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Digital technology and health inequalities: a scoping review

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Affiliations

In 2019, Public Health Wales commissioned The King's Fund to complete a scoping review about the relationship between digital exclusion and health inequalities. The researchers who conducted this review are Matthew Honeyman, David Maguire and Harry Evans who were all members of The King's Fund's Policy team. Collectively they are, in collaboration with Alisha Davies at Public Health Wales, authors of this paper.

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Summary

Framing the relationship between digital exclusion and health inequalities

- National governments and local systems are all seeking to make good and widespread use of digital technologies in the health system. This report draws on existing literature to provide a framework for considering how lack of access, skills and motivation for using digital technologies could affect health outcomes.
- Digital exclusion could lead to worse health outcomes through
 - **direct** routes, where health services use digital technologies in ways they cannot benefit from.
 - **indirect** routes, where access to the wider determinants of health, such as housing or employment opportunities, become dependent on digital access routes.



Patterns in the underlying components of digital exclusion

- There is good evidence to believe that many groups who are already subject to disadvantage and worse health outcomes are also subject to digital exclusion, but the relationship is complex.
- Some national-level evidence involving narrow measures of access and use of digital technologies suggests that gaps in measures of digital technology use between disadvantaged groups and the rest of the population have been narrowing in recent years. However, important differences in access and use persist:
 - People living in rural areas have less access to, and slower, internet infrastructure. Recent data is lacking but deprived areas also seemed to be more likely to lack access.
 - Older people are less likely to own smartphones or connect to the internet.
 - Where differences between ethnic groups persist in internet access this is explained by the age and income profile of these groups. We found few other studies of differences between ethnic groups.
 - People with lower income are less likely to have access to smartphones in their household and be on pay monthly contracts and data plans.

- There is an absence of evidence about differences in the way different social groups engage with digital technologies – for health and other purposes - but there are concepts of digital literacy and health literacy, as well as trust and privacy concerns, that are likely to be important in the success of digital health initiatives. Simple measures of use and access cannot account for these.

How to mitigate against widening health inequalities, when focusing on digital technology for health?

- Approaches to digital inclusion that seek to address barriers of access and skills, as well as trust and privacy concerns, are needed to mitigate against digital approaches contributing to inequalities.
- It should also be recognised that technologies can also be designed to address the specific needs of disadvantaged groups. Approaches found in this review included meaningfully **involving users**, **tailoring** services and interventions to target groups' contexts, delivering **credible** messages and having a **clear logic model** of how services using technology improve health. Development of robust evaluation of these kinds of approaches and their impact on health would be welcomed.
- More United Kingdom (UK) -specific and local data and research about digital exclusion and health inequalities is also needed, alongside constant monitoring of the nature of digital exclusion, which changes over time as technology and its role in our lives change over time.
- Concern that the system inadvertently widens health inequalities should be taken seriously, but it should not mean the pursuit of a more digitised health system be abandoned or curtailed. Indeed, the use of digital technology will present new ways to address some of them. We should invest in inclusion as part of this digitisation.



Chapter 1

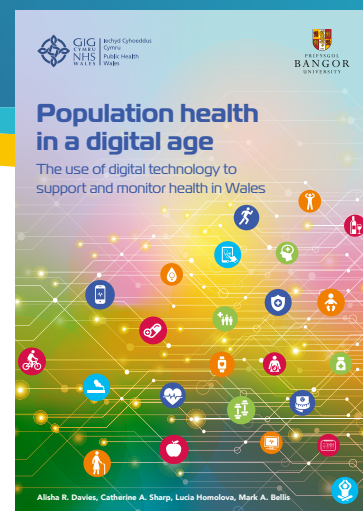
Introduction

In June 2018, the Welsh Government published its strategic plan to deliver a whole system approach to health and social care, *A Healthier Wales* (Welsh Government 2018). Population health and well-being through better prevention and self-management is a core pillar of the transformation described in this plan, and digital technologies are expected to play an important part in delivery.

Achieving this aspiration will need to take into account recognised inequalities in access to the internet, technology and the skills needed to benefit, alongside underlying social differences in the levels of engagement with digital technology to support health. As was recently highlighted in a nationally representative survey conducted by Public Health Wales, 1 in 10 adults (aged 16 years or above) in Wales did not have access to the internet, and whilst 2 in 3 people reported using digital technologies for a range of health-related activities there were marked differences across social groups. Those of older age, least affluent or with poorer self-reported health, were all less likely to engage in digital technologies for health purposes (Davies et al. 2019).

Harnessing the potential for digital technology to improve population health will require action to address underlying digital exclusion. Otherwise, a focus on technology may inadvertently lead the unintended consequences of widening inequalities for the most vulnerable in society. To inform such action in 2019, Public Health Wales commissioned The King's Fund to complete a scoping review mapping out the evidence of differences in the use of digital technologies across population groups; and to identify if there are examples where the application of digital technologies has the potential to reduce health inequalities.

This review seeks to help us understand and offer advice on how equality can be promoted or risks mitigated in the design and use of digital technologies. We hope this scoping review will be of value to those seeking to better understand how the digital and health inequalities intersect, including leaders in national and local public sector organisations, and those involved in research and development of digital health technology.



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**Those of older age,
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(Davies et al. 2019).

1.1 Approach to the review

In 2019, The King's Fund conducted the scoping review to answer:

- What does the published literature tell us about the relationship between health inequalities and the use of digital health technologies, and how might interventions be designed to reduce or mitigate risks of worsening inequality?

