more desirable preferred identities rather than the stigmatised diabetic identity. Both in the interview and in their social environments, they were able to demonstrate status through sharing their superior knowledge of technology. They used this knowledge to gain power and status in their interactions with HCPs. Participants also selected technology that allowed them to demonstrate their preferred identities, such as 'data master' or their cultural and ethnic identity.

Literature exploring the meaning of control and power to people with diabetes is relevant here in the context of digital health. Charmaz et al. (1995) found that when people with diabetes discussed 'control', they were simultaneously expressing two meanings: first they were using the language of biomedicine employed by HCPs and diabetes educators; the second meaning encompassed the desire to assert a positive identity and power in the management of their condition.(Charmaz 1995) In this study participants positioned their technology use in the context of both meanings; helping them to keep their diabetes symptoms under control, and to feel like they had more agency over their lives. Reissman (2003) proposed that people frequently position themselves as having choice or influence over their condition in their illness narratives.(Riessman 2003) This helps people feel they have more control over their diabetic bodies and in their lives generally.(Riessman 2003) This was apparent in many of the accounts of the participants in this study, that they did not surrender 'to the sick self by relinquishing control over illness', which is one of the stages of adaptation to chronic illness described by Charmaz(1995).(Charmaz 1995) Some participants believed they could reverse their diabetes, and used digital interventions as a tool to support that goal by allowing them to control and master their body.

The ability for people to project preferred identities, avoid the stigmatised diabetic identity and control their diabetes through technology use, appeared to be influenced by social structures of equalities. Reissman (2003) referred to social structure of inequalities that constrained lives and the ability for people to narrate them.(Riessman 2003) In this study, participants were able to control their own narrative and how people viewed them by buying discreet technology. Participants described replacing big bulky NHS blood glucose monitors with small ones, which meant they were able to choose to not be socially identified or defined by their condition.(Charmaz 1995) There was also an indication that not everyone interviewed in this study had equal access to resources to control their diabetes. This mirrors qualitative research about self-care outside the digital domain.(Ellis, Boger et al. 2017) The degree of control a person has over their lives have been found to exist on a social gradient.(Marmot 2004) Where people with lower SES have fewer resources to control their lives and people in a more privileged position have more control, which results in a health advantage. (Link and Phelan 1995, Marmot 2004, Phelan, Link et al. 2004, Phelan, Link et al. 2010) This was borne out in this study, where there was an indication not everyone had equal resources to be a 'good' self-manager.(Ellis, Boger et al. 2017) Money could buy technology that afforded people greater control over their symptoms, or a feeling of greater control over their condition.

Previous studies have indicated that there is a moral dimension to the self-care of chronic conditions, so too was there a moral dimension to the way people used technology in this study. Qualitative studies have revealed complex moral inferences around the self-care of chronic conditions, which is linked to the focus on individual autonomy in the self-care model.(Broom and Whittaker 2004, Ellis, Boger et al. 2017) Where the patient is 'empowered' to look after themselves, and is considered to have the power to control their condition.(Broom and Whittaker 2004, Ellis, Boger et al. 2017) The patient has a moral responsibility to do their best to manage their own condition and in doing so minimising dependency of HCPs and health services.(Ellis, Boger et al. 2017) As with Broom et al. (2004) explicit moral terms, such as being 'good' and 'bad' were present in this study.(Broom and Whittaker 2004)Participants described using technology to moderate their behaviour and to highlight when they had been 'bad'. Participants also used technology to demonstrate they had been a 'good diabetic' to HCPs. In doing so they may be avoiding being classified as the 'undeserving sick', ensuring they had access to ongoing support and resources from the HCP.(Broom and Whittaker 2004, Ellis, Boger et al. 2017)

7.3.5. Conclusions

This study has indicated that the technology people with T2D have access to shapes the way in which they are able to come to terms with their diabetic body, their changing identity, and influence how they are viewed by others. Digital interventions were used by participants as tools to better understand their changed diabetic bodies and to enable them to develop their self-care expertise. They used technology to confront and accept their diabetic identity, to project, enact and confirm their preferred positive identities, and as a defence against a stigmatised diabetic identity. Through the use of digital interventions participants felt like they had more control over their diabetes. Some participants used technology to increase their sense of power or status in their interaction with HCPs, while others used technology to demonstrate their 'good'ness and avoid chastisement. There was a sense that technology was enabling moral judgements of 'good' and 'bad' behaviour. There was a suggestion that participants with more financial resources available to them were able to buy more expensive equipment, to which the users attributed their success at keeping their diabetes under control. There was also some indication that those who could afford to buy discreet blood glucose monitors could avoid stigma by conducting subtly performing self-care behaviours without identify them as being diabetic.

CHAPTER 8. DISCUSSION AND CONCLUSIONS

8.1. Chapter overview

This final chapter provides an overview and synthesis of the main findings from the secondary and primary research conducted in this thesis. The secondary research involved two systematic reviews exploring the differences in i) use, and ii) effectiveness of web-based interventions for the self-care of chronic conditions by people from different social groups. The primary research was a qualitative interview study that explored the experiences of people using web-based interventions to support self-care of type 2 diabetes in their everyday lives. This chapter will focus on the combined findings from the whole thesis, rather than the individual research projects which were discussed in previous chapters. Reflections on conducting this mixed methods research will be presented. The findings from the systematic reviews and the qualitative study were synthesised using van Dijk's Digital Technology Access model. This is followed by discussion about the implications of this research for intervention design, research, policy and practice.

8.2. Comparison of findings from the studies

8.2.1. Reflections on the mixed methods approach taken

The systematic reviews and qualitative project were conducted in parallel, with the systematic reviews beginning in advance of the qualitative study. The early findings from the systematic reviews fed into the design and research questions addressed in the qualitative study. The decision to focus on Type 2 Diabetes (T2D) in the qualitative study was guided by the abundance of available web-based interventions for T2D found in the systematic review in comparison to the other targeted health conditions. The systematic review also highlighted an absence of investigation into why there may be differences in web-based intervention use (Chapter 3). The intention early in the thesis planning was to use the findings from the qualitative study to explore plausible explanations for these differences, and to synthesise the findings using the triangulation protocol.(Barbour 1999, O'Cathain, Murphy et al. 2010) However, as the work progressed, it became apparent that the contexts of the qualitative and quantitative studies were too different to allow for meaningful triangulation. Wheeldon et al. (2012) suggested the alternative of combining qualitative and quantitative data in a concept map.(Wheeldon and Åhlberg 2012) They talk about the benefits of ordering or combining findings through existing models, as well as presenting novel graphical depictions of synthesised evidence.(Wheeldon and Åhlberg 2012) Wheeldon et al.(2012) describe how this method is well suited to presenting mixed methods findings and the flexibility of this approach being concordant with the pragmatic approach to research.(Johnson and Onwuegbuzie 2004) Evidence from the systematic reviews and the qualitative study will be discussed in the context of an existing model of the digital divide, specifically van Dijk's Digital Technology Access (DTA) model.(van Dijk 2005)

To allow for comparison of findings between the qualitative and quantitative research, this chapter will focus on the results from the diabetes studies in the systematic review. This author does however, acknowledge the limitations of comparing the findings for the systematic review studies that reported on T1D and T2D against the qualitative study that focussed on the experiences of T2D. This is an example of the ways in which a mixed methods approach that begins with a systematic review (or reviews) presents challenges, as it is not possible to know in advance what studies will be found in the review. In the systematic review, studies evaluating interventions for people with T1D and T2D were synthesised and reported together. This decision was made because the intervention designs and outcomes measured were similar in studies targeting people with T1D and T2D. Several studies also explored the application of a single intervention for both conditions. However, it cannot be assumed that the lived experiences of people with the two types of diabetes are the same considering the differences in aetiology and timing of onset. This research did not gather evidence about the difference in the experiences of people with T1D and T2D but it is reasonable to assume that these are different given the differences in aetiology and timing of onset. For example, we know that people with T2D are more typically diagnosed in adulthood, whereas the majority of those with T1D are unlikely to have experienced living as a non-diabetic adult.(Lasserson, Fox et al. 2012) This means they may have different resources available to them and have different experiences of the conditions, that means they may respond differently to digital behaviour change interventions. Therefore, comparing the subjective experiences of people with T2D against the objective experiences of people with T1D and T2D together has limitations.

8.2.2. Synthesis of findings using an existing theoretical model

The DTA model was used as a framework to synthesise the mixed methods research from this thesis.(van Dijk 2005) This model was selected because it is one of the most influential theories of the digital divide; it not only considers differences in the ability to physically access digital technologies, but also inequalities in how people can make use of technology where they have access and how this can further exacerbate social inequalities.(van Dijk 2005, van Deursen and van Dijk 2010) Other theories of the digital divide (Unified Theory of Acceptance and Use of Technology (Venkatesh, Morris et al. 2003)) were considered, as were theories of individual health behaviours (Self-determination theory(Deci and Ryan 2008)), and individual health behaviours in the context of larger social systems (Social Ecological Model, (Stokols 1992, Golden and Earp 2012, Sallis, Owen et al. 2015)), and Glass and McAtee's (2006) multilevel framework for the study of health behaviours in a social and biological context,(Glass and McAtee 2006)). Of the theories explored, the DTA model could provide the most comprehensive framework to support the understanding of the majority of the findings across the mixed methods studies from this thesis.

Model of Digital Technology Access

Van Dijk developed the evidence-based model over 10 years and the full and final version is presented in Figure 22. The DTA model was discussed in Chapter 2 section 2.4.1 but will also be covered here in more detail. The DTA model proposes that inequalities can be perpetuated through the process of accessing and using technology.(Pick and Sarkar 2016) The model is based on the network or relational theory of inequalities, which focusses not on individuals but on categorical and positional differences between groups of people.(Wellman and Berkowitz 1988) The main argument of the theory is that substantial differences in advantage between people, relates to categorical differences (e.g. black/white, male/female) rather than individual differences (e.g. attributes, propensities).(Tilly 1998) In the model there is a feedback loop where inequalities in 'positional categories' and 'personal categories' result in inequalities in resources, this influences inequalities in access to technology, which leads to disparities in the individual ability to participate in society, and finally participation in the digital technologies influences positional categories.(Pick and Sarkar 2016) The positional and personal categories in the model are those that have frequently been found in digital divide research to create inequalities in resources that lead to differences in access to technology.(Van Dijk 2012) Those who are in the dominant positional and personal group are the first to adopt new technology and can leverage the advantage to increase power in relation to the 'subordinate' category.(Van Dijk 2012) The group presented first in the DTA model (Figure 22) is that where empirical observations indicated people in these groups have more access to technology than the second.(Van Dijk 2012)

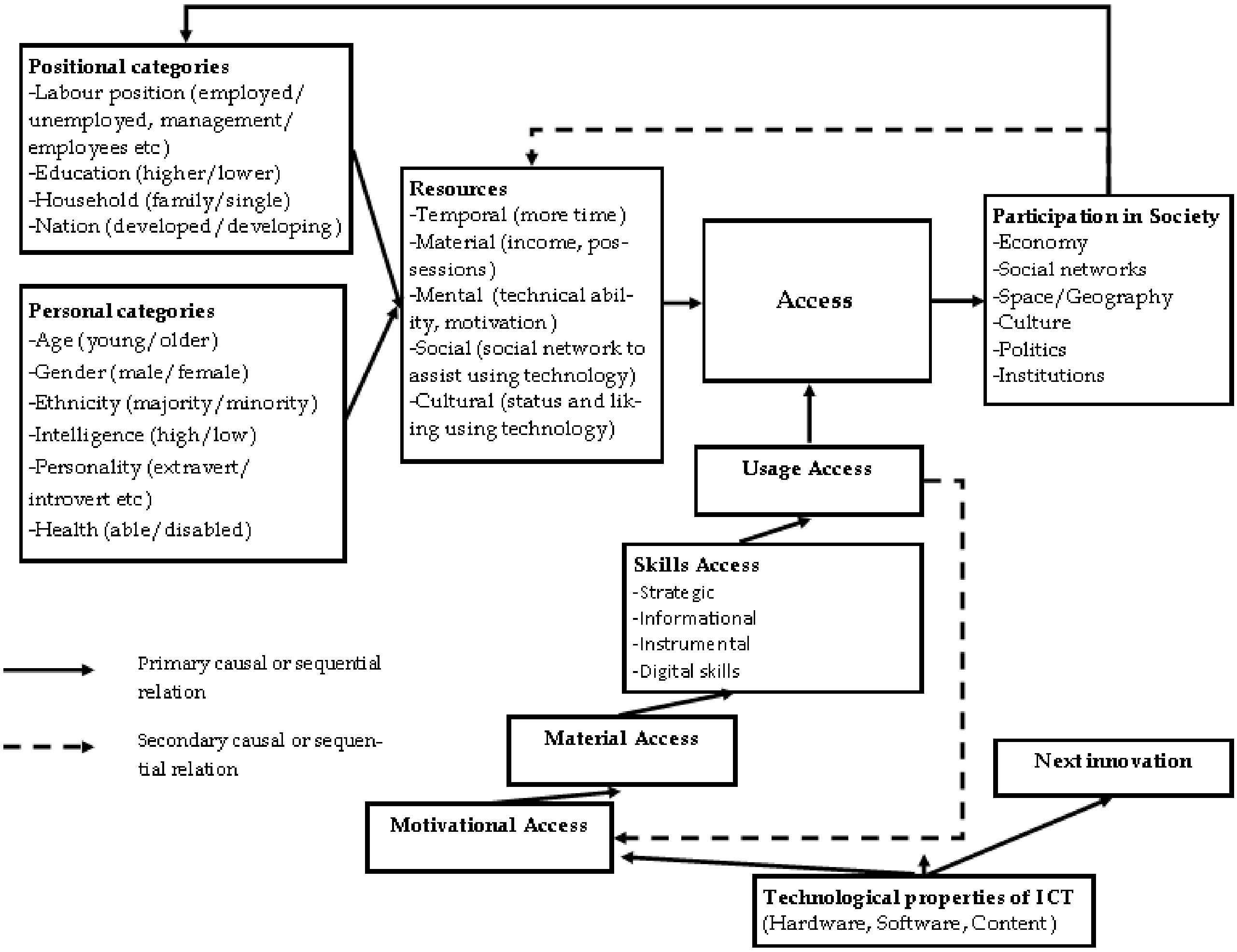


Figure 22: Van Dijk's Digital Technology Access, modified from (van Dijk 2005)

Four different types of access are proposed, which are passed through in succession and are repeated with each new innovation.(Van Dijk 2012) The model suggests that differences in access are first caused by variances in the motivation to use technology, then material capability to access it, followed by skills to use the technology (e.g. being able to navigate a program, or the multimedia presentation of information) and finally differences of 'usage' opportunities (e.g. frequency of use, number and diversity of applications of technology, creativity of use).(van Dijk 2005, Van Dijk 2012)

The influence of 'Technological properties of ICT' considers accessibility and usability issues created by the design of the hardware, software and content of the technology.(van Dijk 2005, Van Dijk 2012) In the model, van Dijk (2012) proposes that some of the properties of technology support 'usage access' and others create barriers for some social groups.(Van Dijk 2012) Complexity of hardware or software might mean only people with very strong digital skills can use it.(Van Dijk 2012) The content of the innovation can cause barriers to some social groups through issues with approachability, literacy and language barriers, cultural considerations and relevance, information overload and usability.(Van Dijk 2012)

There has been some criticism of the DTA model. In a paper comparing four of the leading theories of the digital divide, Pick et al. (2016) suggested there were issues with the methodology used to generate the model and issues with operationalising the model in empirical studies.(Pick and Sarkar 2016) The model was developed predominantly using surveys and policy studies of digital access and use in high income countries, ignoring the wide body of literature from the fields of economics, information systems, and sociology.(Pick and Sarkar 2016) Pick et al. (2016) argue that this may explain why the theory is not widely used in those disciplines and may limit the generalisability of the model.(Pick and Sarkar 2016) Pick et al. (2016) also suggested that due to the complexity of the model, there would be issues with data collection in larger samples and therefore it may be better suited to case study research.(Pick and Sarkar 2016) The authors concluded that of the four models of the digital divide compared, no single best theory exists for all situations. But rather each is suited to an appropriate problem, context and setting.(Pick and Sarkar 2016) Pick et al. (2016) highlights the strength of the DTA theory for research that focuses on the influence of economic, political and social inequalities as drivers of the digital divide.(Pick and Sarkar 2016) As this is the focus of the mixed methods research presented in this thesis, the DTA framework provides a good fit to support the synthesis of the findings.

Comparison with findings from this thesis

Figure 23 presents the framework of the DTA model and provides indication of where findings from this thesis support the model (green text), where evidence is unclear (orange text), where there is no evidence from this study (grey) and where there are new findings from this research (blue).

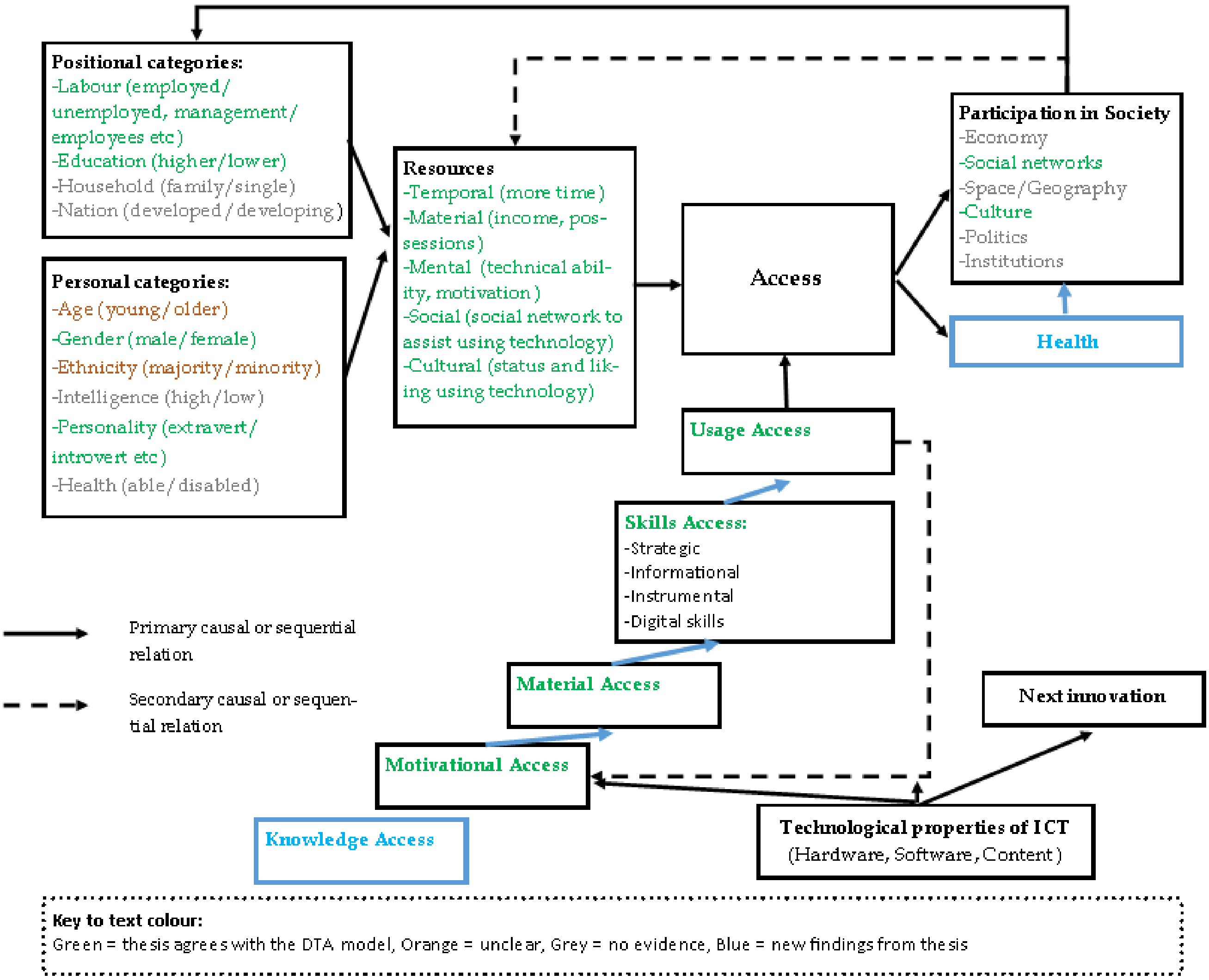


Figure 23: Study findings in the context of Van Dijk's model of Digital Technology Access

Both the systematic reviews (Chapters 3 and 4) and qualitative studies (Chapters 6 and 7) provide evidence that supports the DTA model but also challenges the linear and hierarchical nature of the different types of Access in the model. This research also suggests new elements of Knowledge Access and Health should be added to the model in the context of access to health technology.