Academic and grey literature published in the last ten years were searched with a focus on the following terms; digital health technology, health inequalities and population health; across four literature databases – EMBASE, PubMed, The King's Fund's library database, and PsycINFO. Researchers from The King's Fund used a rapid review approach to reviewing the papers (further detail is available in Appendix 1) in a short period. Given the extensive literature, key narrative reviews identified were then used to help frame the structure of the scoping review and a narrative synthesis of the evidence across the following key areas was completed (Box 1).

Box 1. Key questions considered in the scoping review

1. **digital exclusion across population groups, focusing on those disadvantaged groups at risk of health inequalities;**
2. **approaches for designing digital technology and health interventions to mitigate the risk of increasing inequalities;**
3. **the application of digital technologies and impact on inequalities in health outcomes.**

Due to the time available and extent of the literature, it was necessary to further focus the review by excluding literature on the use of digital medical devices and the use of technology by staff of health and social care providers. Literature from low and middle-income countries was also excluded to take into consideration the generalisability of findings to Wales.

The result is not a comprehensive or systematic evidence review, but one that brings together the literature in this area and provides a framework to inform our understanding of the use of digital health technology and health inequalities.

1.2 The structure of our report

The structure of this report is as follows:

Chapter 2 – Framing the relationship between digital exclusion and health inequalities;

Chapter 3 – Patterns in the underlying components of digital exclusion;

Chapter 4 – How to mitigate against widening health inequalities, when focusing on digital technology for health?;

Chapter 5 – Examples of the application of digital health technology in public health interventions and the impact on health inequalities.

The final chapter (**Chapter 6**) brings together the key findings of the review to offer key considerations to mitigate against digital innovation and widening health inequalities, and potential opportunities where digital technology could help address health inequality.

For reference: Description of common terms used in this report

Population health – The King’s Fund defines population health as an approach aimed at improving the physical and mental health outcomes and wellbeing of people within a defined population, while reducing health inequalities (Buck et al. 2018).

Health inequalities – differences in health status or the distribution of the determinants of health between different social groups, such as ethnicity, age, socio-economic status or others.

Disadvantaged groups – the groups in society that are affected by structural health inequalities the most.

Digital health technology – digital technologies put to use for health purposes. This includes the combination of devices, software, or online services and information. In this report, we are mainly concerned with **person-facing digital health technologies**, which are technologies used directly by individuals or by health professionals with individuals. Staff-facing digital health technologies, that might be used to coordinate staff activity were not included in this review.

Digital exclusion – digital exclusion occurs when people and groups in society are unable to exploit the benefits from technologies including the internet or devices. The gap between those who are excluded and those who are able benefit from technology is known as the **digital divide**. **Digital inclusion** is an approach for overcoming the barriers to opportunity, access, knowledge and skills for using technology (Gann 2018).

e-Health literacy – a concept that essentially describes the capabilities to use digital health technologies for health improvement purposes. Many tools and approaches have been proposed to measure people’s eHealth literacy; the most commonly used example is eHEALTH, the eHealth literacy scale, in which respondents are asked to self-report their knowledge, comfort and skill in using health information found online (Norman and Skinner 2006). More recently, researchers have tried to build on this to reflect more recent developments in technology use, like social media, and also use independent measures to complement the self-reported element (van der Vaart and Drossaert 2017).

Chapter 2

Framing the relationship between health inequalities and digital exclusion

Key messages

There are systematic differences in health outcomes for people occupying unequal positions in society, known as health inequalities. We refer to the groups who are adversely affected by these inequalities as disadvantaged groups.

Digital exclusion is a concept used to describe the situation where any benefits that might be available through using digital technologies are not available to the individual. We consider lack of access, and barriers to use and engagement with technology.

We suggest an adapted theoretical model by which digital exclusion may have an impact on health outcomes and therefore health inequalities through **direct** or **indirect** routes.



2.1 What are health inequalities and disadvantaged groups?

We know there are systematic differences in health outcomes for people occupying unequal positions in society, known as health inequalities (Graham 2010). For example, they occur between:

- different income groups or socioeconomic classes
- different ethnic and racial groups
- people living with disabilities and others
- people who live in different geographic areas, like urban and rural areas or areas with different levels of deprivation
- people with differing sexuality and sexual behaviours
- homeless people and the rest of the population.

Throughout this report, we refer to the groups who tend to be adversely affected by these inequalities as 'disadvantaged groups'. Individuals may be members of one or several of these groups. In doing so, we are discussing groups that may be quite heterogeneous in nature.

2.2 What is digital exclusion and digital inclusion?

Digital exclusion is a concept used to describe the situation when people and groups in society are unable to exploit the benefits that using digital technologies might make available to them.

We found two key reviews that have extensive discussions about conceptualising part of the relationship between digital exclusion and health inequalities (Latulippe et al. 2017; Weiss et al. 2018). From these, we distilled the three key dimensions of exclusion and how they relate to health outcomes.

At an individual level, digital exclusion is a combination of a number of contributing factors reflecting an individuals' access to, use and engagement with digital technology:

Access – This can include access to technology (e.g. access to an internet-enabled phone or computer), or access to the internet (e.g. a home fixed broadband connection, mobile broadband, or access to open access in community areas, etc).

Use – the extent to which different groups with access to technology actively use it (e.g. accessing benefits or information about health services, for shopping, administering gas/electric accounts, paying council tax, using social media, or health services and interventions delivered on digital technological platforms, etc).

Engagement and motivation – the idea that different possible users of the same service might use it in very different ways, stop using it, or choose not to use it. Digital information, interventions and services – including those related to health – are experienced differently by each person. This, in turn, has beneficial or adverse consequences for that person's health.

We explore factors contributing to access, use and engagement, and describe the systematic differences between population groups in greater detail in Chapter 3.

The UK government developed a cross-government scale of digital inclusion to help services to understand how potential users experience digital services. Our search did not find mention or evaluation of its use in health projects, but it has been used operationally across government services since the launch of the UK government's Digital Inclusion Strategy (Government Digital Service 2014):

- individuals may be digitally competent for some purposes, like online banking or seeking out news, and not at all for other purposes, like using health services.
- individuals may have once been users of digital services for particular purposes but might have stopped doing so, because of changing health status like failing eyesight or reduced dexterity, or having been scared off by scams or bad experiences.

UK government's digital inclusion scale categories

1. Never have, never will
2. Was online, but no longer
3. Willing and unable
4. Reluctantly online
5. Learning the ropes
6. Task specific
7. Basic digital skills
8. Confident
9. Expert

2.3 How would digital exclusion lead to poorer health outcomes?

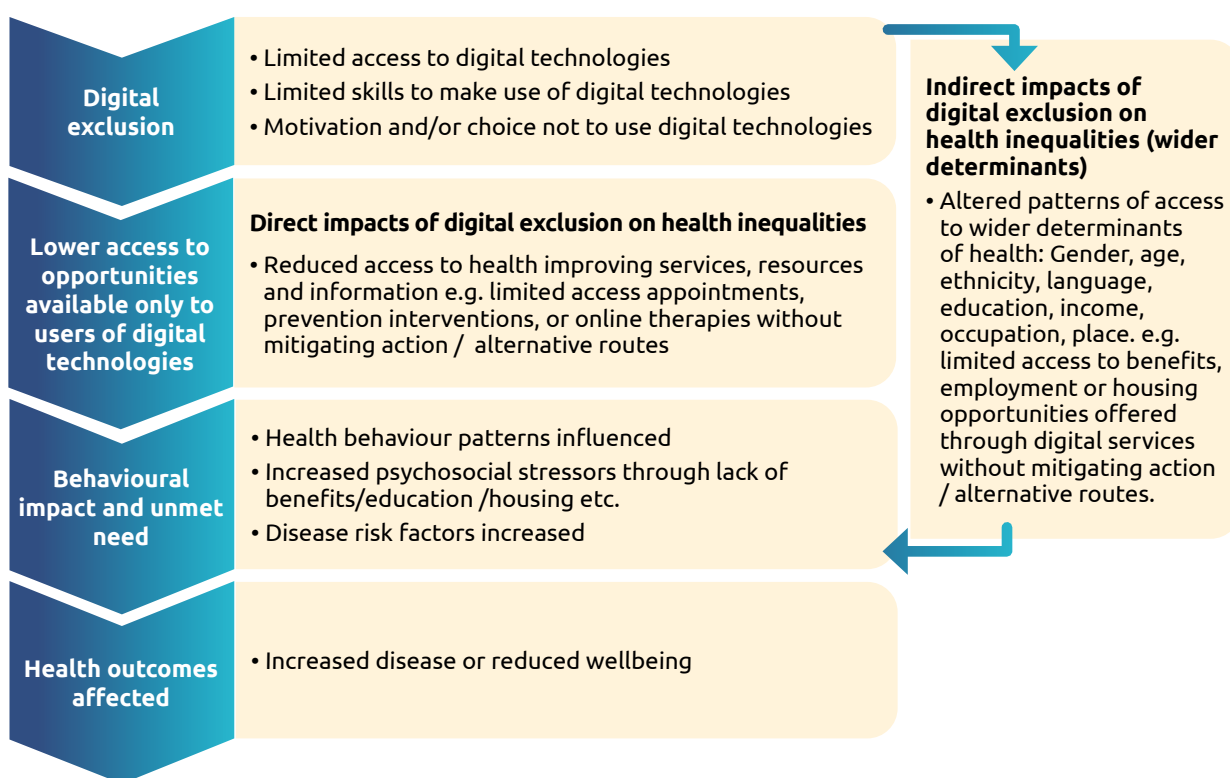
Many studies have reported that disadvantaged groups who suffer from health inequalities are also those more likely to be digitally excluded (further information in Chapter 3).

Any potential association between already-disadvantaged groups (in terms of health inequality) and the digitally excluded needs to be considered in health care and service development and delivery, to mitigate the risk that promotion of digital innovations inadvertently widens health inequalities.

We suggest a theoretical framework for how exclusion can feed through into health inequalities and exacerbate them, drawing on a review by McAuley et al (2014). Our framework is set out in Figure 1.

If digital channels are the only way citizens can access a health-promoting activity or service, then to be digitally excluded will reduce that individual's opportunity to get a better health outcome.

Figure 1 - How digital exclusion may be related to changes in individual health outcome [adapted from McAuley (2014)]



The potential pathway for digital exclusion to contribute to health inequalities as outlined in this framework, needs to be considered within the context of several assumptions. The main assumption being the availability of services on digital platforms that citizens would benefit from were they able to make use of them (i.e. they are effective at improving health status). The other limitation is that this (and the wider concept of digital exclusion) does not take into account the potential harms from using these services or technologies more generally. We do not seek to test whether these assumptions hold or address these limits here.