The use systematic review (Chapter 3) suggested that people with diabetes with fewer material (income) and cognitive/'mental' (health literacy and numeracy) resources were less likely to access and use a digital intervention, in agreement with the DTA model (Figure 23). The evidence for age was mixed, with some studies indicating older participants used the intervention more and others indicating younger participants used them more. This author could not find published investigation into why these differences were found. It is therefore not possible to know which level of access in the DTA model resulted in challenges for participants from these groups. The DTA model can be used to generate hypothesises on how unequal access to resources created barriers to use of the interventions. However, evidence presented in this thesis indicates that the different types of access in the DTA model interact and do not occur sequentially as they have been presented in the model. In one of the studies included in the systematic review it was found that youths from lower income families had used intervention less (lower 'usage access') than those from higher income families, which may have been related to ‘material access’ to technology. The inclusion criteria for the study was that participants needed to have access to high-speed internet at home, school, community, or clinic. Those from families with lower incomes may not have had access to the technology or internet at home, limiting their opportunity to access the intervention, relative to those with internet and computers at home. Differences in use by numeracy and health literacy, are likely to be related to the ‘Technological properties of the ICT’, specifically issues with content. The DTA model suggests that lower ‘usage access’ by participants with lower levels of numeracy was related to lower ‘digital skills’. Where those with lower numeracy may have struggled more with the multimedia nature of technology.(Van Dijk 2012) For those with lower health literacy, digital skills may not have been an issue but the inaccessible content may have been enough to reduce engagement. In both cases, the inaccessibility of the content of the interventions is likely to have reduced ‘motivation access’ in the groups with lower cognitive resources, which resulted in lower levels of use. This was discussed by participants in the qualitative study (Chapter 6), where they talked about being motivated to use technology that reflected what they liked and valued and disengaging from technology if they disliked it or found it challenging to use. Differences found by age may also be related to whether the technology was designed with older or younger people in mind. In addition to whether age has led to gains in knowledge and wealth that make technology more accessible on the material and skills access levels.

The qualitative study supports the assertion in the DTA model that different resources available to individuals influence the four types of access: motivational, material, skills and usage access (Figure 23). But also suggested inequalities can influence whether people hear about new technology (‘knowledge access’). Therefore, ‘Knowledge access’ was added to the model, but no hierarchy has been suggested as there was no set order to the presentation of the types of access (Figure 23). Some participants described being motivated to learn about new technology, and others talked about being motivated to use digital interventions they had heard about. The participants in the study described how they used their cognitive (personal knowledge, research skills) and social resources to learn about new innovations that could support their T2D. The type of technology they were aware of and had access to depended in part to how well informed and connected their networks were. There was evidence that membership of diabetes support and research groups provided access to people with diabetes who were more knowledgeable than people in their personal networks. Online communities also served a similar purpose, connecting people on a much larger scale to a more diverse group of people with diabetes, allowing for a greater diffusion of knowledge and ideas.

‘Motivational access’ was influenced by cognitive, social, and cultural resources. Participants described being motivated to seek out technology to support the self-care of their condition (cognitive resources). They chose technology that allowed them to enact and confirm positive identities (cultural resources) and avoid the stigmatised diabetic identity. Ethnic, cultural and gender identities influenced the type of technology the participants selected (cultural and social resources). There was some indication that the men in the group were less motivated to use technology where they had concerns about security. The women in the group did not express this concern. This is evidence of the importance of the ‘Properties of ICT’ where participants select technology where the content reflects their needs.(Van Dijk 2012)

Although all of the participants had access to at least one type of technology, some described issues with ‘material access’ to more expensive digital interventions (Figure 23). Participants with more financial resources were able to buy more expensive equipment. Material access to technology was also gained through their social resources, specifically through their personal networks (gifting, work perks, use with personal trainer) and group membership (discounts and free samples). They also used their status (cultural resources) as leaders of diabetes groups or as technology experts to gain access to technology prior to general release, or to get replacements for faulty technology. Some participants described how their technical ability (cognitive resources) limited their skills and confidence using technology (‘skills access’). Issues with skills access could be bypassed by using ‘tech buddies’ from their social networks (social resources).

Findings from the qualitative study corresponds with the DTA model where technology supports ‘Participation in society’ (Figure 23*).* The digital interventions themselves acted as a resource that participants could draw on to come to terms with their diabetic identity, support self-care activities, and to influence how they were viewed by others. Through selecting technology that allowed them to present positive identities and avoid being identified with the stigmatised identity they were able to retain and reinforce their status in society (cultural participation). Conversely, those who are not able to access or use these technologies may experience reduced status. Participants described using technology to connect to others (‘social network participation’), through engaging with people over the use of similar technology, sharing their knowledge of innovations and engaging with people in online forums and social platforms. Limited access to these technologies has the potential to leave people more socially isolated. Although this study did not examine the influence of increased participation on 'positional category', the model predicts that increased participation will have a positive feedback effect.

The DTA model supports the interpretation of findings that the resources available to people influence their access to digital interventions to support the self-care of diabetes. However, the model does not explore how the digital interventions themselves can be used as a resource to influence health outcomes. The influence of difference in access to digital healthcare on health has therefore been added to the model (Figure 23). Many of the participants described how the technology they used, supported the management of their condition and some reported improvements in health outcomes. The participants with more material resources were able to buy more expensive technology, to which the users attributed their success at keeping their diabetes under control. The impact of access to technology improving health is likely to feedback to ‘Participation in society’ by enabling people remain engaged economically, spatially (leading a mobile life), and socially.

The effectiveness systematic review (Chapter 4) suggested that health benefits from accessing the interventions can be unequal between groups even when material access is not an issue. The male participants, those with higher health literacy and those from minority ethnic groups benefitted more from the interventions. As with the use systematic review, none of the study teams investigated why these differences were occurring. One of the three studies that found minority groups benefitted more from the intervention suggested that their intervention design may have caused the differences.(Lorig, Ritter et al. 2010) Using the DTA model it is possible to hypothesises the cause of the differences in effectiveness for the remaining ethnicity studies, for health literacy and gender differences. It is possible that the minority ethnic groups may have had greater benefits because they had less access to support and healthcare prior to being provided with the digital health intervention. Therefore, the content of the technology was more relevant to the needs of minority ethnic groups and benefits in the knowledge were greater. This may have also resulted in greater motivation to engage with the intervention. Therefore, access to these types of digital intervention may address health inequalities. Differences found by health literacy and gender are likely to be related to the 'Properties of the ICT', where the content was more relevant or usable for the men and those with higher health literacy. Therefore, even where material access is removed the DTA model still predicts differences in access and use of technology, and the evidence from the systematic reviews and qualitative studies presented in this thesis confirm this.

8.3. Reflections on challenges addressing the primary research questions

There were some challenges in achieving the central aim of this project, which was to explore how digital interventions impact health inequity in chronic conditions. A pragmatic decision was taken to focus on four high burden physical chronic health conditions in the systematic reviews to ensure the systematic review could be delivered in the available time. Although efforts were made to ensure the screening criteria was inclusive, following full text screening the use review contained 16 diabetes studies and one osteoarthritis study. Therefore, there was no evidence for differences in use in the other target conditions (asthma and COPD), and the single osteoarthritis study only provided a limited contribution to the findings. Consequently, from this systematic review it was only possible to draw conclusions about how people with different characteristics interact with web-based interventions for the self-care of diabetes, rather than chronic conditions in general. However, the effectiveness systematic review provided evidence across the four target health conditions. Three conditions (asthma, COPD and diabetes) were represented in the analysis exploring associations between PP groups and study outcomes, and three (COPD, diabetes and osteoarthritis) in the analysis exploring how social groups moderated intervention effectiveness. Therefore, from this systematic review it was possible to draw conclusions about common PP groups that benefitted more or less from these digital interventions across the four high burden chronic health conditions.

It could also be argued that the decision to focus on type 2 diabetes in the qualitative study only provides an indication of the way people with this condition experience accessing and using digital health interventions. Type 2 diabetes was selected as the target population for the qualitative study due to availability of digital interventions in the public sphere for this condition and in acknowledgement of the potential differences in illness experiences across conditions (discussed in 8.2.1). There will be illness experiences that are specific to individuals with type 2 diabetes that mean they have different opportunities to access technology than people with other conditions. For example, people with type 1 diabetes may have experienced greater access to technology from the NHS compared with people with type 2 diabetes due to recommendations in the NICE guidelines (discussed in section 8.7).(NICE 2016) However, there are likely to be common experiences across patient groups with chronic health conditions in terms of their experiences in accessing technology privately. These are likely to include access to internal resources and those in their environment as discussed in Chapters 6, 7 and in section 8.2.2. Therefore, this qualitative research can provide a specific illustration (type 2 diabetes) of the type of experiences people with a chronic condition can have accessing and using digital health technologies.

Limitations in the evidence base meant that is was not possible to address the third of the four primary research questions: *What are the possible causes of differences in use or effectiveness by SE and cultural groups in study settings?* None of the studies included in either of the systematic reviews investigated why the differences were occurring. Exploratory analysis was undertaken in the effectiveness systematic review to investigate one of the secondary research questions, which was: *Can differences in intervention effectiveness for different SE and cultural groups be attributed to the application of theory or behavioural change techniques (BCTs) to intervention design?* This analysis aimed to explore the mechanisms that might cause differences in benefits across social groups. Incomplete reporting of what and how BCTs and theories were used to develop interventions meant it was difficult to draw firm conclusions about how these elements contributed towards unequal benefits from the interventions. There were also challenges in mapping BCTs used to findings of modification of intervention effectiveness by PP group. Michie's Taxonomy of BCTs was used to map the BCTs onto standardised descriptions, but there was no agreed and published methodology for conducting analysis using these BCTs.(Michie, Richardson et al. 2013) Therefore, a pragmatic approach was taken, mapping single BCTs to the finding of a modification of intervention effect or no evidence of an effect. There were limitations in this approach as it could not represent specific combinations of BCTs or theory applied. Due to these limitations, it was not possible to determine whether BCTs and theory did contribute to the difference found. The use systematic review (Chapter 3) indicated social characteristics influenced use of web-based interventions, and prior evidence has indicated that higher use results in greater effectiveness.(Stellefson, Chaney et al. 2013) Therefore differences in use may well have influenced differences in effectiveness. However, only six of the 11 studies that reported modification of intervention effectiveness also reported modification of use by the same characteristics. This in addition to the flawed reporting of use in the literature (discussed in Chapter 3, section 3.3.3) limited the conclusions that could be drawn about whether use mediated effectiveness across social groups.

8.4. Reflections on public involvement

There was no Patient and Public Involvement (PPI) in the systematic reviews or the qualitative project and this is a limitation of this research. Moving forwards the author intends to integrate PPI into her future work from the beginning of the project and throughout. For example, she will ensure in future studies there is a PPI co-applicant on her grant, as evidence suggests this can improve sample diversity and engagement as it can facilitate involvement of people traditionally excluded from research.(Morgan, Thomson et al. 2016) Such a co-applicant could also be involved in data collection, as research also suggests their involvement in activities such as conducting qualitative interviews encourages participants to talk more openly about their views.(Morgan, Thomson et al. 2016)

8.5. Implication for design of web-based self-care interventions for chronic conditions

To ensure digital interventions do not exacerbate health inequities, the design of these web-based interventions should be more carefully considered. As discussed in section 8.2.2 this research supports theories of the digital divide that suggest inequalities in access to eHealth are not only related to issues with physical access to the internet, but also issues with intervention design not being usable for groups of people.(van Dijk 2005, Stellefson, Chaney et al. 2008) Issues with usability can arise from design biases introduced through insufficient consideration of user needs, which can be associated with dissatisfaction with interventions and disengagement.(Johnson, Johnson et al. 2005, Taylor, Sullivan et al. 2011) For example, evidence from the use systematic review (Chapter 3) indicated that those with lower levels of numeracy, health literacy and income engaged with digital health interventions less. The effectiveness systematic review found those with lower health literacy also benefitted less from interventions. Problems with usability of technology can emerge from issues such as cost, time restrictions and lack of user-centred design knowledge by the developers.(Johnson, Johnson et al. 2005)

These design biases can be mitigated through deep exploration of user needs during the design phase, and through involvement of a diverse range of people in the development of the intervention.(Yardley, Morrison et al. 2015) Although traditionally the focus has been on design appealing to the dominant group, there has been an increased movement towards inclusive design which focusses on diversity of people.(University of Cambridge 2018) Yardley et al.(2015) have developed the Person-based Approach as a systematic method of addressing user experience of proposed behaviour change techniques.(Yardley, Morrison et al. 2015) The methodology is designed to enhance use of evidence, and theory-based approaches to the development of interventions.(Yardley, Morrison et al. 2015) The Person-based Approach differs from the user experience process that has been utilised by the private sector through a focus on building an understanding of the psychosocial context in which the users live in addition to eliciting their views of the behavioural aspects of the intervention.(Yardley, Morrison et al. 2015) Along with evaluation of risk of bias in study methodology, evaluation of design bias should be considered, where teams systematically assess and report the processes undertaken to eliminate design bias. Teams developing the interventions should carefully consider the groups of people they wish to target. Whether they want to target the largest group of people, the largest group of people with the health condition, the group most adversely affected by the condition, or the group experiencing the greatest inequities in health status and outcomes. This will have implications for all stages of design, development and evaluation.

8.6. Implications for research

This research has highlighted the limitations of using individual measures of inequalities (such as education and income) to encapsulate the social determinants of health and resources available to a person. The qualitative study provided an insight into how people draw on internal resources and those in the social environment to access technology and to overcome barriers to use. The difference in resources was not well explained by individual social characteristics (e.g. education, occupation and household income) and this methodology revealed a mismatch between simple sociodemographic characteristics (such as chronological age) and people's identities (youthful or old fashioned). The qualitative study revealed that measures such as household income and indices of multiple deprivation score, did not encapsulate the resources people had available to them. These categories do not account for the importance of membership to social groups (e.g. diabetes groups, research groups and online forums) and how these supported access to knowledge about technology, provided shortcuts to accessing new and helpful innovations, and support to overcome issues with usability(tech buddies).(Eriksson 2011)(Putland et al. 2013; Bourdieu 1986)(Putland et al. 2013; Eriksson 2011; Portes 2000; Claridge 2018) There was bridging across social networks through memberships to these groups, which connected people with different levels of SES and meant those from lower SES had access to the knowledge from high status individuals of higher SES who they would not normally interact with. These findings show the value of qualitative research in providing insight into complex social phenomena, where social categories used in quantitative research can be somewhat limited. Even limited use of social data is essential to progress research into health inequalities and quantitative research should continue to investigate these differences, but methodologies should be considered that explore the interactions between social variables (such as Signal Partitioning approach used by Glasgow et el. (2015)).(Glasgow, Strycker et al. 2014) Qualitative research should be used alongside this quantitative investigation to probe the issues in the social environment that maintain social inequalities in health and to support theory in this field.

Future research into health inequities may benefit from using the Intersectionality framework, which supports the understanding of the complexity of the social environment and how this shapes human experience.(Collins and Blige 2016) The framework avoids the binary approach that has been traditionally taken in research that compares one group with another, and provides a more complete model of health inequities.(Caiola, Docherty et al. 2014) Intersectionality proposes that lived experiences are rarely shaped by a single factor, but rather is shaped by hierarchies of race, gender and social class as well as other social locations of disadvantage that interact and influence one another.(Caiola, Docherty et al. 2014, Collins and Blige 2016) The framework focuses on power dynamics and the relationship between privilege and oppression that are inherent in societies.(López and Gadsden 2016) Integral to the theory is the concept of simultaneity, which explains that social constructs exist simultaneously and vary as a function of each other depending on the category to which the person belongs.(Mullings and Schulz 2006) Caiola et al.(2014) provided the following example, "the intersection of social determinants of health for an African-American(*race*) mother (*gender*) living in poverty (*class*) and with HIV may function quite differently than that of an African-American (*race*) father (*gender*) living in poverty (*class*) and with HIV".(Caiola, Docherty et al. 2014) Simultaneity avoids dichotomies such as man/woman, wealthy/poor, white/ethnic minority, and stresses the complexity interacting categories, where no social group is considered homogenous.(Kelly 2009) The application of the intersectionality framework to the field of health research is new and is evolving and there are challenges fitting this new complex way of understanding inequalities to current research methodology. However, this sophisticated approach to social inequalities holds promise for research into health inequities.

This research highlighted challenges with the recruitment of a diverse range of participants to research which limits the generalisability of findings. The majority of the studies involved in the systematic reviews included eligibility criteria that could potentially create additional barriers to study entry for people from lower SES groups who have poorer health outcomes and often underrepresented in research samples.(Mattson, Curb et al. 1985, Dennis and Neese 2000, Ford, Howerton et al. 2008, Ejiogu, Norbeck et al. 2011) Measures of deprivation were often not reported by study teams and representativeness of the study population in comparison to the general population of people with the condition was rarely discussed. Where representativeness was discussed, most teams reported that participants were more likely to be from a higher SES and to be of white ethnicity. Issues with recruiting a sample based on diverse characteristics, was somewhat replicated in the qualitative project conducted in this research. Groups serving people with lower SES and BAME groups were contacted and visited around the primary site at Bristol. National diabetes groups serving BAME people with T2D were also contacted. Despite national and regional targeted recruitment campaigns, there was a low uptake, generally and specifically from people from BAME populations. This may be because few people with T2D currently use technology to support their condition, but also because T2D is a stigmatising disease. Successful recruitment of people from BAME groups came from an established group in Leicester that had been fostering links with the BAME communities over several years. To ensure study samples are representative, study teams should report whether the sample is typical of the wider population with the health condition. Where samples are unbalanced, an additional focus should be made to recruiting a representative sample to ensure intervention use is evaluated for people with different characteristics.(Windsong 2018) Researchers should think carefully about who they want to reach and develop strategies on how to reach people from diverse backgrounds, as opposed to recruiting the people who are the easiest to reach.

There were issues in the systematic reviews with potential reporting bias, where it could not be established whether outcomes and analysis were specified *a priori*. Research teams should clearly report where analyses were specified *a priori* in the study protocol and when they have been investigated *post-hoc*. Where possible study teams should routinely report modification of intervention use and effectiveness by participant characteristics to ensure exploration of both average effect and systematic differences in effectiveness. Theory should be used to select PP groups that may be advantaged or disadvantaged by the digital intervention and comparator categories within these groups. Estimates and standard error should also be reported for all modification analysis rather than those that reach the $p<0.05$ cut off, so strength of the relationship can be established by other research groups.

8.6.1. Future research directions

The projection of identities through technology may be a promising route to focus on in the future development of technology to support people to self-care for T2D. There was a clear story being told by the participants with T2D in the qualitative study about how they used technology to express positive identities, and selected interventions because they supported their preferred identities. This has implications for inequities because some people were able to avoid stigmatised identities through privately purchasing discrete technology, while others were not. Participants in the most part did not select diabetes-specific technology and when they did, they talked about the importance of it being discreet, or framed use in terms of expression of positive identity. Some interventions have addressed identity change through providing educational modules, for example the “Drink Less” app which was designed to tackle excess alcohol consumption.(Garnett, Crane et al. 2016) The module was theory based and designed to support change in identity so individuals did not consider ‘drinker’ as being a central part of their identity. (West and Brown 2013, Garnett, Crane et al. 2016) However, in the systematic review and in searching the literature none were found which considered how using the interventions assists or prevents people’s ability to enact positive identities. For example, considering whether the title of an app includes the name of the disease with the risk of exposure and stigmatisation. Or designing diabetes specific technology (such as a blood glucose monitor) to look like a piece of technology that is popular in the non-diabetic population. Intervention design that highlights people’s preferred identities may be more likely to be used and therefore have more beneficial effects. The role of identity in engagement with digital health interventions and behaviour change is a promising route for future research and intervention development in this field.

The participants in the qualitative study talked about HCPs having limited knowledge of innovations that may be able to help people with T2D. There is currently some evidence from across European countries, that stake holders and practitioners have variable knowledge about eHealth available for physical and cognitive health conditions.(Giannouli and Hyphantis 2017, Topooco, Riper et al. 2017) But there has been no investigation into primary care HCP knowledge of the eHealth interventions that what might help people to self-care for their chronic conditions. Therefore, it would be valuable to investigate whether HCPs need more evidence-based knowledge about available innovations, or support to make recommendations to patient about this type of technology.

There were no economic evaluations conducted in this research, so an economic argument for the investment of technology to support the self-care of T2D cannot be made. However, investing in technology to support the self-care of chronic conditions may reduce long term costs and burden on services. People in this study have described multiple benefits of technologies which include: helping them accept their diagnosis, prompting them to engage in self-care, supporting them to become skilled self-carers, and identifying issues before they become of greater concern. Providing a tool to support people develop their self-care skills, means they will have less reliance on HCPs. Helping people to identify issues before they become serious complications may result in the reduction of expensive hospital admissions. An economic evaluation of the long-term financial gains over short term financial outlay of innovations for people with chronic conditions should be conducted. An economic evaluation could also investigate the different ways in which people can access resources that reduce barriers and increase access to health technology. For example, by considering whether new health innovations can be accessed through older technology (e.g. smartphones), or needs bespoke new purchases (e.g. blood glucose monitors).