Chapter 3

Patterns in the underlying components of digital exclusion

Key messages

A number of factors are related to access and the use of internet-enabled digital health technologies. People on lower incomes seem to have less access overall, which matches existing sources of health inequality. Older people and people living in more rural areas are less likely to have access.

However, over recent years there has been a reduction in the differences in access and use between disadvantaged groups and others in the population.

Engagement with digital health technologies is partly determined by people's capacity and motivations to use technology for health purposes (eHealth literacy) and underlying levels of health literacy. There is less evidence about how this varies across groups, and is much more complicated than simple measures of use and access.

Understanding and addressing the factors contributing to lower levels of access, use and engagement is crucial to ensure that the application of digital technologies to support health does not inadvertently widen inequalities – with the introduction of a 'digital inverse care law'.



Patterns in the underlying components of digital exclusion

In this chapter, we summarise and discuss the evidence relating to the components of digital exclusion.

3.1 Access

Access can be considered as a function of both an individual's access to infrastructure (i.e. fixed line and mobile internet connections) and devices that use this (i.e. laptops, tablets and smartphones).

Infrastructure access

The availability of broadband internet in people's homes is a central part of digital infrastructure, underpinning many digital products and services.

In February 2018, 'superfast' broadband was available in 92 per cent of premises in Wales, and 95 per cent across the UK, and the government expects it to rise to 97 per cent by 2020 (Hutton and Baker 2018).

Deprived areas

Data for deprived areas' access to broadband is patchy and recent studies are lacking. A 2014 survey of UK cities found people living in deprived areas were more likely to have no internet access or reduced speeds and quality of internet service when they do (Ofcom 2014); this covered Cardiff and Bangor in Wales.

Rural areas

A small but significant proportion of premises remain without access to fixed broadband connections, and this is much more likely in remote or rural areas. Citizens without this kind of broadband can get support to connect from specific schemes. For example, Wales runs the Superfast Cymru programme, but there are also grant-funded and community-led schemes that help with setting up this infrastructure. Citizens across the UK were due to have a new universal legal right to a 'decent and affordable' broadband connection under the Universal Service Obligation (USO) from March 2020 (Hutton 2020). This sits alongside the devolved administration's programme. The Office of Communications (Ofcom) estimated that around 3.3% of Welsh premises did not currently have access to fixed connections meeting the USO in 2019, with 12.2% of premises in rural areas lacking access (Ofcom 2020a; Hutton 2020).

People living in rural areas are not only more likely to have no access to a fixed broadband connection in their households, but when they do have access, they are more likely to have slower connection speeds (Hutton and Baker 2018).

In 2018, 77% of UK premises had indoor mobile (4G) internet coverage from all UK providers, but this varies across nations from 69% of premises in Wales to 78% in England. This suggests the urban/rural divide seen in household broadband connections is also reflected in mobile connectivity (Hutton and Baker 2019).

We found no other comparisons between different groups.



Access to digital devices

In general, smartphones are the most ubiquitous device. In 2019, 79% of UK adults had a smartphone; 75% in Wales (Ofcom 2020b). Other devices like laptops, desktops and tablets were not as widely owned, and are now slowly declining with laptops being most common at around 60% in 2019. We focus on differences between groups in smartphone ownership but rates for these and other devices across age and income groups can be accessed on Ofcom's Technology Tracker (Ofcom 2020b).



Age groups

This rate of smartphone ownership was lower in older age groups. For example, while 96% of 16-24 year olds in the UK reported having smartphones, 57% of over 75s had them (though ownership was on a step increase in the preceding years). The gap is wider in Wales; just 18% of over 75s own one (Ofcom 2020b).

Income groups

Access to smartphones is also lower amongst lower-income households. 87% of households in the AB economic group (higher and intermediate managerial, administrative, professional occupations) had them compared to 66% of DE households (semi-skilled and unskilled manual occupations, unemployed and lowest grade occupations) in the UK (Ofcom 2020b)¹. The gradient appears to be less steep in Wales, with 75% in AB and 70% in DE households. In lower-income households, the smartphone is somewhat likely to be the only route to access the internet; one in five 16-64 year olds in the DE income group only go online using a smartphone (Ofcom 2018).

Relevant international evidence finds smartphones are more likely to be the access route to the internet for disadvantaged groups, for example, different racial groups and those from lower socioeconomic status backgrounds in the USA. But mobile-dependent internet users continue to face barriers to accessing the internet, such as data usage limits and limited mobile-optimisation for online content, which presumably affect use and engagement with the technology for health purposes (Graetz et al. 2018). In the UK, most users of smartphones have pay-monthly smartphone contracts, but 28% of mobile subscriptions were 'pay-as-you-go' in 2018 (Ofcom 2020b). We think it likely this group is comprised of lower-income households than monthly subscriptions, but comparable data broken down by demographic is not available.

**...smartphones
are more likely to
be the access route
to the internet for
disadvantaged groups...**

We found little information about access differences between other social groups, such as between ethnic groups.

¹ Ofcom's surveys of households use NRS social grade measures defined by the Market Research Society https://en.wikipedia.org/wiki/NRS_social_grade.

3.2 Use

The second level of exclusion is in the use of health technology. Access is obviously a pre-requisite, but use is also related to having digital skills and capabilities, also known as digital literacy, and services being designed in accessible ways.

Use of the internet

The Office for National Statistics (ONS) estimates that around 89 per cent of Welsh adults have used the internet in the last three months (compared to 90 per cent of UK adults) (Office for National Statistics 2018). In Wales, this represents nearly 300,000 adults in Wales who may not be in a position to benefit from interventions that depend on being able to use the internet; and 5.3 million across the UK.