8.7. Implication for policy

Currently English guidelines for the prescription of technology for people with T2D only includes reference to blood glucose monitors. NICE guidelines specifys self-monitoring of blood glucose for adults with T2D should only be offered if the person is on insulin, having hypoglycaemic episodes, on medication that increases their risk of hypoglycaemia while driving, or if they are pregnant or planning to become pregnant.(NICE 2016) These guidelines appear to be based on an absence of evidence about how to guide the use of blood glucose monitors rather than consideration of effectiveness of these interventions.(NICE 2015) The guidelines state there was:

> *"limited evidence to guide clinical practice in prescribing self-monitoring regimens, in terms of frequency of testing and optimal blood glucose targets. Given the inconvenience and expense of self-monitoring, robust evidence from randomised controlled trials is needed to guide the optimal use of this intervention." pg.36(NICE 2016)*

This highlights lack of confidence in how these digital self-care interventions can be used, and their role in primary care. It is possible that the statement on the basis of limited evidence can be misunderstood by decision-makers in primary care practices as a rationing of resources. Far from being an 'inconvenience' the participants in the qualitative study have indicated that blood glucose monitoring is an essential part of the management of their T2D. These types of digital interventions are used as an external resource that helps them: come to terms with their diagnosis, to learn what self-care works, and to manage their condition. There was also an indication that not everyone had equal resources to access all types of health technology. Given the importance of this piece of technology to people with T2D and the difference in access for those who have fewer resources, assessment of need and risk should consider social determinants of health and the resources a person has available to help them cope in addition to biological need. For example, someone with T2D who is not on insulin, but is living in social isolation who cannot access health services easily and has fewer social and financial resources to draw on, may be higher risk of complications than someone with T2D who is on insulin and has more resources to draw on to cope. Considering the majority of chronic conditions are self-managed, the social determinants of health that should be considered are those that impact someone's ability to care for themselves. These include, age, caring responsibilities, income, social networks, difficulties accessing health-care (e.g. rural location). This is in line with previous recommendations from the King's fund that recommends redirecting resources to patients with the greatest need to "redress the 'inverse care law'". (King's Fund 2015) In addition to the key objectives presented in the WHO and Marmot report to provide universal coverage of health care for all, but with proportional intensity that reflects the level of disadvantage (proportionate universalism).(WHO 2007, Marmot, Atkinson et al. 2010)

Financial barriers to accessing effective technology, could be considered along the lines of current financial barriers to accessing and using non-digital healthcare. Some participants in the qualitative study described financial barriers to accessing certain types of digital self-care interventions. Other participants attributed success in being in control of their diabetes to the expensive technology they used. The central aim of the NHS is to provide good healthcare to all regardless of wealth.(NHS 2011) Although healthcare is universal, inequities can be created in the system where people are unable to access the healthcare, or where higher income groups also access private healthcare.(Goh 2017) There is evidence that even small healthcare costs means people are less likely to use services.(Karter, Parker et al. 2018) Currently the NHS attempts to remove financial barriers to access using means tested assistance schemes (e.g. NHS low income scheme) to support health cost, like travel rebates for attending appointments or subsidised medication.(NHS 2018) On the NHS low income scheme, people are provided with a full help (HC2) or partial help (HC3) certificate depending on income.(NHS 2018) It is possible that technology proven to be beneficial to people with chronic conditions could be considered among the free and subsidised provisions from the NHS.

Policy recommending the increased ‘use of apps to help people manage their own health’, (NHS England 2017) may be running ahead of the evidence, particularly in relation to how these interventions may influence health inequities. There are signs that the NHS is beginning to focus on making better use of technology to support patients.(Castle-Clarke 2018) In an NHS England report ‘Next steps on the NHS five year forward view’ they state that in the next 2 years they would ‘Increase the use of apps to help people manage their own health.’(NHS England 2017) They cite the important role of NHS app library and test beds being conducted by Academic Health Science Networks, which have responsibility for ‘driving national adoption of proven innovations’.(NHS England 2017) However, the NHS app library currently has limitations. Apps need to be either ‘NHS approved’ where there is evidence of benefits to health assessed through a process developed by NICE.(NHS England 2017) Or more recently developers have been able to self-assess their product against NHS criteria, which has the potential to speed up the entry of products into the library.(Castle-Clarke 2018) However, this places the burden on developers to apply, and those whose products are already selling well in the public sphere are unlikely to feel the need to do this.(Castle-Clarke 2018) This may result in patients continuing to use technology outside the healthcare system, while the absence of NHS support for these interventions may lead to unwillingness of HCPs to support the use of these tools, or to be able to utilise data produced by them.(Castle-Clarke 2018) There currently is not enough information about these interventions to inform policy about what technology should be recommended to people with chronic conditions and how these interventions may impact health inequity. The majority of the evidence from this study indicates digital interventions may be less accessible and usable for those already disadvantaged by the healthcare system. However, studies evaluating intervention use and effectiveness currently have issues with methodology and reporting, which makes drawing firm conclusions challenging.

This research has found that as with non-digital interventions, equal offer is not enough to address inequalities in the use and benefits obtained from digital interventions.(O'Neill, Tabish et al. 2014, Goh 2017) A recent NICE technology assessment report considered the impact of the increasing availability of behavioural change interventions on health equity. They noted differences in digital, internet and computer skills and access to the internet, but did not make specific recommendations on how to address these issues.(NICE 2018) To ensure health inequity is not increased by digital interventions, future policy should consider inequalities not only in access (internet connectivity) and use (digital skills) but also differences in whether people know about or can obtain digital technologies to support their health condition. Campaigns to increase awareness of evidence-based digital interventions may help with this.

Those who are not able to access health technology because they have lower digital skills could be supported by providing ‘tech buddy’. Social capital theory proposes that belonging to a social network, provides access to resources and benefits that individuals would not have on their own.(Eriksson 2011) These resources include knowledge, status and capital. In the context of this study, there was an indication that those with higher SES had greater access to knowledge about innovations and the connections and opportunities to acquire the technology. The potential for ‘tech buddy’ support for people with chronic illness could be explored to address unequal access to people with technological knowledge in social networks. Whereby people diagnosed with chronic conditions are linked with people who can discuss potential technological support with them, and troubleshoot issues with technology. Currently available peer support schemes, and social prescribing programmes have been found to be acceptable and beneficial for people with chronic conditions.(Heisler 2010, Moffatt, Steer et al. 2017) Alternatively online support could be offered using existing online health sites such as NHS choices.(NHS 2018)

Finally, this research has highlighted the importance of technology being discrete and not identifying the person as having a chronic illness. Emphasis should be placed on commissioning the development of discrete technology and recommendations for the prescription of these technologies.

8.8. Implications for practice

Barriers to accessing health technology through lack of knowledge about innovations, how to materially access, and how to use technology could be addressed through informing HCPs of available evidence-based technology. Nurses often play a central role in chronic disease management in primary care.(Peters, Hutchinson et al. 2001) For conditions like diabetes, nurses often take responsibility for the diabetes register in the practice, especially where there are specialist diabetes nurses employed.(Peters, Hutchinson et al. 2001) They play a role in educating people newly diagnosed with diabetes, ensuring they receive routine biomedical tests and follow-ups and that they receive ongoing self-management support in the community.(Peters, Hutchinson et al. 2001) A general practitioner may conduct the routine check-up, or take a bigger role in managing people with diabetes depending on the size of the practice and the number of people with diabetes.(Peters, Hutchinson et al. 2001) As policy begins to encourage greater adoption of digital interventions, the HCP who is more involved with ensuring the patient has support to self-manage is likely to play the greatest role in supporting people to access and use these interventions. Therefore, it would be beneficial for these HCPs to be knowledgeable about what innovations are available, to have an idea about how to use common self-care technology and to be able to support people in their use (as a tech buddy).

8.9. Conclusions

Digital interventions have the potential to reduce health inequities by increasing access to healthcare that can be tailored to the needs of the users. However, this research indicated that at present, these interventions are likely to increase inequities in health. There was evidence that resources a person has available to them influences whether they hearabout, have material access to, and can benefit from digital self-care interventions. The digital interventions themselves subsequently acted as a resource people could draw on to come to terms with their diabetic identity, support self-care activities, and to influence how they are viewed by others. The systematic reviews indicated that people with lower SES may be less likely to use these interventions. For those who did use the interventions, men,those with higher levels of health literacy and those from majority groups benefitted more from them. No studies could be found investigating why the differences in use and effectiveness may have emerged. The findings from the systematic reviews should be treated with caution, as most of the evidence came from a small number of low-quality studies. There were several major limitations with methodology and reporting in the studies included in the systematic reviews, which contributed to issues of quality and consequently limited the strength of the evidence. Were these to be addressed by study teams developing and evaluating future interventions, the contribution to the literature would be significantly improved. The qualitative study indicated that the internal (knowledge, digital skills) and external (social, financial, status) resources available to people with T2D influenced whether they heard about, could access and use digital interventions. Participants described digital interventions as a tool to support self-care behaviour change, to better understand their diabetic bodies and to enable them to develop their self-care expertise. They used digital tools to confront their diabetic identity, to project, enact and confirm their preferred positive identities, and as a defence against a stigmatised diabetic identity. Some participants used technology to increase their sense of power or status in their interaction with HCPs, while others used the interventions to demonstrate their 'good'ness to HCPs. This research has demonstrated that these digital interventions can provide an equalising effect on health outcomes for disadvantaged groups, but issues remain with access and usability of interventions.

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APPENDICIES

Appendix 2.1 Definitions of self-care and web-based interventions

Self-care definitions

Table 11: Self-care definitions in the context of web-based interventions

Definition	Title	Author	Date	Source	Comment
Self-care interventions were defined as those predominantly reliant on the individual bringing about self-change through the use of health technologies including written materials (books, booklets, leaflets), CD-Roms, DVDs, computerised software packages and websites.	Efficacy, cost-effectiveness and acceptability of self-care interventions for anxiety disorders: systematic review	Catrin Lewis, Jennifer Pearce, Jonathan I. Bisson	2012	http://bjp.rcpsych.org/content/200/1/15	
Self-management Self-management is a complex concept. In their seminal work, *Unending Work and Care: Managing Chronic Illness at Home,* Corbin and Strauss identified three tasks required for self-management: medical management; emotional management, and role management. Medical management receives the most attention from health professionals and designers of many Web-based interventions. It includes remembering to take medications regularly, managing interactions with health professionals, and adopting healthy behaviors such as eating healthily, exercising more, or stopping	Web-Based Interventions for Behaviour Change and Self-Management: Potential, Pitfalls, and Progress	Murray, E	2012	http://www.medicine20.com/2012/2/e3/	

smoking. From a patient perspective, the other two tasks are just as important and just as challenging. Emotional management refers to the work required for individuals to come to terms with the very strong negative emotions (e.g., guilt, shame, anger, and despair) that accompany a long-term condition. Role management is the work required to adapt to the changes in social roles and relationships (e.g., at work, within the family, or among friends) caused by the long-term condition.					
A self-care intervention can be defined as a psychological treatment in which the patient takes home a standardized psychological treatment protocol and works through it more or less independently	Self-care Interventions for Anxiety Disorders: An Overview	Pim Cuijpers, PhD, and Josien Schuurmans, PhD	2007	http://download.springer.com/static/pdf/960/art%253A10.1007%252Fs11920-007-0034-6.pdf?originUrl=http%3A%2F%2Flink.springer.com%2Farticle%2F10.1007%2Fs11920-007-0034-6&token2=exp=1449142314~acl=%2Fstatic%2Fpdf%2F960%2Fart%25253A10.1007%25252Fs11920-007-0034-6.pdf%3ForiginUrl%3Dhttp%253A%252F%252Flink.springer.com%252Farticle%252F10.1007%252Fs11920-007-0034-6*~hmac=c8096a8b0e881c5ad5b7d4eb51b56a90ed2acef5f9857d15dd559c223259e88f	
We defined self-care as structured programming for smokers trying to quit without intensive contact with a therapist.	Self-care interventions for smoking cessation	T Lancaster*, LF Stead	2002	http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD001118/abstract;jsessionid=731ACE1EBC800F17EB737DA7FDABFFA6.f03t03	

In contrast to human-supported interventions, self-guided therapeutic interventions, like web-based education interventions, are often open websites that provide an invaluable public health function due to their broad reach. Self-guided therapeutic interventions, however, usually require screening and registration (and, in some cases, payment) to gain access. Most human-supported therapeutic interventions have been designed specifically to treat a specific health condition/disorder and are usually controlled, password-protected websites that require registration and assessment (and, in some cases, payment) to gain entry. Although human-supported interventions have a smaller reach than self-guided programs, they provide individualized clinical treatment, similar to traditional face-to-face services. Overall, human-supported and self-guided web-based therapeutic interventions have their respective advantages and disadvantages (i.e., differing degrees of broad reach capability, anonymity, levels of treatment efficacy, and cost) and functions (i.e., individual clinical treatment vs. public health prevention programs), yet both serve important roles (as do web-based education interventions). In the future, the integration of all three types of web-based interventions in a stepped care approach will be of inestimable benefit in increasing access to physical and mental health treatment and significantly reducing health care costs [39].	Defining Internet-Supported Therapeutic Interventions	Barak et al	2009	http://link.springer.com/article/10.1007/s12160-009-9130-7/fulltext.html	

Web-based intervention definitions

Table 12: Web-based interventions definition

Definition	Title	Author	Date	Source
eHealth has been defined as “health services and information delivered or enhanced through the Internet and related technologies”	What is e-health	Eysenbach, G	2001	http://www.jmir.org/2001/2/e20/
As Barak et al 2009 have described, there has been a lack of clarity and consistency in the field of Internet-supported therapeutic interventions. This paper focuses on Barak et al’s “Web-based interventions” defined as: *“...a primarily self-guided intervention programme that is executed by means of a prescriptive online programme operated through a website and used by consumers seeking health- and mental-health related assistance. The intervention programme itself attempts to create positive change and or improve/enhance knowledge, awareness, and understanding via the provision of sound health-related material and use of interactive Web-based components.”* The key components of such interventions include program content, use of multimedia, interactive online activities, and guidance or supportive feedback. Web-based interventions have been developed for three main clinical areas: self-management of long-term conditions (e.g., diabetes, heart disease, arthritis, and asthma), health promotion (e.g., smoking cessation, alcohol reduction, sexual health, diet, and exercise), and mental health (e.g., depression and anxiety).	Web-Based Interventions for Behaviour Change and Self-Management: Potential, Pitfalls, and Progress	Murray, E	2012	http://www.medicine20.com/2012/2/e3/

Several terms that have commonly been used include web-based therapy, e-therapy, cyber-therapy, eHealth, e-Interventions, computer-mediated interventions, online therapy (or counseling), and the like. A number of publications have addressed this issue in an attempt to reduce the ambiguity and to promote clarity and consistency of terms and definitions. It seems, however, that these efforts might not have been successful, perhaps because they referred to specific or limited types of Internet-supported interventions or aspects of thereof. Moreover, it seems that definitions, such as those cited above, focused primarily on *web-based* interventions while overlooking other modes of providing interventions via the Internet. Web-based Interventions In this category, we propose the term *web-based interventions* as the most inclusive relative to a number of other terms commonly used in the field. Terms that incorporate “therapy” and “treatment” are too restrictive, primarily as they do not include prevention, promotion, and education interventions. We provide both a definition of web-based interventions and a preliminary definition/categorization model. A web-based intervention is: *a primarily self-guided intervention program that is executed by means of a prescriptive online program operated through a website and used by consumers seeking health- and mental-health related assistance. The intervention program itself attempts to create positive change and or improve/enhance knowledge, awareness, and understanding via the provision of sound health-related material and use of interactive web-based components.* Based on this definition, three broad *web-based intervention subtypes* are identified: (1) *web-based education interventions*; (2) *self-guided web-based therapeutic interventions*; and (3) *human-supported web-based therapeutic interventions*. We also specify *four major web-*	Defining Internet-Supported Therapeutic Interventions	Barak et al	2009	http://link.springer.com/article/10.1007/s12160-009-9130-7/fulltext.html

based components to encapsulate the essential ingredients that best represent an archetypal web-based intervention. These key components form the basis of the definition/categorization model and are: (a) program content; (b) multimedia use/choices; (c) provision of interactive online activities; and (d) provision of guidance and supportive feedback. It is important to note that these four web-based components are not mutually exclusive. They are interdependent and interconnected and are discussed in more detail below.				

Appendix 2.2 Defining high burden chronic conditions

Burden to the world, and low/middle and high-income countries

Through this work we sought to establish the conditions that are of greatest burden of disease to sufferers, specifically for the conditions which are likely to be encountered by primary care clinicians. Data about health conditions from WHO was available at several different levels: world, low/middle and high income countries.(WHO 2004) As this research was being conducted in a high income country and this is the context of this research, I focussed on conditions that present the highest burden of disease in high income countries only.

Defining high burden chronic health conditions

Several factors were considered when establishing the chronic conditions that had the highest burden to the individuals: i) prevalence of the condition; ii) incidence; iii) duration, and; iv) severity. It was felt that a composite of these factors, rather than any one in isolation, best represented the complexity of individual disease burden. Prevalence and incidence both considered the number of people with the condition, either the number of people suffering at any given moment (prevalence) or the number of episodes reported in a period of time (incidence). These counts of incidence or prevalence did not take into consideration the relative levels of disability (considered to be a proxy for loss of health), severity or duration of the different conditions. Conditions that are more common and result in a higher burden on health services as a result of a higher frequency of encounters with health care services, are not necessarily the conditions that have the highest burden of disease for the individuals. A health condition can have a relatively low incidence or prevalence, but can result in a high burden of disease or a high number of life years lost because of disability or death. Conversely, acute conditions that are more common, may have less impact on the individual resulting in a lower burden of disease and fewer life years lost. (WHO 2004)

Therefore, I considered three measures of illness severity provided by the WHO:

- High prevalence of moderate and severe disability for leading disabling conditions in high income countries
- Leading causes of years lost due to disability (YLD) in high income countries
- Top 10 Highest cause of mortality high income countries
- WHO- Non-Communicable Diseases (Chronic conditions) Global Monitoring Framework 2025 targets

Whilst it could be argued that death is the worst outcome for the individual, mortality statistics in isolation are not an adequate to measure of the burden of a disease. This is because death rates underestimate burden of disease by not providing information about non-fatal health conditions.(WHO 2009) Summary measures of the impact of conditions on health, such as YLD, are necessary to capture the effect both fatal and non-fatal conditions. Therefore, I chose to focus on the conditions that were in the top 10 of conditions that cause the greatest number YLD primarily; but also considered conditions in the top 20 prevalence of moderate and severe disability for leading disabling conditions; and were in the WHO non-communicable diseases Global Monitoring Framework 2025 targets.

Appendix 2.3 Systematic review search strategies

Final OVID search:

Search strategy

Searches	Results	Search Type
1	exp *Self Care/ or self care.ti,ab. or self-care.ti,ab. or self-management.ti,ab. or self management.ti,ab. or self-regulation.ti,ab. or self regulation.ti,ab. or exp *Self Efficacy/ or self-help.tw. or self help.tw. Ovid MEDLINE(R) <1946 to present> (47184) AMED (Allied and Complementary Medicine) <1985 to January 2016> (2123) Embase <1980 to 2016 Week 02> (97704) PsycINFO <1987 to January Week 1 2016> (40118)	187129
2	((behavio?r* adj3 change$) or behavio?r* change technique$).tw. Ovid MEDLINE(R) <1946 to present> (40890) AMED (Allied and Complementary Medicine) <1985 to January 2016> (742) Embase <1980 to 2016 Week 02> (49698) PsycINFO <1987 to January Week 1 2016> (29523)	120853
3	exp *Behavior Therapy/ Ovid MEDLINE(R) <1946 to present> (36974) AMED (Allied and Complementary Medicine) <1985 to January 2016> (0) Embase <1980 to 2016 Week 02> (15341) PsycINFO <1987 to January Week 1 2016> (8972)	61287
4	behavio?ral counselling.ti,ab. Ovid MEDLINE(R) <1946 to present> (106) AMED (Allied and Complementary Medicine) <1985 to January 2016> (2) Embase <1980 to 2016 Week 02> (136) PsycINFO <1987 to January Week 1 2016> (36)	280
5	lifestyle counselling.ti,ab. Ovid MEDLINE(R) <1946 to present> (175) AMED (Allied and Complementary Medicine) <1985 to January 2016> (3) Embase <1980 to 2016 Week 02> (227) PsycINFO <1987 to January Week 1 2016> (40)	445
6	**exp *Cognitive Therapy/** **Ovid MEDLINE(R) <1946 to present> (12481)** **AMED (Allied and Complementary Medicine) <1985 to January 2016> (0)** **Embase <1980 to 2016 Week 02> (13464)** **PsycINFO <1987 to January Week 1 2016> (9445)**	**35390**
7	or/1-6 Ovid MEDLINE(R) <1946 to present> (121177) AMED (Allied and Complementary Medicine) <1985 to January 2016> (2837) Embase <1980 to 2016 Week 02> (169733) PsycINFO <1987 to January Week 1 2016> (84960)	378707
8	*Internet/ or internet$.ti,ab. Ovid MEDLINE(R) <1946 to present> (49975) AMED (Allied and Complementary Medicine) <1985 to January 2016> (695) Embase <1980 to 2016 Week 02> (58824) PsycINFO <1987 to January Week 1 2016> (35458)	144952
9	(web or web-based).ti,ab. or (world wide web or worldwide web or website*).tw. Ovid MEDLINE(R) <1946 to present> (71427) AMED (Allied and Complementary Medicine) <1985 to January 2016> (969) Embase <1980 to 2016 Week 02> (90571) PsycINFO <1987 to January Week 1 2016> (30479)	193446
10	*Telemedicine/ or (mhealth or m-health or "m health").tw. or (telemedicine or Tele-medicine).tw. or cellphone.tw. or exp Cellular phone/ or ((cell$ or mobile$) adj3 phone$).tw. or (smartphone$ or smart-phone$).tw. or (personal$ adj3 digital$).tw. or "mobile health".tw. or (telehealth$ or tele-health$).tw. or (telecare$ or tele-care$).tw. Ovid MEDLINE(R) <1946 to present> (25500)	65125