...around 89 per cent of Welsh adults have used the internet in the last three months

(Office for National Statistics 2018).

Overall figures suggest that population-level inequalities of internet use for some disadvantaged groups have narrowed slightly in the past few years (Office for National Statistics 2019; Martin et al. 2016). Gaps in internet use between socioeconomic strata now exist mainly for older age groups (Scobie and Schlepper 2018).

Differences by ethnicity, on the other hand, have reversed. In 2011, the proportion of non-users of the internet was higher amongst Bangladeshi adults (31%) compared to white adults (21%), whereas in 2018 the opposite pattern is true (only 8% Bangladeshi adults compared to 11% white adults are non-users). The remaining differences largely reflect the age differences within those groups (Scobie and Schlepper 2018). There is a similar message from international evidence where age, educational attainment and income are most associated with use, and ethnicity is less important than it used to be (Reiners et al. 2019; Hong and Cho 2017).

There is little difference in internet use between employed and unemployed people but disabled people continue to use the internet less than those without disabilities (Scobie and Schlepper 2018).

Use of digital technology to support health

A nationally representative survey amongst the adult (aged 16+ years) population in Wales (carried out by Public Health Wales) showed two thirds of adults were already using internet-enabled digital devices (including wearable technologies) to support their health across a range of activities (Davies et al. 2019). This included 34 per cent of adults who used digital technology to “self diagnose”, to 14% who used it to make appointments. Yet the same study found marked differences in the use of technology to support health between social groups. Only 51 per cent in the most deprived group used digital technology, compared to 84 per cent of the most affluent groups.



3.3 Engagement and motivation

Engagement and motivation encompasses a variety of factors that can impact whether a user ultimately benefits from the digital health technologies that they might use (alongside the efficacy of the technology and interventions themselves). These factors include but are not limited to digital literacy, health literacy and trust.

We found little data in our literature search that shed light on engagement with digital health technologies and how this differs across groups, particularly for the UK. From the international literature, we found how attitudes were likely to influence some aspects but this is a very patchy picture.

Digital literacy

An individual's ability to find and evaluate information on digital platforms is associated with levels of use and engagement with digital technology and the internet. For example, people with higher digital literacy were more likely to seek health information online following medical appointments in one study (Li et al. 2014).

Those who are less digitally literate come disproportionately from population groups with lower socio-economic status, education, and are of older age, putting them at greatest risk of exclusion (Tinder Foundation 2016). Understanding and addressing factors contributing to digital literacy is therefore, key to addressing inequalities in use of digital health technologies.

Health literacy

Health literacy is defined as 'a person's ability to find and understand information about health and services in order to make health-related decisions' (World Health Organization. Regional Office for Europe 2016). A policy paper from The Organisation for Economic Co-operation and Development (OECD) highlights that at least one third of the population in 18 OECD countries may have poor health literacy levels, though they do not explore differences between groups (Moreira 2018).

As authors of international comparisons note, lower health literacy may mean that health information accessed through digital technologies is misinterpreted, adversely influencing health behaviours (Chesser et al. 2016; Moreira 2018)

In a study in the USA, older, less educated, unemployed respondents were more likely to report confusion when reading doctors' notes after being granted online access (Root et al. 2016).

...highlights the need to ensure digital health services are delivered alongside resources that support both health literacy and digital health literacy

The examples above highlight the need to ensure digital health services are delivered alongside resources that support both health literacy and digital health literacy.

Perceptions of privacy and trust

Another major factor in the decision to use, and how people use digital health technologies, are the perceptions of privacy and trust of the service. We found little evidence about this for UK contexts or existing digital health interventions, and international evidence does not paint a clear picture.

A USA study by Mackert et al (2016) explored variation in the perception of privacy and trust, and their role in the adoption of digital health technology (2016). The study found that lower eHealth literacy was associated with lower trust in government or health technology companies, but increased likelihood to place trust in health care providers. Attitudes towards technologies that involve self-tracking and monitoring are related to people's socioeconomic background in several studies, with some groups who are already disadvantaged reporting trust in services being lower (Regnier and Chauvel 2018; Humble et al. 2016; Spooner et al. 2017).

3.4 Summary

Three overarching components contribute to digital exclusion – access, use and engagement. The evidence suggests that access to digital technology is heavily influenced by the available infrastructure, either home or mobile internet access, which often has an adverse effect on rates for people living in rural and more deprived areas.

Three overarching components contribute to digital exclusion – access, use and engagement.

There remain some areas where individuals have poor access to the internet, in particular rural areas, and whilst use of the internet has increased and differences by ethnicity declined, gaps for age groups remain.

Simple metrics of access and use mask the other factors that prevent people from getting the most from digital health technology. For example, even in groups where divides in use and access have reduced, concerns over privacy and the use of information, or preferences for non-digital services may mean we see less 'engagement'.

The most pressing gap for further research is what factors influence people's engagement with digital health technologies, and the differences across groups in these factors. Motivations, perceptions of trust and privacy and underlying health literacy all clearly influence the eventual outcomes of using health services (not just digital ones), but not enough research has tried to tease out the nuances and the differences among groups.

Because of the systematic differences in access, use and engagement across deprivation groups, some have reflected on the risk of a 'digital inverse care law' (Mack et al. 2014; Laing 2018; Tudor Hart 1971) - where disadvantaged groups that already have worse health outcomes, are also unable to access digital services and interventions - could be exacerbated without efforts to offer alternatives or support digital inclusion.