	AMED (Allied and Complementary Medicine) <1985 to January 2016> (722) Embase <1980 to 2016 Week 02> (30011) PsycINFO <1987 to January Week 1 2016> (8892)	
11	(e-health or ehealth or "e health").tw. Ovid MEDLINE(R) <1946 to present> (2253) AMED (Allied and Complementary Medicine) <1985 to January 2016> (22) Embase <1980 to 2016 Week 02> (2576) PsycINFO <1987 to January Week 1 2016> (838)	5689
12	computeri?ed.ti,ab. or ((computer-assist* or computer-based) adj6 (therap* or treatment* or education*)).tw. or (interactive or online or on-line or cellular phon* or mobil* phon*).tw. Ovid MEDLINE(R) <1946 to present> (176206) AMED (Allied and Complementary Medicine) <1985 to January 2016> (5225) Embase <1980 to 2016 Week 02> (222867) PsycINFO <1987 to January Week 1 2016> (88364)	492662
13	(app$ adj3 (smartphone$ or smart-phone or mobile$ or phone$)).tw. Ovid MEDLINE(R) <1946 to present> (3149) AMED (Allied and Complementary Medicine) <1985 to January 2016> (37) Embase <1980 to 2016 Week 02> (4110) PsycINFO <1987 to January Week 1 2016> (1382)	8678
14	(*technology/ and *inventions/) or technology?based.tw. Ovid MEDLINE(R) <1946 to present> (4) AMED (Allied and Complementary Medicine) <1985 to January 2016> (0) Embase <1980 to 2016 Week 02> (19) PsycINFO <1987 to January Week 1 2016> (0)	23
15	*mobile applications/ or *video games/ Ovid MEDLINE(R) <1946 to present> (2606) AMED (Allied and Complementary Medicine) <1985 to January 2016> (0) Embase <1980 to 2016 Week 02> (7211) PsycINFO <1987 to January Week 1 2016> (4004)	13821
16	*Therapy, Computer-Assisted/ Ovid MEDLINE(R) <1946 to present> (4040) AMED (Allied and Complementary Medicine) <1985 to January 2016> (0) Embase <1980 to 2016 Week 02> (2060) PsycINFO <1987 to January Week 1 2016> (0)	6100
17	(Software or software design).tw. Ovid MEDLINE(R) <1946 to present> (100389) AMED (Allied and Complementary Medicine) <1985 to January 2016> (1065) Embase <1980 to 2016 Week 02> (159090) PsycINFO <1987 to January Week 1 2016> (18163)	278707
18	or/8-17 Ovid MEDLINE(R) <1946 to present> (372779) AMED (Allied and Complementary Medicine) <1985 to January 2016> (7786) Embase <1980 to 2016 Week 02> (502099) PsycINFO <1987 to January Week 1 2016> (147536)	1030200
19	asthma$.tw. or exp *Asthma/ Ovid MEDLINE(R) <1946 to present> (136852) AMED (Allied and Complementary Medicine) <1985 to January 2016> (1801) Embase <1980 to 2016 Week 02> (198613) PsycINFO <1987 to January Week 1 2016> (5440)	342706
20	Diabetes mellitus.tw. or exp *Diabetes Mellitus/ or exp *Diabetes Complications/ or diabet$.tw,ot. or (IDDM or NIDDM or MODY or T1DM or T2DM or T1D or T2D).tw,ot. or (non insulin$ depend$ or noninsulin$ depend$ or non insulin?depend$ or noninsulin?depend$).tw,ot. or (insulin$ depend$ or insulin?depend$).tw,ot. Ovid MEDLINE(R) <1946 to present> (485739) AMED (Allied and Complementary Medicine) <1985 to January 2016> (4505) Embase <1980 to 2016 Week 02> (686185) PsycINFO <1987 to January Week 1 2016> (22247)	1198676
21	exp Diabetes Insipidus/ or diabet$ insipidus.tw,ot. Ovid MEDLINE(R) <1946 to present> (9660) AMED (Allied and Complementary Medicine) <1985 to January 2016> (7) Embase <1980 to 2016 Week 02> (12189) PsycINFO <1987 to January Week 1 2016> (191)	22047

22	20 not 21 Ovid MEDLINE(R) <1946 to present> (477816) AMED (Allied and Complementary Medicine) <1985 to January 2016> (4498) Embase <1980 to 2016 Week 02> (677478) PsycINFO <1987 to January Week 1 2016> (22056)	1181848
23	Osteoarthr$.tw. or exp *Osteoarthritis/ or arthrosis.tw. Ovid MEDLINE(R) <1946 to present> (61695) AMED (Allied and Complementary Medicine) <1985 to January 2016> (3128) Embase <1980 to 2016 Week 02> (86348) PsycINFO <1987 to January Week 1 2016> (1447)	152618
24	*Depressive Disorder/ or Unipolar depressive disorders.tw. or depressive disorder$.tw. or *Depression/ or (depress$ or dysthymi$).tw. or *mood disorder/ or *adjustment disorder/ Ovid MEDLINE(R) <1946 to present> (362387) AMED (Allied and Complementary Medicine) <1985 to January 2016> (6865) Embase <1980 to 2016 Week 02> (453366) PsycINFO <1987 to January Week 1 2016> (215824)	1038442
25	exp *Alcoholism/ or exp *Alcohol-Related Disorders/ or Alcohol use$.tw. or "Alcohol use disorder".tw. or (alcoholism or "alcohol disorder$").tw. or (alcohol adj ("use disorder?" or disorder? or illness* or dependence or abuse or misuse)).ti,ab. Ovid MEDLINE(R) <1946 to present> (107245) AMED (Allied and Complementary Medicine) <1985 to January 2016> (521) Embase <1980 to 2016 Week 02> (114206) PsycINFO <1987 to January Week 1 2016> (46758)	268730
26	"drug use disorder".tw. or exp *Substance-Related Disorders/ or drug dependence.tw. or "drug dependence and problem use".tw. or "drug problem use".tw. or ((substance related or cannabis or tobacco or stimulant or hallucinogen or opioid or morphine or marijuana or heroin or cocaine) adj ("use disorder?" or disorder? or illness* or dependence or abuse or misuse)).ti,ab. Ovid MEDLINE(R) <1946 to present> (183405) AMED (Allied and Complementary Medicine) <1985 to January 2016> (79) Embase <1980 to 2016 Week 02> (156740) PsycINFO <1987 to January Week 1 2016> (9886)	350110
27	25 or 26 Ovid MEDLINE(R) <1946 to present> (210898) AMED (Allied and Complementary Medicine) <1985 to January 2016> (595) Embase <1980 to 2016 Week 02> (200339) PsycINFO <1987 to January Week 1 2016> (54955)	466787
28	Chronic respiratory disease.tw. or exp *Lung Diseases, Obstructive/ or COPD.tw. or exp *Pulmonary Disease, Chronic Obstructive/ or emphysema$.tw. or (chronic$ adj3 bronchiti$).tw. or (obstruct$ adj3 (pulmonary or lung$ or airway$ or airflow$ or bronch$ or respirat$)).tw. or COAD.tw. or COBD.tw. or AECB.tw. or (chronic obstructive pulmonary disease* or chronic obstructive lung disease*).tw. Ovid MEDLINE(R) <1946 to present> (197633) AMED (Allied and Complementary Medicine) <1985 to January 2016> (2105) Embase <1980 to 2016 Week 02> (145308) PsycINFO <1987 to January Week 1 2016> (2457)	347503
29	19 or 22 or 23 or 24 or 27 or 28 Ovid MEDLINE(R) <1946 to present> (1310707) AMED (Allied and Complementary Medicine) <1985 to January 2016> (18271) Embase <1980 to 2016 Week 02> (1681365) PsycINFO <1987 to January Week 1 2016> (287193)	3297536
30	7 and 18 and 29 Ovid MEDLINE(R) <1946 to present> (2467) AMED (Allied and Complementary Medicine) <1985 to January 2016> (35) Embase <1980 to 2016 Week 02> (3319) PsycINFO <1987 to January Week 1 2016> (1004)	6825
31	30 and 2006:2015.(sa_year). Ovid MEDLINE(R) <1946 to present> (2144) AMED (Allied and Complementary Medicine) <1985 to January 2016> (28) Embase <1980 to 2016 Week 02> (3002) PsycINFO <1987 to January Week 1 2016> (856)	6030

CINAHL

Total number of hits: 2086

Search Terms	Search Options	Hits
S1	(MH "Asthma+") OR "asthma"	(23,531)
S2	((MH "Diabetes Mellitus+") OR TX "Diabetes mellitus" OR TX "diabetes mellitus" OR TX diabetes OR TX "glucose intolerance" OR (MM "insulin resistance" OR TX "insulin resistance") OR (TX IDDM or TX NIDDM or TX MODY or TX T1DM or TX T2DM or TX T1D or TX T2D) OR TX "Diabetes Complications" NOT ((MH "Diabetes Insipidus") OR TX "Diabetes Insipidus")	(110,802)
S3	(MH "Osteoarthritis+") OR TX Osteoarthritis OR osteoarthr* OR (TX degenerative n1 TX arthritis) OR TX arthrosis	(14,656)
S4	((MH "Depression") OR TX depression OR (TX "depressive disorder*") OR (TX "unipolar depressive disorder*") OR (TX depress*) OR (TX "mood disorder*")	(82,980)
S5	(MH "Alcohol-Related Disorders+") OR TX "alcohol disorder*" OR TX alcoholism OR TX "alcohol use disorder*" OR (TX alcohol N1 (TX "use disorder*" OR TX disorder? OR TX illness* OR TX dependence OR TX abuse OR TX misuse))	(32,107)
S6	(MH "Substance Use Disorders+") OR (TX "drug use disorder*") OR (TX "drug dependence*") OR (TX "drug dependence and problem use") OR (TX "drug problem use") OR ((TX "substance related" OR TX cannabis OR TX tobacco OR TX stimulant OR TX Hallucinogen OR TX opioid or TX morphine or TX marijuana or TX heroin or TX cocaine) N1 (TX "use disorder*" OR TX disorder? or TX illness* or TX dependence or TX abuse or TX misuse))	(80,989)
S7	S5 OR S6	(90,049)
S8	(MH "Pulmonary Disease, Chronic Obstructive+") OR (TX "chronic respiratory disease*") OR (TX "obstructive lung disease*") OR TX COPD OR (TX emphysema*) OR TX "chronic Obstructive Pulmonary Disease" OR TX "Chronic Obstructive Airway Disease" OR TX "Chronic Obstructive Lung Disease" OR TX "pulmonary emphysema" OR TX "chronic bronchitis" OR TX COAD OR TX COBD OR TX AECB OR TX "Chronic Airflow Obstruction"	(13,768)
S9	S1 OR S2 OR S3 OR S4 OR S7 OR S8	(314,983)
S10	MH "Internet+" or TX internet* or MH "World Wide Web+" or TX web or MH "Website Development" or MH "World Wide Web Applications+"	(115,984)
S11	MH "Telemedicine" OR MH "Telehealth" OR MH "Mobile Applications" OR TX mhealth OR TX m-health OR MH "Mobile Applications" OR ((TX application or TX app?) N1 (TX smartphone? or TX smart-phone or TX mobile? or TX phone?))	(8,022)

S12	MH "Therapy, Computer Assisted" OR TX ehealth OR TX e-health OR MH "Decision Making, Computer Assisted+" OR ((TX computer-assist* or TX computer-based OR TX computeri?ed OR TX computer*) N1 (TX therap* or TX treatment* or TX education*))	(13,360)
S13	(MH "Video Games+") OR (MH "Games")	4,255)
S14	(MH "Cellular Phone+") OR TX cellphone OR ((TX cell? or TX mobile?) N1 TX phone?) OR ((TX smartphone? or TX "smart-phone?") or (TX personal* N1 TX digital?) or TX telehealth? or TX tele-health? or TX telecare* or TX "tele-care*" OR TX interactive or TX online or TX "on-line" or TX "cellular phon*" or TX mobil* TX phon* OR TX telemedicine OR TX "Tele-medicine"	(97,805)
S15	MH "User-Computer Interface" OR TX "decision aid?" OR TX "Interactive health communicat*"	(5,087)
S16	S10 OR S11 OR S12 OR S13 OR S14 OR S15	(213,085)
S17	MH "Self Care+" OR TX "self care" OR TX "self-care" OR TX "self-management" OR TX "self management" OR MH "Self Regulation" OR TX "self regulation" OR TX "self-regulation" OR MH "Self-Efficacy" OR TX "self-efficacy" OR TX "self efficacy"	(49,692)
S18	(MH "Attitude to Illness") OR TI attitude OR AB attitude	(36,739)
S19	MH "Behavior Therapy+" OR MH "Behavior Modification" OR (TX behavio#r* N1 TX change?) OR (TX behavio#r* N1 TX "change? technique?")	(22,405)
S20	TX "behavio#r* counselling" or MH "Cognitive Therapy+"	(9,019)
S21	MH "Life Style Changes" OR TX "life style counselling" OR TX "life-style counselling"	(5,842)
S22	S17 OR S18 OR S19 OR S20 OR S21	(108,272)
S23	S9 AND S16 AND S22	(2,694)
S24	S9 AND S16 AND S22 **Limiters** - Published Date: 20060101-20151231	2086

Appendix 3.1 Table with papers that met the inclusion criteria for the use systematic review but did not include the analysis of interest

Table 12: Papers that met the inclusion criteria for the use systematic review but analysis of interest was not presented, the data could not be disaggregated by PP group or the paper could not be located

Author	Condition	Year Published	Full inclusion Decision	Title	Research aim	Comments on paper access	Followed up with author check disaggregation	Data extracted	Comments on data
Ahmed, S., Bartlett, S. J., Ernst, P., Lin, C. J.,	Asthma	2011	Could not find paper or author contact details	My asthma portal: Preliminary results of a web-based self management intervention	Unsure	Asked for full paper/ whether SES or cultural vars included in any other analysis	No	No	Contacted for the second time 25/08/2016 to check if full paper is available. Conference abstract-age gender. Data cannot be disaggregated from abstract exclude
Bond, G.E., Burr, R., McCurry, S. M., Wolf, F. M.,	Chronic illness	2007	Exclude	Psychosocial outcomes of a twelve-month Internet intervention	Unsure	Contacted author for full paper	No	No	author contacted again 25/08/2016. Full results Results covered in RefID 832
Bossen, D., Veenhof, C., Dekker, J., De Bakker, D.	Osteoarthritis	2012	author confirmed only abstract not full paper available	The design and feasability of a web-based physical activity program for patients with osteoarthritis of hip or knee	Unsure		No	No	Author contacted 14/07/2016: It is a conference presentation- abstract age

Chien, M.N., Liu, L., Chiang, H. C., Wu, C. C., Le	Diabetes	2006	Could not find paper or author contact details	Building a certificate-based secure and quick response telemedical health-care system for diabetic patients	Unsure		No	No	Can't find contact: interlibrary loan requested. Not received
Cohen, J.L., Johnson, P., Batra, M., Puryear, J. S	Diabetes	2015	Could not find paper or author contact details	Engagement with a mobile health diabetes self-management program	Unsure	Can't find contact	No	No	Can't find contact: Inter-library requested: University holdings appears to direct to the incorrect article ' Brown and Beige Fat: Molecular Parts of a Thermogenic Machine' but the info about the journal and issue no etc appear to be correct?! Will request from interlibrary to see if the article is sent?
Couch, C.E., Speck, A. L., Baptist, A. P.	Asthma	2015	Could not find paper or author contact details	Electronic asthma self-management program can improve asthma control and quality of life in young, African Americans	Unsure	Can't find contact	No	No	Can't find author's contact details to ask if there is a full paper available

Cunningham, S.G., Brillante, Massimo, Allardice, Brian, McAlpine,	Diabetes	2014	Exclude	My Diabetes My Way: Providing online support for diabetes self-care in Scotland	Unsure		No	No	gender- this is one of the main papers for conference abstract 1552- author contacted on research gate & interlibrary loan requested 01/09/2016
Cunningham, S.G., Wake, D. J., Morris, A. D., Wall	Diabetes	2013	Exclude	My Diabetes My Way: An electronic personal health record for people with diabetes	Uptake		No	No	Gender-descriptive only
Glasgow, R.E., Kurz, Deanna, King, Diane, Dickman,	Diabetes	2010	Social characteristic data cannot be disaggregated	Outcomes of minimal and moderate support versions of an internet-based diabetes self-management support program	Both		Yes	Yes	Not heard back 22/02/2017. Followed-up with author (first and last, first bounced) 13/12/2016 to check full models are available so can check individual contribution of SES vars. age, gender, Income & education & health literacy
Ling, E., Mohammed, M., Kvedar, J., Jethwani, K.	Diabetes	2012	Could not find paper or author contact details	Diabetes connected health evaluation	Unsure		No	No	author contacted 26/05/2016 no response to check whether there was a full paper. Exclude based on contents of abstract.

Magee, M.F., Nassar, C. M., Khan, N. H.	Diabetes	2011	Could not find paper or author contact details	Improvement in glycemic control in diabetes patients adopting a personal health record: EHealth2go	Unsure		No	No	interlibrary loan requested- abstract.E library contacted again 07/12/16 :Author contacted 14/07/2016: Looks like abstract only: age, ethnicity. Descriptive only
McIlhenny, C.V., Guzic, B. L., Knee, D. R., Demuth	Chronic conditions	2011	Exclude	Using technology to deliver healthcare education to rural patients	Uptake		No	No	Attrition only: gender & age, rural
Meer, V., Bakker, M. J., Hout, W. B., Rabe, K. F.,	Asthma	2009	Exclude	Internet-based self-management plus education compared with usual care in asthma: a randomized trial	Uptake		No	No	Non-responders rather than use: gender, education, age, Socioeconomic status
Mulvaney, S., Johnson, K., Dietrich, M., Rothman,	Diabetes	2010	Exclude	An examination of cell phones to measure situational barriers to diabetes self-management in adolescents	Unsure		No	No	Author contacted: Only abstract- author confirmed 31/05/2016 did not explore socioeconomic or cultural variables
Mulvaney, S.A., Rothman, Russell L., Dietrich, Mar	Diabetes	2012	Exclude	Using Mobile Phones to Measure Adolescent Diabetes Adherence	Uptake		No	No	Does not look at differences in use

Mulvaney, S.A., Rothman, R. L., Lybarger, C., Wall	Diabetes	2009	Exclude	Modeling problem solving with an internet-based self-management intervention for adolescents with type 1 diabetes	Unsure		No	No	Author contacted: Only abstract- author confirmed 31/05/2016 did not explore socioeconomic or cultural variables in those studies
Piccinno, E., Ortolani, F., Vendemiale, M., Tummol	Diabetes	2013	Could not find paper or author contact details	New technologies for promoting hypoglycaemia self-management in type 1 diabetic children	Unsure		No	No	Author contacted 07/06/2016 – no response. Conference abstract only
Quinn, C.	Diabetes	2014	Could not find paper or author contact details	Mobile health: Patient engagement in diabetes care	Unsure		No	No	Author contacted 07/06/2016 no response. Conference abstract only
Quinn, C.C., Gruber-Baldini, A. L., Shardell, M. D	Diabetes	2012	Could not find paper or author contact details	A cluster-randomized trial of a mobile phone behavioral intervention for blood glucose control: Primary and secondary outcomes	Unsure		No	No	Author contacted 07/06/2016: No response. Conference abstract No reporting of differences by PP group

Ramadas, A., Chan, Carina, Oldenburg, Brian, Hussi	Diabetes	2015	Exclude	A Web-Based Dietary Intervention for People with Type 2 Diabetes: Development, Implementation, and Evaluation	Uptake	User acceptance testing	No	No	Process evaluation- like pilot/feasibility No association with SES and usablity or effectiveness reported
Rikkers-Mutsaerts, N., Beerthuizen, T., Winters, A	Asthma	2014	Could not find paper or author contact details	Internet-based self-management in adolescents with asthma: The role of education, monitoring and symptom perception	Unsure		No	No	Can't find contact details 07/06/2016: No exploration of differences by PP group mentioned in the abstract
Rikkers-Mutsaerts, N., Winters, A., Bakker, M., Va	Asthma	2013	Could not find paper or author contact details	Online self-management for adolescents with asthma	Unsure		No	No	Can't find contact details or paper, or UoB library 07/06/2016:
Sanchez-Morillo, D., Crespo, Mario, Leon, Antonio,	COPD	2015	Exclude	A novel multimodal tool for telemonitoring patients with COPD	Uptake		No	No	Development and Evaluation of a prototype
Sarkar, U., Karter, A., Liu, J., Adler, N., Nguyen	Diabetes	2011	Could not find paper or author contact details	Uptake of an internet-based patient portal and ethnic and educational disparities: The diabetes study of	Unsure		No	No	Author contacted 07/06/2016 no response. Conference abstract

				northern california (distance)				
Stukus, D.R., Phillips, G., Farooqui, N.	Asthma	2014	Could not find paper or author contact details	Improved education and self-management in children and adolescents with asthma using a personalized smartphone application	Unsure		No	No	Conference abstract: No exploration of differences by PP group mentioned in the abstract. Can't find contact details to ask about whether there is a full paper
Taite, A., Minard, J., Ferrone, M., Licskai, C., T	Asthma	2015	Could not find paper or author contact details	AsthmaLife portal: Supporting clinical care and research at the point of care	Unsure		No	No	Interlibrary loan requested 28/07/16 they couldn't find it. Followed up on the 07/12/2016. On 13/12/2016 concluded they could not obtain it. Conference article
Teilmann, G., Boisen, K., Hommel, E., Olsen, B., P	Diabetes	2014	Could not find paper or author contact details	mhealth app for young people with diabetes type 1 transferring from pediatric to adult care*	Unsure		No	No	Conference abstract- No exploration of differences by PP group mentioned in the abstract Author contacted 23/05/2016 to ask if full paper. No response

Trawley, S., Browne, J. L., Hagger, V., Pouwer, F.	Diabetes	2015	Exclude	The use of mobile applications among adolescents with type 1 diabetes: Results from diabetes Youth-Australia	Uptake		No	No	Author contacted 07/06/2016 full paper is not yet published: Conference abstract.