Chapter 4

How to mitigate against widening health inequalities, when focusing on digital technology for health?

Key messages

There are two main approaches to addressing digital exclusion that can be applied to disadvantaged and marginalised groups: support and training for people, and co-design design of technology.

Digital inclusion involves skills training and building capability within communities to share digital skills. More research and robust evaluation is needed about overall impacts, but there have been major programmes that have supported citizens to use digital technologies.

Systems that seek to use digital technologies in health interventions should be looking to use inclusive design practices, through participatory design and delivering appropriately tailored interventions for those groups. Interventions should have clear logic models for how they will improve citizens' health.

In this chapter, we look at how barriers to use digital health technologies can be addressed through digital inclusion approaches and more effective design.

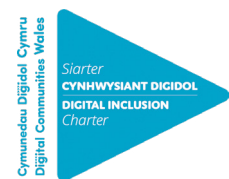
First, we consider a set of approaches known as digital inclusion and existing policy efforts by health systems to promote it (Section 4.1). Then we draw on examples from the literature to explore how technologies can be designed to mitigate the risk of making health inequalities worse (Section 4.2).



4.1 Digital inclusion approaches

Digital inclusion encompasses a set of approaches to ensure an individual has the opportunity to benefit from digital technologies (Gann 2018). There are many different approaches to digital inclusion being applied (such as the Digital Inclusion Charter in Wales, described below), through to individualised support including skills training, using social prescribing approaches to improve digital skills, and via digital champions in community and patient groups (Gann 2019). These approaches are all designed to extend the ability of people to access and use digital technology and encourage engagement with technologies for health.

In Wales, a Digital Inclusion Charter is supported by 300 organisations across private and public sectors (Digital Communities Wales n.d.). Signatories commit to helping digitally excluded people enjoy the benefits of technology by signing up to six principles of inclusion. These include ensuring staff and volunteers have an opportunity to learn basic digital skills; that inclusion is embedded in day-to-day activities; and that organisations work with local communities to co-ordinate their inclusion activities locally.



In England, NHS England and the Good Things Foundation set up the Widening Digital Participation programme to explore different approaches for reaching large numbers of digitally excluded people (Tinder Foundation 2016). The programme works with unemployed people, older people and those on low incomes, as well as disabled people, those with poor mental health and ethnic minority communities. The programme identified different models of engaging communities to 'successfully address the overlap between digital and health inequalities'. These models ranged from establishing 'digital surgeries' in GP practices to upskill those who are heavy users of primary care to training health and social care professionals to work intensively with people who need digital support (see Box 2).

Box 2. The Seaview Project – a digital inclusion case study

The Seaview Project is a homeless charity in Hastings that is supporting local homeless and insecurely housed people use technologies to access health services (Good Things Foundation 2018).

Rough sleepers and those in unstable housing are not engaging with health services to look after their health. The pathfinder provides individuals with access and support in public spaces such as libraries, using technology to find health information and support online.

An outreach team also provides devices to link rough sleepers with health professionals to triage illness and injuries. The project wants to see this at-risk group become more aware of their health and confident to seek support.

The project has been incorporated as a pathfinder in wave two of the Widening Digital Participation programme (available here: <https://digital-health-lab.org/>) and demonstrates how technologies can be used to directly address health inequality if properly tailored and designed for at-risk populations.

Because of the urban/rural divide in internet access covered in section 3.1, improvements in the infrastructure should be a key concern for digital interventions that seek to improve the health of disadvantaged groups specifically in rural areas, such as telehealth (Mack et al. 2014; Schwarz et al. 2014; Greenberg et al. 2018). There are examples where initiatives are trying to address infrastructure barriers to engagement with digital health in rural access with some success, for example in Cornwall (see Box 3).



Box 3. Improving infrastructure to promote inclusion

If infrastructure is part of the access problem, then infrastructure could also be part of the solution. A natural experiment study in Cornwall looked at the impact of improved superfast broadband infrastructure on a self-reported measure of 'Personal eHealth Readiness'. This is a composite measure of people's access to, use of, and confidence with digital tools for health purposes. As well as understanding if improved infrastructure made a difference to readiness, the researchers also examined two interventions to improve self-reported eHealth readiness by providing information and support for accessing eHealth services and information (Abbott-Garner et al. 2019). One of these interventions involved the researchers speaking to GPs about how they might encourage internet use by their patients. The other intervention was a tailored leaflet for households in the improved infrastructure catchments.

The trial found that the improved broadband infrastructure may have led to improved readiness to embrace eHealth. The GP practice and leaflet interventions did not have an impact on eHealth readiness. Positively, the authors found no evidence that the new infrastructure was benefiting people who were already eHealth-ready over those that were not, suggesting that improving infrastructure may be a way of improving readiness for health technology equally.

Unfortunately, we found little evidence in the literature that conclusively links digital inclusion approaches to social outcomes, like health outcomes. More research is needed to understand the efficacy of these approaches for improving individual health outcomes, and ultimately outcomes between groups.

4.2 Developing health technologies for disadvantaged and marginalised groups

This section draws on approaches we found reported in the literature that have been adopted by health systems and professionals in digital service design for specific groups. It then brings together overarching general principles we developed through our own brief thematic analysis of the literature for developing health technologies for disadvantaged and marginalised groups. Services designed in this way may be more inclusive or more effective at meeting the needs of already disadvantaged and marginalised groups, reducing the risk of exacerbating health inequalities.