Vaala, S.E., Hood, Korey K., Laffel, Lori, Kumah-C	Diabetes	2015	Social characteristic data cannot be disaggregated	Use of Commonly Available Technologies for Diabetes Information and Self-Management Among Adolescents With Type 1 Diabetes and Their Parents: A Web-Based Survey Study	Both		Yes	No	Never got back with disaggregated data- Therefore excluded. Followed up on the 24/02/2017, author confirmed table presents univarable association with SES not full models. Said will re-run syntax for us. 22/02/2017 03/05/2017.Chased again on the 17/03/2017.

Valerio, M.A., Joseph, C. L., Peterson, E. L.	Asthma	2012	Exclude	Examining health literacy and asthma outcomes in an urban adolescent population	Unsure		No	No	Conference abstract. Association of health literacy and outcome. Not intervention and outcome mediated by literacy. Exclude
Van Bastelaar, K.M.P., Pouwer, F., Cuijpers, P., S	Diabetes	2009	Could not find paper or author contact details	Web-based cognitive behavioural therapy for diabetes patients with co-morbid depression: first findings	Unsure		No	No	Author contacted 07/06/2016-email bounced: Conference abstract
Veen, J.I., Mennema, B., Beekhof, A. L., Van Noort	COPD	2015	Could not find paper or author contact details	Adherence to online self-management in patients with COPD or asthma: The role of disease burden	Unsure		No	No	Can't find authors contact 07/06/2016: No exploration of differences by PP group mentioned in the abstract
Wang, J., Siminerio, L. M.	Diabetes	2011	Could not find paper or author contact details	Using a web-based system for behavioral goal monitoring in diabetes education	Unsure		No	No	Conference proceeding 12/07/16 : author contacted for full paper no response

Welch, G., Zagarins, S., Garb, J.	Diabetes	2009	Could not find paper or author contact details	A brief intervention using a computerized patient self management assessment tool improves blood glucose control (HbA1c)	Unsure		No	No	Conference abstract. Found author contact and send request for full paper 12/12/2016 no response received. Interlibrary loan requested they say we have the record but it looks like we don't have the suppliment in question.

Appendix 3.2 Table with evidence of differences in use by PP variables

Table 13: Evidence of differences in use by PP variables

Study	**Study id**	**Study size**	**Study type**	**Measure of use group**	**Rob**	**Older**	**Male**	**Minority ethnic**	**High education**	**Employed**	**Higher income**	**Higher Numeracy**	**Higher health literacy**	**Married**	**Insured**
Case, 2014	1	45	RCT	2	Unclear			_							
Glasgow, 2011	2	270	RCT	2	High			0	0				0		
Glasgow, 2014	2a	270	RCT	2	High	0	0	0	0			+	+	0	
Goh, 2015	3	84	Non-RCT	2	Critical	0	-								
Heinrich, 2012	4	135	RCT	2	Unclear	0	0		0						
Holmen, 2014	5	164	RCT	2	Low	+	0		0						
Huang, 2014	6	81	RCT	2	Unclear	+									
Lau, 2014	7	157	Non-rct	1	Critical	_	0								
Lee, 2007	8	274	Non-rct	2	Serious	--			+						
McCarrier, 2009	9	78	RCT	1	Unclear	0	0	0	0					+	0
Mulvaney, 2011	10	48	RCT	2	Unclear	0	--								
Nijland, 2011	11	50	Non-rct	1	Critical	0	0		0						
Pacaud, 2012	12	79	RCT	2	High		0								
Roelofsen, 2014	13	1378	Non-rct	1	Critical	0	0		0	0					

Skrovseth, 2012	14	30	Non-rct	2	Critical	+	0								
Umapathy, 2015	15	277	Non-rct	1	Critical	0	0								
Wangberg, 2008	16	64	RCT	2	Unclear	0	0		+						
Whittemore,2013	17	320	RCT	2	Low	--	0	0			+				

+ Positive association; 0 No association; - Negative association

Appendix 4.1 Table with papers that met the inclusion criteria for the effectiveness systematic review but the analysis of interest was not presented

Table 14: Papers that met the inclusion criteria for the effectiveness systematic review but analysis of interest was not presented, the data could not be disaggregated by PP group or the paper could not be located

Author	**Condition**	**Year Published**	**Full inclusion Decision**	**Title**	**Research aim**	**Comments on paper access**	**Followed up with author check disaggregation**	**Data extracted**	**Comments on data**
Ahmed, S., Bartlett, S. J., Ernst, P., Lin, C. J.,	Asthma	2011	Could not find paper or author contact details	My asthma portal: Preliminary results of a web-based self management intervention	Unsure	Asked for full paper/ whether SES or cultural vars included in any other analysis	No	No	Contacted for the second time 25/08/2016 to check if full paper is available. Conference abstract-age gender. Data cannot be disaggregated from abstract exclude

Bond, G.E., Burr, R. L., Wolf, F. M., Feldt, K.	Diabetes	2010	Social characteristic data cannot be disaggregated	The effects of a web-based intervention on psychosocial well-being among adults aged 60 and older with diabetes: a randomized trial	Effectiveness		Yes	Yes	Not heard back 22/02/2017 followed up again as had previously received responses. Followed-up with author 13/12/2016 to check full models are available so can check individual contribution of SES variable. Double check about disaggregation. age,gender, Education, income, ethnicity
Bossen, D., Veenhof, C., Dekker, J., De Bakker, D.	Osteoarthritis	2012	author confirmed only abstract not full paper available	The design and feasability of a web-based physical activity program for patients with osteoarthritis of hip or knee	Unsure		No	No	Author contacted 14/07/2016: It is a conference presentation-abstract age
Chien, M.N., Liu, L., Chiang, H. C., Wu, C. C., Le	Diabetes	2006	Could not find paper or author contact details	Building a certificate-based secure and quick response telemedical health-care system for diabetic patients	Unsure		No	No	Can't find contact: interlibrary loan requested. In Chinese

Cohen, J.L., Johnson, P., Batra, M., Puryear, J. S	Diabetes	2015	Could not find paper or author contact details	Engagement with a mobile health diabetes self-management program	Unsure	Can't find contact	No	No	Can't find contact: Inter-library requested: University holdings appears to direct to the incorrect article ' Brown and Beige Fat: Molecular Parts of a Thermogenic Machine' but the info about the journal and issue no etc appear to be correct?! Will request from interlibrary to see if the article is sent?
Couch, C.E., Speck, A. L., Baptist, A. P.	Asthma	2015	Could not find paper or author contact details	Electronic asthma self-management program can improve asthma control and quality of life in young, African Americans	Unsure	Can't find contact	No	No	Can't find author's contact details. From conference abstract: age, ethnicity
Cunningham, S.G., Brillante, Massimo, Allardice, Brian, McAlpine,	Diabetes	2014	Exclude	My Diabetes My Way: Providing online support for diabetes self-care in Scotland	Unsure		No	No	gender- this is one of the main papers for conference abstract 1552- author contacted on research gate & interlibrary loan requested 01/09/2016

Czernohorsky, G., Roth, R., Lothaller, H.	Diabetes	2012	Exclude	"moPras" - The impact on physical and mental health and quality of life in newly diagnosed type 2 diabetics	Effectiveness		No	No	This is not an internet intervention. With partial translation it looked like it was an internet intervention provided by mobile. When in fact it was trained MoPras assistants that were moving around so 'mobile' that attended peoples homes -AgnES doctor-in-charge, municipalities, e-health-assisted, systemic intervention) was created in December 2007, also referred to as "Mobile Practice assistant "(MoPras)
Glasgow, R.E., Kurz, Deanna, King, Diane, Dickman,	Diabetes	2010	Social characteristic data cannot be disaggregated	Outcomes of minimal and moderate support versions of an internet-based diabetes self-management support program	Both		Yes	Yes	Not heard back 22/02/2017. Followed-up with author (first and last, first bounced) 13/12/2016 to check full models are available so can check individual contribution of SES vars. age, gender, Income & education & health literacy

Hamar, G.B., Rula, Elizabeth Y., Coberley, Carter,	Diabetes	2015	Social characteristic data cannot be disaggregated	Long-term impact of a chronic disease management program on hospital utilization and cost in an Australian population with heart disease or diabetes	Effectiveness		Yes	Yes	Message bounced 15/12/2016

Jaser, S.S., Whittemore, Robin, Chao, Ariana, Jeon	Diabetes	2014	Exclude	Mediators of 12-month outcomes of two Internet interventions for youth with type 1 diabetes	Effectiveness		Yes	Yes	Ref 2514 and 6587 cover 6 and 18 month outcome- same data different focus. This analysis focused on mediating effects of effectiveness by the ways in which they cope with the stress of diabetes, their self-efficacy for diabetes management , their social competence , and family functioning . Controls for SES variables but does not add anything extra to papers 2514 and 6587. Used mixed methods analysis. Grey responded and forwarded to Sangchoon- study statician ref id 2514. Not heard back 22/02/2017. Followed-up with author 13/12/2016 to check full models are available so can check individual contribution of SES variables. gender, age, Parental education, annual income

Joseph, C.L., Ownby, D. R., Havstad, S. L., Saltzg	Asthma	2013	Exclude	Evaluation of a web-based asthma management intervention program for urban teenagers: reaching the hard to reach	Effectiveness		No	No	Reporting on a new version of the intervention with added submodules based on findings from the 2010 study: Look at difference by emotional support and rebelliousness rather than cultural and socio-demographics. age, gender, ethnicity, Qualify for free or reduced lunch
Joseph, C.L.M., Ownby, Dennis R., Havstad, Suzanne L., Saltzgaber, Jacqueline, Considine, Shannon, Johnson, Dayna, Peterson, Ed, Alexander, Gwen, Lu, Mei, Gibson-Scipio, Wanda, Johnson, Christine Cole	Asthma	2013	Exclude	Evaluation of a Web-Based Asthma Management Intervention Program for Urban Teenagers: Reaching the Hard to Reach	Effectiveness		No	No	Recruited 98% African American and did not compare by ethnic group. No other SES variables reported. Therefore exclude

Kelley, H., Chiasson, M., Downey, A., Lockhart, B.	Diabetes	2009	Exclude	Web-based versus face-to-face education: A longitudinal experiemental study	Effectiveness		No	No	Author contacted Conference abstract. Author confirmed there was no a full paper published therefore drop: gender mentioned
Kumah-Crystal, Y.A., Hood, Korey K., Ho, Yu-Xian,	Diabetes	2015	Exclude	Technology Use for Diabetes Problem Solving in Adolescents with Type 1 Diabetes: Relationship to Glycemic Control	Effectiveness	It isn't an intervention, but looking at technology use in general- speak to supervisors about this.	No	No	Did not testing an intervention, but rather technology use in general. Impossible to extract data.age,gender,ethnicity, parent household income, parent education, SES score
Landau, Z., Mazor-Aronovitch, Kineret, Boaz, Mona,	Diabetes	2012	Exclude	The effectiveness of Internet-based blood glucose monitoring system on improving diabetes control in adolescents with type 1 diabetes	Unsure		No	No	Discussed with supervisors. Remote monitoring of patient by clinician, telehealth rather than self management-just upload blood glucose data and get a call to tell them if change treatment

Ling, E., Mohammed, M., Kvedar, J., Jethwani, K.	Diabetes	2012	Could not find paper or author contact details	Diabetes connected health evaluation	Unsure		No	No	author contacted 26/05/2016 no response to check whether there was a full paper. Exclude based on contents of abstract: Conference abstract:age, gender
Magee, M.F., Nassar, C. M., Khan, N. H.	Diabetes	2011	Could not find paper or author contact details	Improvement in glycemic control in diabetes patients adopting a personal health record: EHealth2go	Unsure		No	No	interlibrary loan requested- abstract.E library contacted again 07/12/16 :Author contacted 14/07/2016: Looks like abstract only: age, ethnicity. Descriptive
Moy, M.L., Janney, A. W., Nguyen, H. Q., Matthess,	COPD	2010	Social characteristic data cannot be disaggregated	Use of pedometer and Internet-mediated walking program in patients with chronic obstructive pulmonary disease	Effectiveness	feasibility trial	Yes	No	Not heard back 22/02/2017. Followed-up with author 13/12/2016 to check full models are available so can check individual contribution of SES vars. Age,gender

Mulvaney, S., Johnson, K., Dietrich, M., Rothman,	Diabetes	2010	Exclude	An examination of cell phones to measure situational barriers to diabetes self-management in adolescents	Unsure		No	No	Author contacted: Only abstract- author confirmed 31/05/2016 did not explore socioeconomic or cultural variables in those studies: Age, gender, year in school
Mulvaney, S.A., Rothman, R. L., Lybarger, C., Wall	Diabetes	2009	Exclude	Modeling problem solving with an internet-based self-management intervention for adolescents with type 1 diabetes	Unsure		No	No	Author contacted: Only abstract- author confirmed 31/05/2016 did not explore socioeconomic or cultural variables in those studies:
O'Day R, F., Oberleitner, L., Greenhut, J., Wang,	Diabetes	2011	Could not find paper or author contact details	The impact of an online tailored diabetes management program on behavior change outcomes and program satisfaction among hispanics and	Effectivenes s		No	No	Can't find contact details 07/06/2016:Intralibrary loans received: Poster presentation. As only a poster drop

				non-hispanic whites					
Orsama, A.-L., Lahteenmaki, Jaakko, Harno, Kari, K	Diabetes	2013	Social characteristic data cannot be disaggregated	Active assistance technology reduces glycosylated hemoglobin and weight in individuals with type 2 diabetes: results of a theory-based randomized trial	Effectiveness		Yes	No	Not heard back from biostatisitician 22/02/2017. Followed-up with author 13/12/2016 to check full models are available so can check individual contribution of SES vars. Age,gender, yrs of education- no mention of internet but it is an app &mentions browser based interface so included on this basis
Piccinno, E., Ortolani, F., Vendemiale, M., Tummol	Diabetes	2013	Could not find paper or author contact details	New technologies for promoting hypoglycaemia self-management in type 1 diabetic children	Unsure		No	No	Author contacted 07/06/2016 - although the email address seemed a bit odd. Conference abstract: None mentioned

Porter, S.J., Chapman-Novakofski, K. M., Scherer,	Diabetes	2009	Exclude	Your guide to diet and diabetes: Web-based diabetes education tailored to Hispanics	Effectiveness		No	No	Summary of info from pilot study. No real detail. Focus on Hispanic population no comparitor group
Quinn, C.	Diabetes	2014	Could not find paper or author contact details	Mobile health: Patient engagement in diabetes care	Unsure		No	No	Author contacted 07/06/2016 no response. Conference abstract:
Quinn, C.C., Gruber-Baldini, A. L., Shardell, M. D	Diabetes	2012	Could not find paper or author contact details	A cluster-randomized trial of a mobile phone behavioral intervention for blood glucose control: Primary and secondary outcomes	Unsure		No	No	Author contacted 07/06/2016: Conference abstract None listed in abstract- need to ask authors. No response
Rikkers-Mutsaerts, N., Beerthuizen, T., Winters, A	Asthma	2014	Could not find paper or author contact details	Internet-based self-management in adolescents with asthma: The role of education, monitoring	Unsure		No	No	Can't find contact details 07/06/2016: Not mentioned in the abstract-need to ask for full paper

				and symptom perception					
Rikkers-Mutsaerts, N., Winters, A., Bakker, M., Va	Asthma	2013	Could not find paper or author contact details	Online self-management for adolescents with asthma	Unsure		No	No	Can't find contact details or paper, or UoB library 07/06/2016:
Ruiz, J.G., Andrade, Allen D., Anam, Ramanakumar ,	Diabetes	2014	Exclude	Computer-based programmed instruction did not improve the knowledge retention of medication instructions of individuals with type 2 diabetes mellitus	Effectivenes s		No	No	Not clear if internet based- contacted author 02/12/2016. age, education, health literacy. Contacted final author on the 13/12/2016 also. Author confirmed intervention was not web-based
Sarkar, U., Karter, A., Liu, J., Adler, N., Nguyen	Diabetes	2011	Could not find paper or author contact details	Uptake of an internet-based patient portal and ethnic and educational disparities: The diabetes study of northern california (distance)	Unsure		No	No	Author contacted 07/06/2016: Conference abstract

Stukus, D.R., Phillips, G., Farooqui, N.	Asthma	2014	Could not find paper or author contact details	Improved education and self-management in children and adolescents with asthma using a personalized smartphone application	Unsure		No	No	Conference abstract: None mentioned in the abstract. Can't find contact details to ask about whether there is a full paper
Taite, A., Minard, J., Ferrone, M., Licskai, C., T	Asthma	2015	Could not find paper or author contact details	AsthmaLife portal: Supporting clinical care and research at the point of care	Unsure		No	No	Interlibrary loan requested 28/07/16 they couldn't find it. Followed up on the 07/12/2016. On 13/12/2016 concluded they could not obtain it. Conference article
Tang, P.C., Overhage, J. Marc, Chan, Albert Solomo	Diabetes	2013	Social characteristic data cannot be disaggregated	Online disease management of diabetes: Engaging and Motivating Patients Online With Enhanced Resources-Diabetes (EMPOWER-D), a randomized controlled trial	Effectiveness		Yes	No	Not heard back 22/02/2017. Followed-up with author 13/12/2016 to check full models are available so can check individual contribution of SES vars. age, gender, education

Teilmann, G., Boisen, K., Hommel, E., Olsen, B., P	Diabetes	2014	Could not find paper or author contact details	mhealth app for young people with diabetes type 1 transferring from pediatric to adult care*	Unsure		No	No	conference abstract-non mentioned. Author contacted 23/05/2016 to ask if full paper. No response

Vaala, S.E., Hood, Korey K., Laffel, Lori, Kumah-C	Diabetes	2015	Social characteristic data cannot be disaggregated	Use of Commonly Available Technologies for Diabetes Information and Self-Management Among Adolescents With Type 1 Diabetes and Their Parents: A Web-Based Survey Study	Both		Yes	No	Never got back with disaggregated data. Therefore excluded 03/05/2017.Chased again on the 17/03/2017. Followed up on the 24/02/2017, author confirmed table presents univarable associations with SES not full models. Said will re-run syntax for us. 22/02/2017 chased up with authors- responded still not clear whether to included have followed up by sending them data tables as an example. Checking with author whether table 4 is multivariate model including SES or univariate analysis of SES associations with outcome- if latter EXCLUDE. Adolescent use of web intervention for diabetes: age, education, gender, income, employment,

Valerio, M.A., Joseph, C. L., Peterson, E. L.	Asthma	2012	Exclude	Examining health literacy and asthma outcomes in an urban adolescent population	Unsure		No	No	Conference abstract. Association of health literacy and outcome. Not intervention and outcome mediated by literacy. Exclude
Van Bastelaar, K.M.P., Pouwer, F., Cuijpers, P., S	Diabetes	2009	Could not find paper or author contact details	Web-based cognitive behavioural therapy for diabetes patients with co-morbid depression: first findings	Unsure		No	No	Author contacted 07/06/2016-email bounced: Conference abstract
Veen, J.I., Mennema, B., Beekhof, A. L., Van Noort	COPD	2015	Could not find paper or author contact details	Adherence to online self-management in patients with COPD or asthma: The role of disease burden	Unsure		No	No	Can't find authors contact 07/06/2016: None mentioned in abstract
Wang, J., Siminerio, L. M.	Diabetes	2011	Could not find paper or author contact details	Using a web-based system for behavioral goal monitoring in diabetes education	Unsure		No	No	Conference proceeding 12/07/16 : author contacted for full paper no response: age gender ethniticy

Welch, G., Zagarins, S., Garb, J.	Diabetes	2009	Could not find paper or author contact details	A brief intervention using a computerized patient self management assessment tool improves blood glucose control (HbA1c)	Unsure		No	No	Emails bounced 2 different addresses tried Conference abstract. Found author contact and send request for full paper 12/12/2016. interlibrary loan requested they say we have the record but it looks like we don't have the suppliment in question.