Low-income and deprived groups

Interventions for people with low incomes should take account of the economic and financial circumstances that constrain their health choices, particularly understanding how these might constrain access and interactions with technology.

For example, low-income workers might be more likely to face strict rules or practical limitations on accessing technology at work; or work in shift patterns making it more difficult to adopt a healthy diet and sleep patterns (Tabak et al. 2018).

The built and social environment, in particular in deprived areas, can constrain people in making healthy choices. Digital tools have been used as part of interventions to help citizens learn about how these environments affect their health choices and help them effect political change (see Box 4).



Box 4. The FEAST study and the use of technology in individual health education and community empowerment

The FEAST study in the USA looked at the way digital technologies can play a role in documenting and changing the social environments in which they live. It combined smartphone and tablet apps with public health advocacy methods to help people in low-income areas advocate for changes that would help remove barriers to healthy living in their area (Sheats et al. 2017). The app was combined with in-person support from researchers and training in advocacy methods to enable people to participate in these settings. Recommendations ensuring apps' accessibility and usability for all users in diverse low-income populations included large buttons and limited use of text instructions, and GPS for mapping the walking route. Interestingly, this is an example of the way digital technologies were used in an intervention that not only had individual behavioural change model in mind (certain food choices lead to better health outcomes) about which participants learned, but also a model of structural change and how it might be achieved (in this case, through empowering citizens and communities).

Other international examples we found for low-income populations used user-centred design methods to understand low-income mothers (a frequently targeted group for public health interventions) and their preferences for consuming health information, public health messaging and interactions on social media (Guerra-Reyes et al. 2016; Le et al. 2018; Kim et al. 2018)

In general, we found little evidence comparing lower-income groups against others to understand the preference. These groups might be quite homogenous, so design decisions taken for these groups should not necessarily be adopted without testing from another context.

Ethnic minorities

Digital design for different groups seeking to encourage should be tailored to be culturally appropriate.

The representation of diverse groups (while avoiding stereotypes) in the content of interventions delivered through technology is important, for example in the visual images of body types (Ceasar et al. 2019), or in written content (Le et al. 2018).

Methods for developing culturally appropriate digital health technology interventions are very similar to best practice for other kinds of interventions for these groups. They included running small scale pilot studies, using focus groups and interviews with participants to discuss the acceptability of messaging, information or services delivered through digital technologies. These approaches or co-design practices are intended to ensure solutions are designed appropriately and we found several examples using them (Verbiest et al. 2018; Le et al. 2018; Cueva et al. 2018).

Some studies have reported good engagement with digital solutions for health amongst specific disadvantaged groups in the USA, including African American churchgoers (Brewer et al., 2018), new mothers on low incomes (Guerra-Reyes et al. 2016) and parents of children in obesity reduction interventions (Loh et al. 2018). But these did not assess the overall benefits or harms of the intervention. Another used an iterative approach to designing tablet-based healthy weight interventions for children in ethnic minorities (Verdaguer et al. 2018).

Where ethnic minority communities are recent immigrant communities too, Zibrik et al (2015) recommend services link to existing community networks to reach these groups and engage users and cultural experts in the digital design process to understand these characteristics and develop culturally appropriate content.

People living with disabilities

Our search returned few studies that made recommendations for inclusive design for disabled people. This may be a result of the diversity of this group of people and their needs and our search strategy not being sensitive to this.

One key study of disabled people's experience with technology in England found digital



technologies can be the source of additional challenges for disabled people. The author worries ubiquity of digital technology may mean increasing the social exclusion and ultimately health inequality experienced by disabled people (Macdonald and Clayton 2013).

However, there are ways in which digital technologies can be designed to be more accessible for disabled people, though this covers a very heterogeneous group. In the UK, there are a range of health and public service-specific standards that apply to the design of public services website and apps. For example, all public sector websites must comply with the W3C web content accessibility standard or its European equivalent. Existing websites have until September 2020 to comply. The NHS in Wales also has an existing Accessible Information Standard seeking to ensure disabled people are provided with information about NHS services in appropriate ways.



Rural areas

As described in the previous chapter, people living in rural areas have lower levels of access when using health technologies. One of the key risk mitigation strategies is therefore to address access barriers. Rural communities may particularly benefit from digital interventions, overcoming the challenge of distance; authors of a study in the USA note, users of their web-based smoking cessation tool were more likely to be from rural geographies despite lower access overall (Amato and Graham 2018).

Sexuality

A small part of the literature we reviewed discussed sexuality and the use of digital channels to reach people from groups who experience stigma.

It has been suggested that digitally-mediated interventions can provide a perception of anonymity, promoting engagement from marginalised groups on topics that they experience stigma (Huxley et al. 2015), though the same author worries it may make it harder to form new trusting relationships with professionals.

International survey evidence suggests that digital channels to information are particularly important for older members of historical minority and persecuted sexual groups, who were more likely to seek out health information online than the general population (Lee et al. 2017).

Homeless populations

Smartphones have been provided as part of health interventions for some homeless populations. Appropriately designed content is of particular importance to these groups if they seek information about health concerns and services that can affect the wider determinants of health like housing or food services (VonHoltz et al. 2018).

4.3 General themes for design approaches

We analysed the evidence that we found in our literature search to identify common themes in design practices on digital interventions for disadvantaged groups.

They were:

- involve users through participatory research and design practices;
- tailor services and interventions to address the context of people in disadvantaged groups;
- make sure sources of information or products and services are credible to users;
- have a realistic and actionable model of how changed behaviour through using the technology leads to improved health outcomes.