Appendix 4.2 Standardisation of Behavioural Change Techniques (BCTs) descriptions using Michie's et al.'s Behavioural change taxonomy

Table 15: Standardisation of Behavioural Change Techniques (BCTs) descriptions using Michie's et al.'s Behavioural change taxonomy

Higher level grouping- based on Michie et al Behavioural change Taxonomy	**Grouped BCTS**	**BCTs as described by the authors**
2. Feedback & monitoring	Assessment of behaviours and perceptions at baseline	Assess health behaviours
		Assess self- efficacy
		Self-assessment
		Assess level of social support
	Health monitoring and logging	Diabetes outcomes monitoring
		Self-monitoring of health outcome (blood glucose and pressure)
		Accurate self-monitoring
		Health monitoring and logging
	Online journal/log	Tools for patient and patient–clinician capture of personal health information
		Online journal (for interaction with nurse-social support?)
	2.2 Feedback on behaviour	Provide feedback on current behaviour
		Provide feedback on progress
		Tailored feedback
		Step count feedback
		Tailored SMS-an automated SMS algorithm that provided disease management decision support
		Tailored messages
	Communication/support from health professionals/study team	Health care team communications portal
		Interactive tools to communicate with clinicians
		Support from health professional
		Asynchronous and interactive communication
1. Goals and Planning	Action planning/Goal setting	Facilitate action planning
		Goal setting
		Use assessment results for tailoring goal setting
		Action planning/goal setting
		Motivating patients for behaviour change by setting concrete realistic goals
	1.9 Commitment	Prompt commitment to a healthful lifestyle : Encourage participants to affirm or reaffirm a strong commitment to start, continue, or restart their goal-attainment efforts.
	1.2 Problem solving	Facilitate relapse prevention and coping using behaviour change: Help participants understand how lapses occur and how they lead to

		relapse, and to develop specific strategies for preventing lapses or avoiding lapses turning into relapse
		Facilitate barrier identification: Help participants identify general barriers (e.g., susceptibility to stress) that might make it harder to eat a healthful diet, engage in regular PA, or take medications.
		Facilitate strategy generation for overcoming barriers: Help participants identify strategies for addressing barriers (e.g., don't go food shopping when hungry; specific relaxation techniques and how and when to apply them instead of eating).
		Identify reasons for establishing and maintaining healthful lifestyle behaviour: Help participants understand how lapses occur and how they lead to relapse, and to develop specific strategies for preventing lapses or avoiding lapses turning into relapse
	1.4 Action planning	Prompt tracking of lifestyle behaviours : Help participants establish a routine of recording their daily diet, physical activity, and medication taking to track their own progress toward goals.
	Informed decision making	Informed decision making
	?? General aspects of the interaction (R) focusing on the delivery of the intervention (D)	Emphasize choice: Emphasize participant choice within the bounds of evidence-based practice.
15. Self-belief	15.4 Self-talk	Cognitive behaviour modification
	Motivational support	Motivational support
		Boost motivation and self-efficacy
6. Comparison of behaviours	6.2 Social comparison	Provide normative information
		Provision of case studies
		Ethnically diverse graphic novel characters to present information (relating to peers)
4. Shaping knowledge	Training/information provision	Social skills training
		Assertive communication training
		Stress reduction and conflict resolution training
		Education
		Motivating patients for behaviour change by setting concrete, realistic goals; and education
	Direction to community resources	Adopt appropriate local community resources: Give information about options for additional support for diet and PA (e.g., websites, self-help groups, telephone helpline)
3. Social support	Peer learning/support	Peer learning and support boards
		Online community for social support
		Peer support/moderation
		Advise on/facilitate use of social support
10. Reward and threat	10.10 Reward (outcome)	Provide rewards contingent on successful goal attainment

Appendix 4.3 Overview of available interaction data

Table 16: Overview of available interaction data

Condition	**Number of studies where there is evidence of modification of intervention effect by PP variable/ Total number of studies that explored modification of intervention effect**	**What PP interactions did they look at?**	**Outcome**	**Evidence of an interaction**	**Interactions found**
Asthma	**NA**	**None**	**NA**	**?**	**No interactions tested**
Osteoarthritis	**0/1**	gender, age, ethnicity, and people living in their household	**Health**	**No**	**0 Pain composite (Intensity and unpleasantness) x Age, gender, ethnicity in people living in the household working age adults opting in to a web-based pain management programme (no range given)(Nevedal, Wang et al. 2013)**
COPD	**1/2**	**Age** **Gender** **Education** **Employment** **Urban/rural**	Health	**No**	**0 QoL x** Age in veterans age ≥ 40 years old. No other participant characteristics were investigated **(Moy, Collins et al. 2015)**
			Behavioural	**Yes**	0 Physical activity x Age, gender, education, employment adults aged between 40–70 years of age(Voncken-Brewster, Tange et al. 2015) **- Daily step count x Age(increasing):** Each 1-year increase in age was associated with a 33-point decrease in change in daily step counts (P = .03) in US army veterans age ≥ 40 years old. No other participant characteristics were investigated **(Moy, Collins et al. 2015)**
			Knowledge	**?**	**No interactions tested**
			Psychosocial	**?**	**No interactions tested**
Diabetes	**7/8**	**Age**	**Health**	Yes	0 HbA1c x Age, gender,ethnicity, income in youth aged 11-14 years with T1D.(Whittemore, Jaser et al. 2012)

		Gender **Ethnicity** **Education** **Health Literacy** **Numeracy** **Income**			+ HbA1c x Gender (male): trend for a group by time by gender interaction for change in A1C from baseline to the final visit was found (F[2, 62]=2.76, p=0.071). Males in the Web Interactive group and the Web Static group tended to drop in A1C by the final visit, but males in the control group showed a slight increase in A1C from the first to final visit (F[2, 29]=3.05, p=0.063).) No associations were found for women in a study of people with T2D(no age limit given). No other interactions with PP groups were explored.(Pacaud, Kelley et al. 2012) **+ Blood pressure x Ethnicity (minority group): Latinos had a greater reduction in blood pressure than non-Latinos in the intervention arm, while Latinos had a lower reduction in the control arm** (no estimates available p=.006)**.** But 0 Blood pressure x Age, gender, education, health literacy and numeracy in adults with T2D aged 25-75 years at 12 months (Glasgow 2012) **+ Blood pressure x Ethnicity (minority group): mean decrement in blood pressure in adults** >18years with T1 or T2D **was** greater within the patients of African-Caribbean heritage, compared with the Caucasians and Indo-Asians in the intervention arm. The mean SBP increased for the Caucasians and to a much lesser extent, the African- Caribbean's in the control arm. The Indo-Asian's mean SBP decreased in both intervention group and to a slightly greater extent in the control group (no estimates). No other interactions with PP groups investigated (Istepanian 2009)
			Behavioural	**Yes**	0 Patient initiated communication x Age, health literacy in adolescents with T1D IBD and CF aged 12-20 years transitioning into adult care.(Huang, Terrones et al. 2014) 0 Overall behavioural change x Age, gender, Latino ethnicity, education, health literacy or numeracy in adults with T2D aged 25-75 years at 12 months**.**(Glasgow 2012) 0 Maintenance of behaviour x Age, gender, Latino ethnicity, health literacy, education, numeracy(Glasgow, 2014) 0 Self-care x Gender in people with T2D(no age limit given) (Pacaud, Kelley et al. 2012) +Self-care: improvement was positively correlated with age (0.04/year, 95% CI: 0.02, 0.06), p <0.001). 0 self-care x gender, ethnicity, education, employment, income or health literacy in people aged ≥ 25 years with T2D (Yu, Parsons et al. 2014) **+ Activity Limitation x Ethnicity(minority group):** strong association between decrease in activity limitation for AI/AN program participants compared with the control group in adults with T2D aged ≥18 years (effect size 0.337, P (ITT) 0.028, p=0.012). No other interactions with PP groups investigated (Lorig, Ritter et al. 2010)
			Knowledge	**Yes**	0 Diabetes knowledge x Age, gender or education in adults with T2D aged 40–70 years. (Heinrich, de Nooijer et al. 2012) / gender in people with T2D(no age limit given) (Pacaud, Kelley et al. 2012)

					+ Chronic disease management knowledge x Health Literacy(high): in adolescent participants with T1D IBD and CF aged 12-20 years in the intervention arm with 'adequate literacy levels' demonstrated greater improvements in disease management knowledge over the study period compared with those with 'inadequate literacy levels' (no estimates provided). But 0 Chronic disease management knowledge x Age.(Huang, Terrones et al. 2014)
			Psychosocial	**Yes**	**0 Self-efficacy x Health literacy, age** in adolescents with T1D IBD and CF aged 12-20 years transitioning into adult care,(Huang, Terrones et al. 2014) / age, gender, Latino ethnicity, education, health literacy or numeracy in adults with T2D aged 25-75 years at 12 months (Glasgow 2012) / ethnicity in adults with T2D aged ≥18 years .(Lorig, Ritter et al. 2010) / **gender** in people with T2D(no age limit given) (Pacaud, Kelley et al. 2012) **+ Diabetes QoL x Gender(male):** boys in the Managing Diabetes program had greater improvements in diabetes QOL compared with TEENCOPE participants (4.19 ± 1.01 vs. 1.03 ± 0.89; mean difference 3.16 (SE 0.159) p = 0.019). But 0 Diabetes QoL x age, ethnicity or income in youth aged 11-14 years with T1D.(Whittemore, Jaser et al. 2012) + Diabetes distress x age (increasing), gender (male) : improvements in diabetes distress following the use of the intervention was greater for older (estimate -0.34, SE 0.15, 95%CI -0.64 - -0.05, p=0.01) males (gender(male) estimate -9.12, SE 3.62, 95% CI -16.22 - -2.02, p=0.006) participants aged ≥ 25 years with T2D. 0 Diabetes distress x ethnicity, education, employment, income or health literacy (Yu, Parsons et al. 2014)

Appendix 4.4 Modification of effectiveness for PP categories in the diabetes studies

Table 17: Modification of effectiveness data available for PP categories in the diabetes studies

Study	**Study id**	**Health condition**	**Study size**	**Study type**	**RoB**	**Outcome**	**Age (increasing)**	**Gender (male)**	**Ethnicity (minority)**	**Education (high)**	**Employed**	**Income (higher)**	**Numeracy (high)**	**Health literacy (high)**
Moy, 2015	1	COPD	239	RCT	Low	Health	0							
						Behaviour	_							
Voncken-Brewster, 2015	2	COPD	1325	RCT	High	Behaviour	0	0		0	0			
Glasgow, 2012	3	Diabetes	463	RCT	High	Health	0	0	+	0			0	0
						Behaviour	0	0	0	0			0	0
						Psychosocial	0	0	0	0			0	0
Glasgow, 2014	3a	Diabetes	463	RCT	High	Behaviour	0	0	0	0			0	0
Heinrich, 2012	4	Diabetes	135	RCT	Unclear	Knowledge	0	0		0				
Huang, 2014	5	Diabetes	81	RCT	Unclear	Behaviour	0							0
						Knowledge	0							+
						Psychosocial	0							0
Istepanian, 2009	6	Diabetes	137	RCT	High	Health			+					
Lorig, 2010	7	Diabetes	761	RCT	Unclear	Behaviour			+					

						Psychosocial			0					
Pacaud, 2012	8	Diabetes	79	RCT	High	Health		+						
						Behaviour		0						
						Knowledge		0						
						Psychosocial		0						
Whittemore,2012	9	Diabetes	320	RCT	Low	Health	0	0	0			0		
						Psychosocial	0	+	0			0		
Yu, 2014	10	Diabetes	81	Non-RCT	Critical	Behaviour	+	0	0	0	0	0		0
						Psychosocial	+	+	0	0	0	0		0
Nevedal, 2013	11	Osteoarthritis	645	Non-RCT	Critical	Health	0	0	0					

+ Positive association; 0 No association; - Negative association

Appendix 4.5 Table with association between modification of intervention effectiveness by PP groups and the application of theory

Table 18: Association between modification of intervention effectiveness by PP groups and the application of theory

Study	Evidence of equalising effect for disadvantaged group	Evidence of difference?	Theory/Theories applied	How many	Theory considers the influence of social characteristics?	How did they apply theory?
Huang et al. 2014	No- disadvantaged those with lower Health Literacy	0 Patient initiated communication x Age, health literacy in adolescents with T1D IBD and CF aged 12-20 years transitioning into adult care. + Chronic disease management knowledge x Health Literacy(high):But 0 x Age. 0 Self-efficacy x Health literacy, age in adolescents with T1D IBD and CF aged 12-20 years	Bandura's Social Cognitive Theory.	Single	Yes- considers barriers and facilitators in the environment	Use of theory to tailor intervention techniques
Pacaud et al. 2012	No- disadvantaged female participants	+ HbA1c x Gender (male) 0Self-care x Gender in people with T2D(no age limit given) (Pacaud et al. 2012) 0 Diabetes knowledge x gender in people with T2D(no age limit given) (Pacaud et al. 2012)	None mentioned- custom built eHealth system, developed by the research team in consultation with a diabetes education clinic	None	Not applicable	None

		0 Self-efficacy x gender in people with T2D(no age limit given) (Pacaud et al. 2012)				
Whittemore et al. 2012	No- disadvantage female participants	0 HbA1c x Age, gender, ethnicity, income in youth aged 11-14 years with T1D + Diabetes QoL x Gender(male):). But 0 Diabetes QoL x age, ethnicity or income in youth aged 11-14 years with T1D.(Whittemore, Jaser et al. 2012)	Framework of the study was based on stress adaptation model (Pollock, 1986) that describes the process of adaptation specific to childhood T1D (Whittemore, Jaser, Guo, & Grey, 2010). This framework suggests that pre-existing characteristics, such as age, duration, gender, treatment modality, race or ethnicity, and socioeconomic status, as well as individual responses such as depressive symptoms, moderate the level of individual adaptation. Intervention was based on Social cognitive theory	Single	Yes- considers social characteristics	Use of theory to tailor intervention techniques
Moy et al. 2015	No-disadvantage older people	− Step count x age(increasing), 0 gender, Urbanisation/urban vs rural) 0 Health related QoL x Age, gender, urban vs rural in veterans age ≥ 40 years old	Self-regulation theory. Goal setting is based on Lock and Latham's demonstration that high, hard goals improve performance as long as the goals are not too high. The Taking Healthy Steps intervention targets the cycle of self-regulation with four components: 1) step-count feedback from a pedometer and personal website, 2) automated, gradually incrementing goals, 3) tailored motivational messages, and 4) an online community to enhance social support.	Single	No	Use of theory to tailor intervention techniques
Yu et al. 2014	No- disadvantage younger people and female participants	+ Diabetes distress x age(increasing) & gender (male) 0 x ethnicity, education, employment, income or health literacy participants aged ≥ 25 years with T2D +Self-care: improvement was positively correlated with age (0.04/year, 95% CI: 0.02, 0.06), p <0.001). 0 self-care x gender, ethnicity, education, employment, income or health literacy in people	Self-efficacy theory	Single	No	Use of theory to tailor intervention techniques

		aged ≥ 25 years with T2D (Yu, Parsons et al. 2014)				
Heinrich et al. 2012	None	0 Diabetes knowledge x Age, gender or education in adults with T2D aged 40–70 years.	None- they used evidence-based information	NI	Not applicable	None
Nevedal et al. 2013b	None	0 Pain composite (Intensity and unpleasantness) (Nevedal et al. 2013b) x Age, gender, ethnicity, people living in the household working age adults	The online pain management program integrated evidence-based theories of cognitive behavioural treatment, chronic disease self-management, motivational enhancement, and theories of health behaviour change, including social cognitive theory, theory of reasoned action, theory of planned behaviour, and self-determination theory	Multiple	Yes- considers barriers and facilitators in the environment	Use of theory to tailor intervention techniques
Voncken-Brewster et al. 2015	None	0 Physical activity x Age, gender, education, employment adults aged between 40–70 years	They used the I-Change model as theoretical framework in their intervention. This model includes the Attitude-Social influence-Self-efficacy model (ASE), which incorporates ideas of the Theory of Planned Behaviour, the Social Cognitive Theory, the Transtheoretical Model, the Health Belief Model, and Implementation and Goal setting theories	Multiple	Yes- considers barriers and facilitators in the environment	Use of theory to tailor intervention techniques
Glasgow et al. 2012 & 2014.	Yes- Minority ethnic group	+ Blood pressure x Ethnicity (minority group): But 0 Blood pressure x Age, gender, education, health literacy and numeracy in adults with T2D aged 25-75 years at 12 months 0 Overall behavioural change x Age, gender, Latino ethnicity, education, health literacy or numeracy in adults with T2D aged 25-75 years at 12 months.(Glasgow 2012) 0 Self-efficacy x age, gender, Latino ethnicity, education, health literacy or numeracy in adults with	Social cognitive theory and a social-ecological theory were the primary intervention frameworks used. Social-ecological theory and the "5 As" self-management model Intervention was provided in English and Spanish From an ecological perspective on health behaviour change (14), it is also not known whether website use and outcomes are influenced by factors such as individual characteristics, especially factors such as level of computer use and health literacy and	Multiple	Yes- considers barriers and facilitators in the environment	Use of theory to tailor intervention techniques Use of theory to select participants for the intervention- selectively recruited more people from ethnic minorities Use of theory to tailor intervention techniques to participants????

		T2D aged 25-75 years at 12 months (Glasgow 2012) 0 Maintenance of behaviour x Age, gender, Latino ethnicity, health literacy, education, numeracy(Glasgow, 2014)	numeracy; social network/social support; and community/environmental influences. The study was conducted in five primary care clinics within Kaiser Permanente Colorado (KPCO). Clinics were selected based on variability in size, location and socioeconomic status of neighbourhood, and to maximize percentage of Latino patients			Provided in Spanish- but otherwise no
Istepanian, Sungoor, and Earle 2009	Yes- Minority ethnic group	+ Blood pressure x Ethnicity (minority group)>18years with T1 or T2D	None mentioned in main paper or the paper describing intervention design and implementation The study sought to recruit people from diverse ethnic backgrounds and from an area where the social deprivation score is higher than national average. No theory was provided for why this was done	None	Not applicable	None
Lorig et al. 2010	Yes- Minority ethnic group	+ Activity Limitation x Ethnicity(minority group): in adults with T2D aged ≥18 years 0 Self-efficacy x ethnicity in adults with T2D aged ≥18 years	None Explored intervention effectiveness in American Indians/Alaskan Natives. The decision to focus on this group was not described to be driven by theory, but because there were few studies of community-based interventions in this population	None	Not applicable	None

Appendix 4.6 Table with association between differences in effectiveness for people with different characteristics and application of theory

Table 19: Association between differences in effectiveness for people with different characteristics and application of theory

PP variable	Single			Multiple theory			None			Not enough information		
	Evidence of +ve Effect	No Effect found	Evidence of -ve Effect	Evidence of +ve Effect	No Effect found	Evidence of -ve Effect	Evidence of +ve Effect	No Effect found	Evidence of -ve Effect	Evidence of +ve Effect	No Effect found	Evidence of -ve Effect
Age (increasing)	~Self-care (Yu, Parsons et al. 2014) Diabetes distress: (Yu, Parsons et al. 2014)	~HbA1c &Psych QoL Whittemore,2012 ~Patient initiated communication & Disease management knowledge & Self-efficacy Huang, 2014 ~Health QoL Moy, 2015	~Daily step count Moy, 2015		~Blood pressure & Behavioural change & Self-efficacy Glasgow, 2012 & Maintenance of behavioural change Glasgow, 2014 ~Physical activity Voncken-Brewster, 2015 ~Pain composite (Intensity and unpleasantness) (Nevedal et al. 2013b						~Diabetes knowledge Heinrich, 2012	
Gender (male)	~Psych QoL Whittemore,2012 ~Diabetes distress: (Yu, Parsons et al. 2014)	~HbA1c Whittemore,2012 ~Self-care (Yu, Parsons et al. 2014) ~Health QoL & Daily step count Moy, 2015			~Blood pressure & Behavioural change & Self-efficacy Glasgow, 2012 & Maintenance of behavioural change Glasgow, 2014 ~Physical activity Voncken-Brewster, 2015 ~Pain composite (Intensity and unpleasantness) (Nevedal et al. 2013b		~HbA1c Pacaud, 2012	~Diabetes knowledge & Self-care & Self-efficacy Pacaud, 2012			~Diabetes knowledge Heinrich, 2012	

Ethnicity (minority group)		~HbA1c & Psych QoL Whittemore,2012 ~Diabetes distress:& Self-care (Yu, Parsons et al. 2014)		~Blood pressure Glasgow, 2012	~Behavioural change & Self-efficacy Glasgow, 2012 & Maintenance of behavioural change Glasgow, 2014 ~Pain composite (Intensity and unpleasantness) (Nevedal et al. 2013		~Blood pressure Istepanian, 2009 ~Activity limitation Lorig, 2010	~Self-efficacy Lorig, 2010				
Education (Higher level)		~Diabetes distress:& Self-care (Yu, Parsons et al. 2014)			~Blood pressure & Behavioural change & Self-efficacy Glasgow, 2012 & Maintenance of behavioural change Glasgow, 2014 ~Physical activity Voncken-Brewster, 2015						~Diabetes knowledge Heinrich, 2012	
Income (higher)		~HbA1c & Psych QoL Whittemore,2012 ~Diabetes distress:& Self-care (Yu, Parsons et al. 2014)			~Blood pressure Glasgow, 2012 & Maintenance of behavioural change Glasgow, 2014							
Employment (employed)		~Diabetes distress:& Self-care (Yu, Parsons et al. 2014)			~Physical activity Voncken-Brewster, 2015							
Urban (vs Rural)		~Health QoL & Daily step count Moy, 2015										
Health literacy (higher)	~Disease management knowledge Huang, 2014	~Diabetes distress & Self-care (Yu, Parsons et al. 2014) ~Patient initiated communication & Self-efficacy Huang, 2014			~Maintenance of behavioural change Glasgow, 2014							
Numeracy					~Blood pressure Glasgow, 2012							

Number of people in the household	▨	▨	▨		~Pain composite (Intensity and unpleasantness) (Nevedal et al. 2013b		▨	▨	▨	▨	▨	▨
Grey cells= No evidence												

Appendix 5.1 Ethics application for the qualitative study

Title of the research:

The CAuSEWAY study: Cultural And SocioEconomic differences in the use of Web-bAsed Self-care interventions for tYpe 2 diabetes

Name of Applicant, with job title and contact details including email:

Sophie Turnbull PhD student

Name of Supervisor (if applicant is a postgraduate or undergraduate student), with job title and contact details including email:

Dr Christie Cabral, University of Bristol School of Social and Community medicine, email christie.cabral@bristol.ac.uk, tel +44 (0) 117 3314569

Dr Patricia Lucas, University of Bristol School of Policy studies, email patricia.lucas@bristol.ac.uk, tel +44 (0) 117 331 0866

Prof Alastair Hay, University of Bristol School of Social and Community medicine, email alastair.hay@bristol.ac.uk, tel +44 (0) 117 928 7376

Other investigator(s) involved, with job title:

NA

Source of funding:

NIHR SPCR

Start date and duration of the project:

April 2017-April 2018

Where will the study take place?

It will be based in Bristol, but we will be recruiting across the country to ensure a diverse sample is achieved.

Background and aims of the study:

1. *Background*

The rapid evolution of technology and internet use has naturally led to the development of web-based interventions applied to healthcare. Web-based interventions are already being used to deliver self-care and there is evidence that these interventions can be effective for a range of different healthcare outcomes, when compared to non-web interventions and control conditions. (Wantland, Portillo et al. 2004, Murray 2012, Kohl, Crutzen et al. 2013, de Jong, Ros et al. 2014) However, the benefit of these interventions is being limited by low uptake, attrition and lack of engagement.(Eysenbach 2005) There is some evidence that people with lower levels of education, income(Kohl, Crutzen et al. 2013) and SES (Eysenbach 2005) are less likely to engage with web-based interventions. (Kontos, Blake et al. 2014) It is essential that we gain an insight into why this differential is occurring if we are to tap into the potential of internet interventions to reduce health inequalities.

The main aim of this study is to gain an insight into the different experiences of, and the facilitators and barriers to use web-based self-care interventions, for people from different cultures and socioeconomic groups (SE) who have had been diagnosed with Type 2 Diabetes. I will be conducting qualitative interviews with people with a diverse range of experience of web-interventions, from different cultures and SE groups.

2. *Research aims and objectives*

3. To investigate different experiences of the use (uptake and engagement) of web-based self-care Type 2 Diabetes interventions by people from different SE and cultural backgrounds
4. To investigate facilitators and barriers to use (uptake and engagement) of web-based self-care Type 2 Diabetes interventions by people from different SE and cultural backgrounds

Outline the design of the study and list the procedures to which the participants will be subjected, the anticipated testing time and any treatments administered:

5. **Qualitative interviews.**

Recruitment

Participants will be recruited from a variety of sources to optimise the diversity of the sample. These may include: Charity groups (e.g. Diabetes UK), Diabetes clinics, Diabetes support groups/forums, multipurpose clinics (e.g. Wellspring healthy living centre, Charlotte Keele centre, Knowle west health park), PPI groups, collaboration with a commercial partner. Each source will be contacted to establish the best way to communicate the study details to the potential participants. Once a participant has expressed an interest in being involved in the study, they will be contacted by the PI to discuss the study with them and to answer any questions before they decide whether to take part. The PI will check that the participant meets the inclusion criteria of having a diagnosis of Type 2 Diabetes and that they are currently using or have previously used a web-based intervention to help them self-care for their condition. If the participant meets the eligibility criteria and confirm they would like to enter the study they will be sent a link to an online consent form and information sheet or paper copies depending on preference. Once the consent form has been completed and has been received by the study team they will be sent a link to the online screening questionnaire. The screening questionnaire will confirm that the individual meets the inclusion criteria and collect background information on the type of web-based interventions that the participant has tried, as well as SE and cultural variables. This information will be used to select a purposive sample to maximise diversity in terms of:

- Type of intervention that they have used
- SE and cultural variables: Age, gender, ethnicity, education, religion, income, IMD

Once the sample have been selected they will be contacted by phone or email (whichever is preferred) to arrange an interview. Those who have not been selected will also be contacted to thank them for their interest. The sample size will be determined by the number of participants that are needed to reach data saturation, where no new themes are emerging from the interviews. It is expected that this will be up to 30 participants.

Data collection and interview conduct

The interviews will be conducted in a location convenient to the participant. To ensure as wide a range of people as possible to participate, phone/skype interviews will be offered as an alternative to a face-to-face meeting. The interviews will be semi-structured and conducted by the study PI, supervised by a skilled qualitative researcher (CC). The interviews will be audio recorded and the transcribed, anonymised, and the script will be checked for accuracy. The transcribed interview will be imported into NVivo for analysis.

Please outline how study data will be analysed.

Analysis be ongoing and iterative and will begin soon after data collection has begun. Insights from this analysis will inform subsequent data collection and the topic guide will be revised to reflect emerging themes from the analysis. Data will be analysed using the Thematic approach(Braun and Clarke 2006): we will identify patterns (or themes) that are prominent in the interviews with individuals and across the participants. A subset of the interview transcripts will be independently coded by a second member of the team (CC) to ensure the coding scheme is robust.

Does your study involve the collection or use of any human tissue or exudate? If yes, what is the material to be collected?

No

If you have answered 'yes' to Q11, has confirmation been obtained from your Departmental Human Tissue Act Advisor that collection and storage of this material will be undertaken under an appropriate licence?

NA

Has a reviewer been contacted? It is the applicant's responsibility to do this. The peer review form must be submitted with this application and any comments noted in the review must be actioned prior to submission.

Yes- Dr Christie Cabral as PhD supervisor

Who will be recruited to participate in this study?

People with a diagnosis of Type 2 Diabetes and that are currently using or have previously used a web-based intervention to help them self-care for their condition. A diverse sample of individuals will be selected for interview based on SE variables (age, gender, ethnicity, education, religion, income and IMD).

Are there any potential participants who will be excluded? If so, what are the exclusion criteria?

People who had never used an internet intervention

How many participants will be recruited?

Maximum of 30

How will the participants be recruited?

Participants will be recruited from a variety of sources to optimise the diversity of the sample. These may include: Charity groups (e.g. Diabetes UK), Diabetes clinics, Diabetes support groups/forums, multipurpose clinics (e.g. Wellspring healthy living centre, Charlotte Keele centre, Knowle west health park), PPI groups, collaboration with a commercial partner. Each source will be contacted to establish the best way to communicate the study details to the potential participants.

How will informed consent be obtained from all participants or their parents/guardians prior to individuals entering the research study?

Once a participant has expressed an interest in being involved in the study, they will be contacted by the PI to discuss the study with them and to answer any questions before they decide whether to take part. The PI will check that the participant meets the inclusion criteria of having a diagnosis of Type 2 Diabetes and that they are currently using or have previously used a web-based intervention to help them self-care for their condition. If the participant meets the eligibility criteria and confirm they would like to enter the study they will be sent a link to an online consent form and the Participant Information Sheet (PIS) or paper copies depending on preference. Once the consent form has been completed and has been received by the study team they will be sent a link to the online screening questionnaire.

How long will potential participants have to decide whether to give consent?

At least a week. A reminder may be sent to participants that have expressed an interest and not completed the consent form after a week depending on recruitment numbers. They will be able to return the consent form at any point up until the end of data collection and we will consider including them in the sample, again depending on numbers.

Will participants be kept informed of new information that becomes available during the study which may influence their continued participation?

Yes, if any new information emerges.

Will the study involve actively deceiving, or withholding information from, the participants?

No

Will participants be made aware that they can withdraw from the study at any time without having to give a reason for doing so?

Yes

Describe potential risks (physical, psychological, legal, social) arising from these procedures:

The researcher will be working in the field conducting interviews at a range of locations. Although these are all within fairly secure settings, we will follow the University of Bristol lone worker safety policy. The researcher will leave a copy of the location details for each interview with a responsible person (Dr Cabral or other suitable colleague) and will arrange a time to call in after each interview to confirm that it was completed and the location left safely. If no call is received, the responsible person will follow the standard escalating procedures to check on the safety of the researcher, first calling their contact details, then contacting the police.

How will participants be informed about the outcome of the study?

Findings will be published on the study website and participants will receive an email newsletter.

How will the results of the study be disseminated and reported?

They will be published in an academic paper and will be written up in a chapter of Ms Turnbull's thesis.

Is any payment other than reimbursement of expenses to be made to participants?

No payment will be provided. But a £10 voucher will be given to the participants as a thank you for their time.

Will personal data, beyond that recorded on the consent form, be used in the research?

Yes, the name recorded on the consent form will be linked to the audio recording by a study id number to enable us to ensure that all data included in the study is properly consented. Some names or other identifying details may be mentioned during the audio interview.

Will the participants be audio-recorded or video - recorded?

Audio recorded.

What arrangements have been put in place to ensure confidentiality and security of data gathered in the study?

Recordings will be made on encrypted audio-recorders and transferred to the University of Bristol secure servers where they will be kept in accordance with the Data Protection Act. Paper versions of consent forms will be scanned, electronic copies will be kept on the secure server and paper copies will be stored in locked filing cabinets or storage. When the audio recordings are transcribed, they will be anonymised (all names or other identifying material removed). Only anonymised quotes will be reported. The anonymised transcriptions will be kept separately from the identifiable information on the consent forms, so they cannot be linked.

Has this proposal been seen by another ethics committee?

No

Do any of the investigators have any actual or potential conflict of interest in this study?

No

How will the data be made available at the end of the project?

Restricted and anonymised data will be made available on request for secondary analysis with ethical oversight

Level of Access:

Controlled

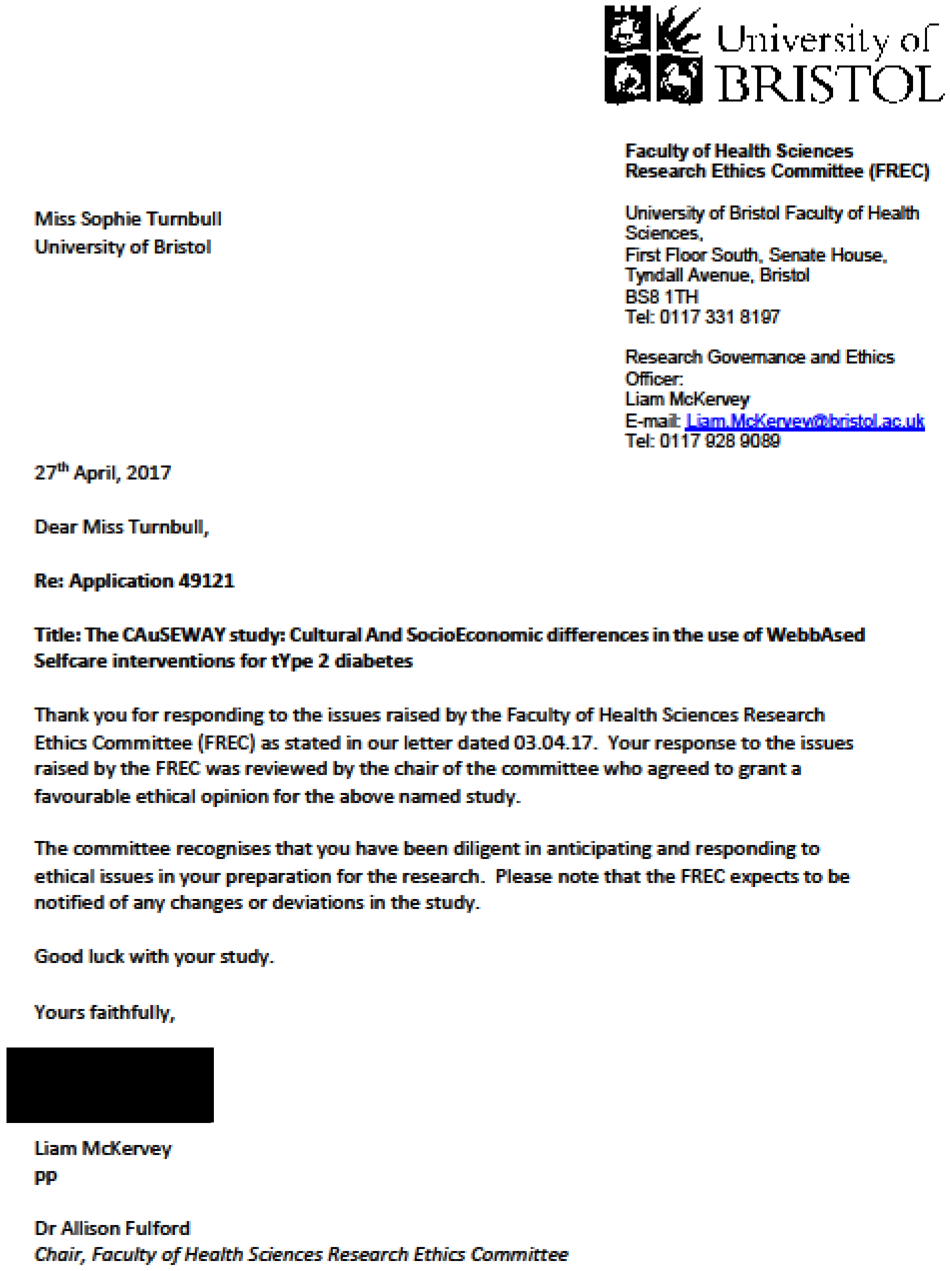
Is there any other relevant information you would like to make known to the committee?

No

Have you read and understood the guidelines for filling in this form and the Committee Statement ?

Yes

Favourable Opinion letter



University of
BRISTOL

**Faculty of Health Sciences
Research Ethics Committee (FREC)**

University of Bristol Faculty of Health Sciences,
First Floor South, Senate House,
Tyndall Avenue, Bristol
BS8 1TH
Tel: 0117 331 8197

Research Governance and Ethics Officer:
Liam McKervey
E-mail: Liam.McKervey@bristol.ac.uk
Tel: 0117 928 9089

Miss Sophie Turnbull
University of Bristol

27th April, 2017

Dear Miss Turnbull,

Re: Application 49121

Title: The CAuSEWAY study: Cultural And SocioEconomic differences in the use of WebbAsed Selfcare interventions for tYpe 2 diabetes

Thank you for responding to the issues raised by the Faculty of Health Sciences Research Ethics Committee (FREC) as stated in our letter dated 03.04.17. Your response to the issues raised by the FREC was reviewed by the chair of the committee who agreed to grant a favourable ethical opinion for the above named study.

The committee recognises that you have been diligent in anticipating and responding to ethical issues in your preparation for the research. Please note that the FREC expects to be notified of any changes or deviations in the study.

Good luck with your study.

Yours faithfully,

[redacted]

Liam McKervey
pp

Dr Allison Fulford
Chair, Faculty of Health Sciences Research Ethics Committee

Appendix 5.2 Qualitative study screening questionnaire

University of BRISTOL

CAuSEWAY

ID:

Participant Questionnaire

The CAuSEWAY study: Cultural And Socio-Economic differences in the use of Web-bAsed Self-care interventions for tYpe 2 diabetes

Thank you for your interest in the CAuSEWAY study. This questionnaire will take around 5 minutes to complete. We will be talking with around 30 people for this study, so there is a small chance you may not be interviewed. We will be in touch to let you know either way.

Date completed:____________________

Eligibility criteria

1. Have you been diagnosed with Type 2 Diabetes
    a. Yes/No
2. Do you speak and understand English?
    a. Yes/No
3. Have you used an online intervention before or are you currently using one?
    - These can include Diabetes websites (e.g Diabetes UK), internet forums or apps you have downloaded onto your smartphone or tablet.
    a. Yes/No
    b. Please list the interventions you have used

If you have answered no to question 1, 2 or 3 you do not meet the inclusion criteria for this study. Thank your time and interest in the CAUSEWAY study.

Please tell us a bit about yourself

4. I identify my gender as: Male/Female/Trans/Other
5. Date of birth:______________
6. What is the highest level of education you have completed?
    a. Left school before 16 years of age
    b. Secondary school or equivalent
    c. Intermediate between secondary level and university (e.g. NVQ3-5, diploma, apprenticeship)
    d. University degree or equivalent
7. Ethnicity
    a. White:
        i. British

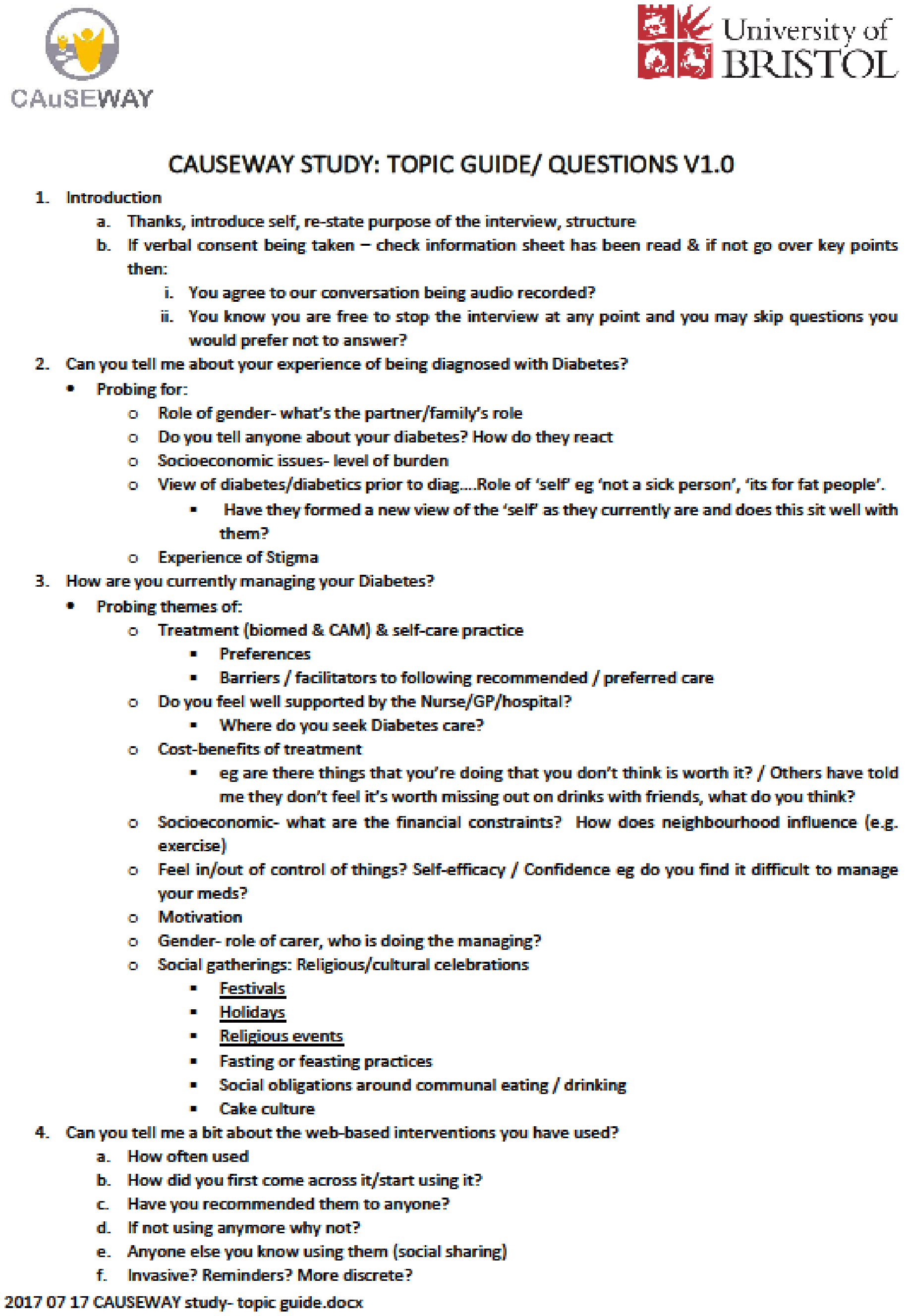
        i. Irish
        ii. Any Other White background__________
    b. Mixed
        i. White and Black Caribbean
        ii. White and Black African
        iii. White and Asian
        iv. Any Other Mixed background_____________________
    c. Asian or Asian British
        i. Indian
        ii. Pakistani
        iii. Bangladeshi
        iv. Any Other Asian background_________________________
    d. Black or Black British
        i. Caribbean
        ii. African
        iii. Any Other Black background______________________
    e. Chinese
    f. Other ethnic group
2. What's your religion
    a. No religion
    b. Christian
    c. Muslim
    d. Jewish
    e. Sikh
    f. Hindu
    g. Buddist
    h. Other_________________________
3. Estimated household income last year(before tax and not including benefits)
    a. <£16,000 and/or eligible for means tested benefits
    b. £16,000 to £24,999
    c. £25,000 to £34,999
    d. £35,000 to £44,999
    e. >£45,000

NHS
National Institute for
Health Research

This research is funded by the National Institute for Health Research School for Primary Care Research (NIHR SPCR). www.spcr.nihr.ac.uk

Appendix 5.3 Qualitative study Topic guide

Version 1.0 (original version)



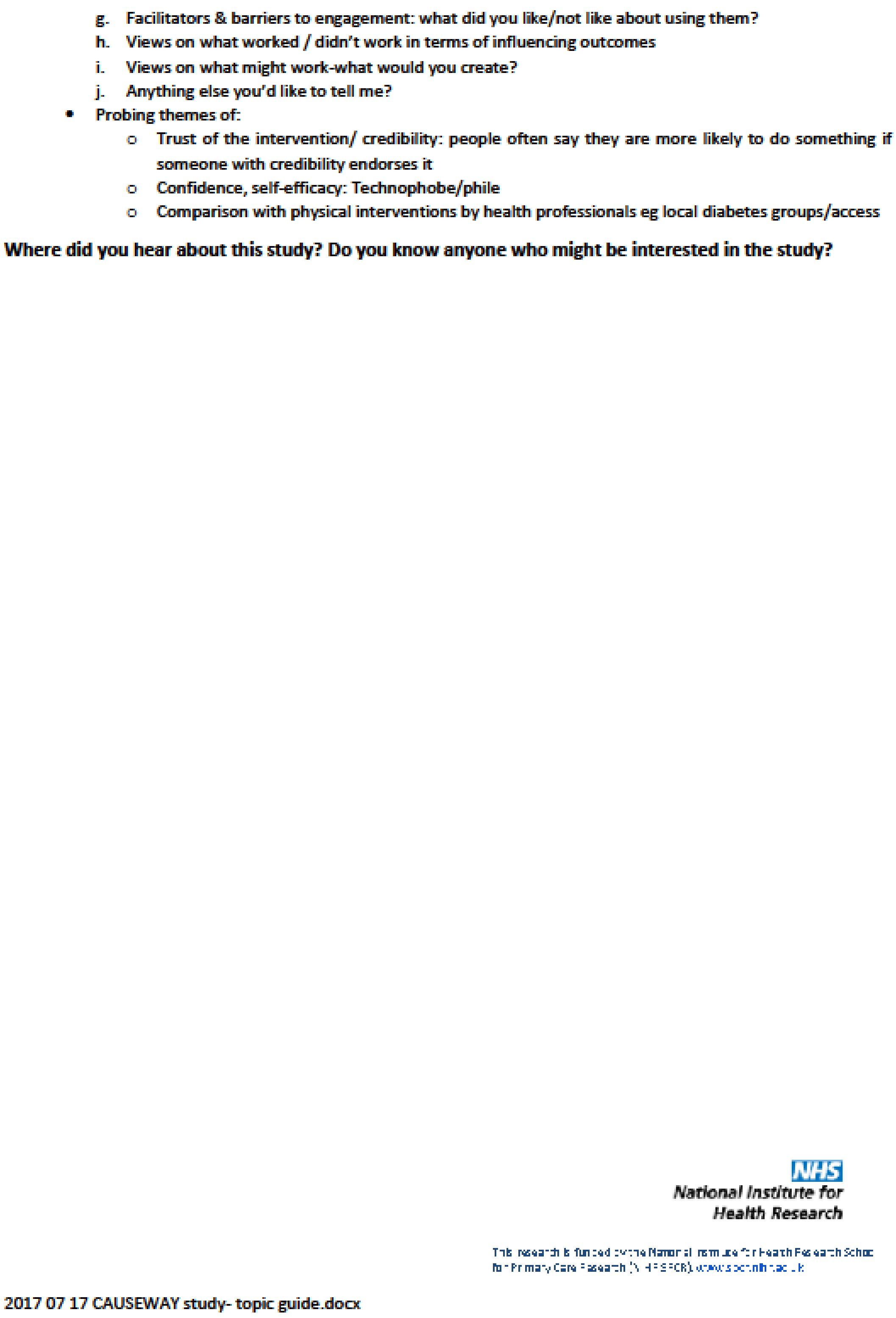
CAuSEWAY

University of BRISTOL

CAUSEWAY STUDY: TOPIC GUIDE/ QUESTIONS V1.0

1. Introduction
    a. Thanks, introduce self, re-state purpose of the interview, structure
    b. If verbal consent being taken – check information sheet has been read & if not go over key points then:
        i. You agree to our conversation being audio recorded?
        ii. You know you are free to stop the interview at any point and you may skip questions you would prefer not to answer?
2. Can you tell me about your experience of being diagnosed with Diabetes?
    - Probing for:
        - Role of gender- what's the partner/family's role
        - Do you tell anyone about your diabetes? How do they react
        - Socioeconomic issues- level of burden
        - View of diabetes/diabetics prior to diag....Role of 'self' eg 'not a sick person', 'its for fat people'.
            - Have they formed a new view of the 'self' as they currently are and does this sit well with them?
        - Experience of Stigma
3. How are you currently managing your Diabetes?
    - Probing themes of:
        - Treatment (biomed & CAM) & self-care practice
            - Preferences
            - Barriers / facilitators to following recommended / preferred care
        - Do you feel well supported by the Nurse/GP/hospital?
            - Where do you seek Diabetes care?
        - Cost-benefits of treatment
            - eg are there things that you're doing that you don't think is worth it? / Others have told me they don't feel it's worth missing out on drinks with friends, what do you think?
        - Socioeconomic- what are the financial constraints? How does neighbourhood influence (e.g. exercise)
        - Feel in/out of control of things? Self-efficacy / Confidence eg do you find it difficult to manage your meds?
        - Motivation
        - Gender- role of carer, who is doing the managing?
        - Social gatherings: Religious/cultural celebrations
            - Festivals
            - Holidays
            - Religious events
            - Fasting or feasting practices
            - Social obligations around communal eating / drinking
            - Cake culture
4. Can you tell me a bit about the web-based interventions you have used?
    a. How often used
    b. How did you first come across it/start using it?
    c. Have you recommended them to anyone?
    d. If not using anymore why not?
    e. Anyone else you know using them (social sharing)
    f. Invasive? Reminders? More discrete?

2017 07 17 CAUSEWAY study- topic guide.docx



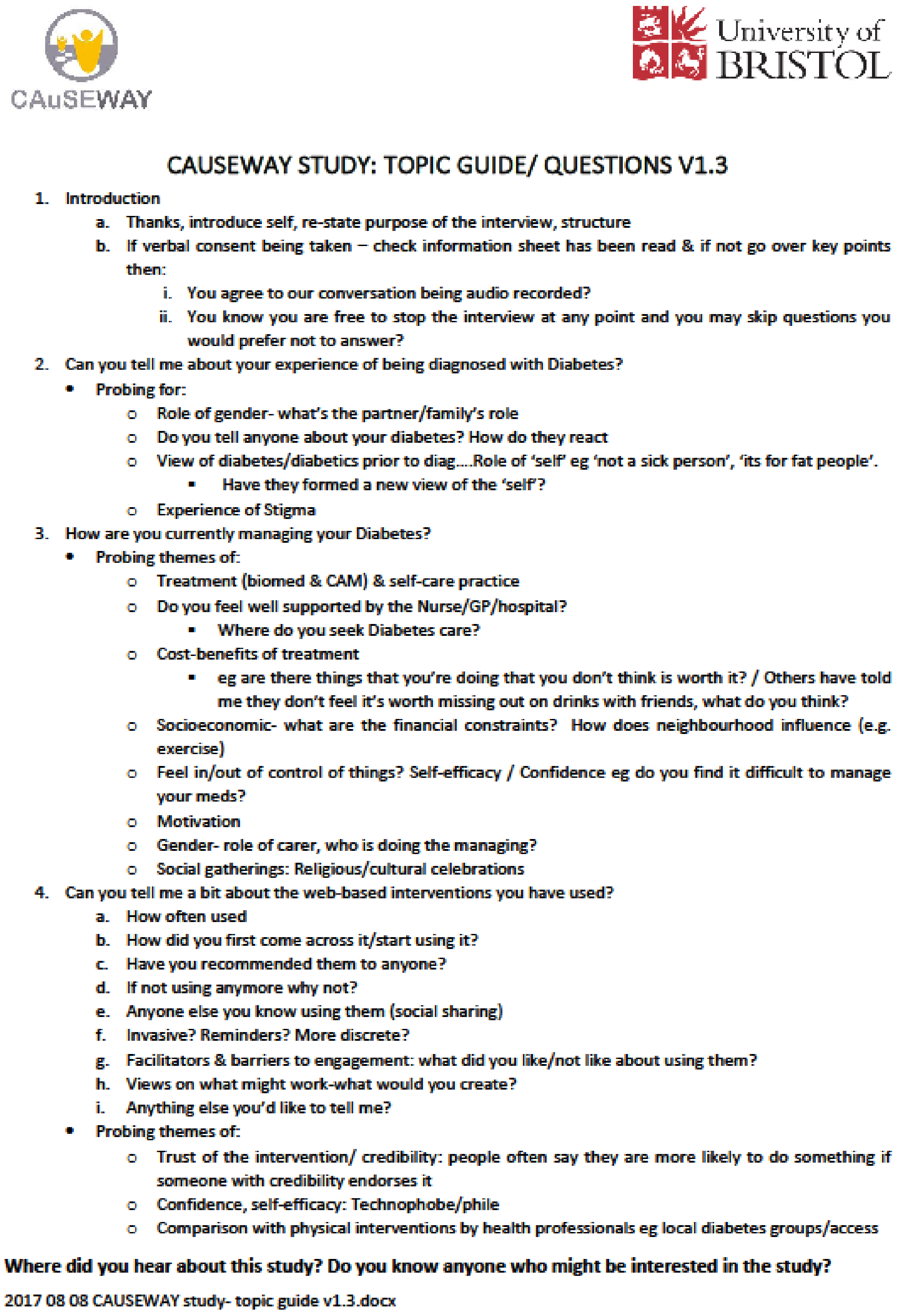
g. Facilitators & barriers to engagement: what did you like/not like about using them?
h. Views on what worked / didn't work in terms of influencing outcomes
i. Views on what might work-what would you create?
j. Anything else you'd like to tell me?

- Probing themes of:
    - Trust of the intervention/ credibility: people often say they are more likely to do something if someone with credibility endorses it
    - Confidence, self-efficacy: Technophobe/phile
    - Comparison with physical interventions by health professionals eg local diabetes groups/access

Where did you hear about this study? Do you know anyone who might be interested in the study?

This research is funded by the National Institute for Health Research School for Primary Care Research (NIHR SPCR) www.spcr.nihr.ac.uk

Version 1.3 (final version)



CAuSEWAY

University of BRISTOL

CAUSEWAY STUDY: TOPIC GUIDE/ QUESTIONS V1.3

1. Introduction
   a. Thanks, introduce self, re-state purpose of the interview, structure
   b. If verbal consent being taken – check information sheet has been read & if not go over key points then:
      i. You agree to our conversation being audio recorded?
      ii. You know you are free to stop the interview at any point and you may skip questions you would prefer not to answer?
2. Can you tell me about your experience of being diagnosed with Diabetes?
   - Probing for:
     - Role of gender- what's the partner/family's role
     - Do you tell anyone about your diabetes? How do they react
     - View of diabetes/diabetics prior to diag….Role of 'self' eg 'not a sick person', 'its for fat people'.
       - Have they formed a new view of the 'self'?
     - Experience of Stigma
3. How are you currently managing your Diabetes?
   - Probing themes of:
     - Treatment (biomed & CAM) & self-care practice
     - Do you feel well supported by the Nurse/GP/hospital?
       - Where do you seek Diabetes care?
     - Cost-benefits of treatment
       - eg are there things that you're doing that you don't think is worth it? / Others have told me they don't feel it's worth missing out on drinks with friends, what do you think?
     - Socioeconomic- what are the financial constraints? How does neighbourhood influence (e.g. exercise)
     - Feel in/out of control of things? Self-efficacy / Confidence eg do you find it difficult to manage your meds?
     - Motivation
     - Gender- role of carer, who is doing the managing?
     - Social gatherings: Religious/cultural celebrations
4. Can you tell me a bit about the web-based interventions you have used?
   a. How often used
   b. How did you first come across it/start using it?
   c. Have you recommended them to anyone?
   d. If not using anymore why not?
   e. Anyone else you know using them (social sharing)
   f. Invasive? Reminders? More discrete?
   g. Facilitators & barriers to engagement: what did you like/not like about using them?
   h. Views on what might work-what would you create?
   i. Anything else you'd like to tell me?
   - Probing themes of:
     - Trust of the intervention/ credibility: people often say they are more likely to do something if someone with credibility endorses it
     - Confidence, self-efficacy: Technophobe/phile
     - Comparison with physical interventions by health professionals eg local diabetes groups/access

Where did you hear about this study? Do you know anyone who might be interested in the study?

2017 08 08 CAUSEWAY study- topic guide v1.3.docx

Appendix 5.4 Qualitative analysis coding tree

Self
Age related
Challenges to self healthy image
Embraced new image diabetic
Positive reinforcement from others
Externalising diabetes or othering
Feeling different or alien
'Good diabetic'
Failure if illness progresses
Low carber
Psychological issues around diagnosis
Stigma
Being overweight
Bothering others
Taking insulin near children
Cultural stigma
Different for type 1 then type 2
Doing too well
Experienced stigma
Felt stigma
From health care professionals
Judgement from other diabetics
Judgement from others
Not normal
Not share diagnosis with many people
Passing concealling diabetes
Problematic media presentation of T2D
Reductionist labelling
Young to have it
Technology
Features they like

- Features they like
  - Comparative information
    - Case studies
  - Dietary advice
    - Logging calories
    - Recipes
    - Shows content of foods
  - Educational programme
    - Exercise videos
  - Fun vs boring
    - Humour
  - Info in case of emergencies
  - Medication options
  - Monitoring
    - Blood glucose levels
    - Blood pressure
    - Heart rat monitoring
    - Weight
  - Sleep tracking
  - Styling
    - Visual presentation of info
  - Tracking activity
    - Active minutes
    - Logging different types of exercise
  - Waterproof
- Practical things they like
  - Alerts and Alarms
  - Automatic updating
  - Charge life
  - Data easy to extract
  - email updates

Gadget to make life easier emails etc
Larger formats
Reliable
Simple to use
Support from developer
Synchronises across devices
Wear rather than clipping on and off pedometer
How do people use digital interventions
Adapted tech to suit needs
Used for
Blood Glucose monitoring
Exercise
Heart rate monitor
Management of meds
Nutrition
Preparation for events
Using before Diabetes Diag
Ideal tech would contain
Features
Activity tracker
Active minutes
Bike
Breathing
Connect to clinician
Contents of food
Identify cals in food from picture
Monitoring
Blood glucose monitor
Blood pressure
Calorie tracking
Heart rate monitor

Medicine logging or reminders
Sleep tracking
More discrete
Discrete
Motivational feedback
Feedback after the event
Food excercise comparison calories burn
Give guidance on what should do
Propt to do activity on regular basis
Visual representation of info
Not invasive no needles
Personalised
Connected Drs notes
Cultural and language tailoring
Feedback on how food effects blood sugar
Lipid profile
Provide correct medication
Provide feedback 247
Reminders of check ups
Tell you if having Hypo
Track ketones
Track metrics like body fat
Recipe guide step by step
Social element
Specifically diabetes related
Practical considerations
Can be used on phone
Conveience lifestyle features like alarms and phone calls
Different mediums for communication
Entertaining
Little input from user

Long battery life
More advanced
Reliable accurate
Simple to use
Watch
Waterproof
Limitations of tech
Access
No longer supported
Only available on certain phones
Phone has no reception
Tech not utilised properly by NHS
What to do with the information
Not meaningful
Only says what have done
Cost
Expensive
In app or product purchases
Not funded by NHS
Cost or access
Felt not for them
Instructions were incorrect or confusing
Not aware of features
Needle
Practical limitations
Basic layout on phone
Battery life
Forgetting to log or update
Forgoe design features in smaller model
Lack of support from developers
Light wakes you up

Lots of memory
Lots of set up
Not easy to use
Lots of logging
Not waterproof
Only has store bought food or not own brand
Only records walking or running
passwords
Patch comes off
Slow to load
Strap broke
Texts and emails etc
Too much detail
Tech for tech sake
What digital interventions
Access or cost
Age
Assets personal confidence
Know what tech to use
Hard to know which ones work
Barriers to uptake
Age
Cost
Data hard to understand
info not accessible
Support to use tech
Which ones to pick
Networks
Family friends
Received as present
Forums

Involvement in research
Through involvement in support group
Trusted person
Work
nhs
Health professional
Not available all phone brands
Others using tech with or for them
Personal skills confidence
Researched it
Technophile or phobe
Early adopter
Lack of awareness of tech not on radar
Support to set up
Technophile
Aesthetics
Brand loyalty
Construction of gender
Differences in forum use
Cultural differences
Novelty
Type of tech
Access to medical records d
Age related differences
Apple watch d
Blood glucose monitor d
Blood pressure monitor d
Carbs and Cals app d
Change4life d
Couch 2 5k d
Cycling computer d

Dario meter
Diabetes Diary d
Description of tech
Diabetes UK app d
Diabetes UK website d
diabetes.co.uk d
Digital scales d
Salter MyBody scales
Email questions to practice
Facebook d
Fitbit d
Food smart
Forums d
Freestyle libre d
Garmin d
Generic smart watch d
GP practice app d
Habits d
Health app iphone d
Health unlocked NHS d
IG IBG star meter provider app
Microsoft band d
My fitness pal app d
NHS local websites
NHS Choices d
Pedometer apps (all) d
Reminders on phone
Samsung health d
Slimming world app d
Social media twitter instagram etc
Sports tracker

Tap and Track
Trueyou mini
Water app
Whatsapp
Youtube lectures
Using tech unconsiously
Why do people use digital interventions
Digital social platforms their cultural relevance and influence on self care
Bypass medical model cultural consensus
Critical
Engaged in forum
Disengage bad
Forum tribalism
Improve access to information
Lurkers
Opinions
Motivational feedback
Breaks down limiting beliefs
Goal celebrations
Goal setting and challenges
Immediate feedback
Physical or visual prompts
Passing
Bulky
More discrete
More discrete or neater
Perceptions about technology
Accuracy of measuring or reporting
Accuracy will improve
Believes is accurate
Data not logical

Doesnt measure blood sugar interstitial fluid
Only measures while wearing limitations
Wear of have on you at all the time doesn't record while charging
Only need an indication of how doing
Just need to establish trend
Provides part of the big picture
Queries accuracy
Aimed at type 1
Comparison to physical courses support
Complimentary
Compulsory vs chosen
Physical better
Background on how diabetes works
Getting people to do activity in physical intervention
Information from other diabetics
Physical prompts
Tech better than physical
Can access when want
Could get tech before got on course covered elsewhere renegotiation of treatment
Culturally sensitive information
Different types of people
personalised vs wide guidelines
Short vs long
Tech better
Unhelpful guidelines
Credibility
Personal confidence
Trusted body
Research studies
Trust brand
Trusted person

Family or friend
With diabetes
User reviews
Distrust may be agenda
Distrust peoples opinions
Online reviews eg apple store
Not helpful for diabetes
Cant use for driving check for hypos
Can't use for driving
Not motivating
Only works for motivated people
Older people eg care homes
Things stablised
After a while not saying anything new
Lose motivation over time
To know if trustworthy
Bank details or hacking details
Insidious being watched
What are they doing with info
Which tech to trust
SECD differences
Age difference
Course older people
Culturally sensitive or appropriate woven throughout
Mental health
Encourage health anxiety
Social sharing
Competitions and supportive friend on tech
Comparitive information not people know
Diffusion of knowledge about tech through social group
As professional in the group

To other diabetics
Physical courses or support meet people
Emotional support
Online friends or support
Peer support
Talking point relate to non diabetics
Sharing achievements online
Social status of tech
Novelty
Gone out of fashion
Wanted to know what the fuss was about
Status conferred by brand or latest thing
Why do they use it
Feel in control
Control over care
Control over interactions with HCPs
Control over interactions with healthcare service
Of information they receive
Feel in control of health or diabetes
Feels gives control and self control
Not intrusive
Feeling have to do what computer tells you
Out of usual routine
Back up
Only need initially to learn about foods
People without tech have less understanding about whats going on
Self efficacy
Self efficacy only good for what you can change
Tech works because they have diabetes under control
Interaction with HCP
Access to clinicians

    - Avoid staff or system interaction
    - Avoiding medication
    - Feel ownership over care
    - Negotiate care
    - No waiting times
    - Plug gap in support not provided by NHS
    - Proof of activity
    - Replace dr diagnosis and treatment of opinion not part of why
    - Talking point with clinicians
- Motivation to get tech covered in access
    - Family and friends
    - Health circumstance changed
- Personalised care
    - Can do at own pace extract to TS
    - Can't get away from the data
    - Everyone is different
    - People without tech have less understanding about whats going on
    - Personal coach
    - Trial and error
    - Wide guidelines vs detail
        - Tangible evidence
- Supports management of diabetes
    - Associates health or beh changes with tech
        - Feedback confirmed by experience
        - Improved motivation
    - Breaking down limiting beliefs about excercise is
    - Tech used as a tool
        - Tool
        - Tool to support change
    - Trial and error
- Understand body better

Can't hide from evidence
Checking on track
Prevention of illness
Picking up on illness before a problem
Evidence or feeback on psysiology
Feel like an athlete
Indication of fitness
Interest in data
Link to trends in blood glucose
Understand how body responds to food