These are described in the table below.

Disadvantaged groups	Themes from literature
Cross cutting	<ul style="list-style-type: none"> • involve users • tailor services and interventions to address context • make sure sources of information, products and services are credible to the groups involved (often, but not always 'people like me') • have a realistic and actionable model of how changed behaviour leads to better health outcomes.
Specific groups	
Low income and deprived groups	<ul style="list-style-type: none"> • Consider ability to afford technology and access infrastructure • Design for employment situations that affect when they are able to use technology
Ethnic minority groups	<ul style="list-style-type: none"> • Design culturally appropriate content • Tailor content to language skills • Recent migrant groups may also have challenges of language and geography
People with disabilities	<ul style="list-style-type: none"> • Meet accessibility standards where appropriate • Enable tailoring to the needs of individual users with disabilities as much as possible
Rural areas	<ul style="list-style-type: none"> • Design with an understanding of rural internet infrastructure in mind • Remote services can overcome distance problem in rural areas, once users are online

Methods for involvement and design

Many of the studies explored different aspects of digital technology interventions using participatory research. Design techniques ranged from discrete choice experiments where members of targeted groups were asked to choose between different elements of intervention design (Ramirez et al. 2016), focus groups with prospective users (Abraham et al. 2017) through to continuous involvement from design to continued operation of the intervention itself (Sheats et al. 2017).

One study reports that citizens were dissuaded from using digital health technologies by early struggles (McCloud et al. 2016), so using these approaches to get things right first time seems important.

Once insights into the barriers to healthy behaviours for different disadvantaged groups are gathered, tailoring approaches to those insights can help ensure digital health technologies are not perpetuating them, or be rendered ineffective by them (Huh et al. 2018).

In the evidence we found and reviewed, there were few examples of behavioural science principles being embedded into interventions' design practices and evaluations and other studies we cover here. Having an underlying model of behaviour change to provide a structure and theoretical basis for the behaviours that you are trying to influence, and the impact that you would like to see are all important in the development of public health interventions (Murry et al. 2018). There was one exception – see Box 5.

Box 5 – An example of using behavioural science principles in designing a technologically-aided public health intervention

An example of research using behavioural science principles to support the design and deployment of an intervention was Handley et al's (2016) study of the STAR-MAMA program in the USA the design of a telephone-based behaviour change to serve low-income Latina mothers with gestational diabetes. They used the Capability, Opportunity and Motivation Model of Behaviour (COM-B) to structure the research that went into designing this intervention. It seeks to systematically investigate the complex web of factors that lead to better or worse health outcomes for these groups and seek to understand how interventions might tackle them. In this case, they blended technological and non-technological elements together.

Practical examples in the UK applying some of the design approaches in this chapter

We present some select real-world case studies from organisations dedicated to mitigating digital health inequalities by supporting accessibility and improving the experiences of services for disadvantaged groups. These examples seem to draw on the participatory approaches (often referred to as co-production or co-design) outlined in this chapter, in which users are involved in development. They have not been the subject of formal research or evaluation, hence why they are not included in the main text of our review.

Digital health for isolated older people – a case study for digital inclusion

Age UK Sunderland is tackling digital exclusion in isolated older people, as well as aiming to increase their ability to engage with health information online. This project intended to improve engagement with digital tools in isolated older people through peer support and skill building. This involved supporting older people to develop basic technological literacy to enable access to digital tools, while facilitating social inclusion within group-based settings. The purpose of this pathfinder project was to increase social inclusion, support independent use of health technology and facilitate health information seeking for better health outcomes in isolated older people.

<https://www.ageuk.org.uk/sunderland/get-involved/volunteering/digital-inclusion-project2/>

DigiBete – a case study for co-design with young people

This co-design project produced a website where young people can receive support in self-managing type 1 diabetes. Co-design workshops were held with mHabitat, developing the content and aesthetic of the website alongside young people, their families and clinicians for DigiBete. The intervention aims to better self-esteem, long-term health outcomes and improve self-management of diabetes in younger people. <https://wearemhabitat.com/case-studies/digibete>

Engaging excluded BAME young people in their health through digital

In Tower Hamlets, young people of BAME backgrounds experience some of the highest rates of child poverty, with 2/5 children overweight and at risk of diabetes. An estimated 10% of young people in this borough suffer from poor mental health. This pathfinder programme still in early stages of design considers how digital health can be used to ensure young people from BAME backgrounds are not excluded from engaging with their health through digital platforms.

<https://digital-health-lab.org/tower-hamlets>

4.4 Summary

To mitigate the risk of exacerbating health inequalities, a combination of digital inclusion approaches are needed, providing people with the skills and access to digital technology, and also to co-design digital services. These should help to achieve better fit of services to the particular needs and context of disadvantaged groups. In turn, this should promote more effective services that meet those people's needs, rather than excluding them in the switch to digital.

...a combination of digital inclusion approaches are needed, providing people with the skills and access to digital technology, and also to co-design digital services

However, there is a dearth of evidence in this area that sheds light on the relationship between already-disadvantaged groups, health inequalities and whether digital services are excluding them or if they are particularly likely to benefit from digital. To do that we would hope to see more comparisons across groups. What we found tended to be accounts of digital services designed for a particular target group.

We would also hope to see greater use of explicit behavioural models in the literature on digital health interventions, so we echo the comments of authors of a systematic review of mHealth public health interventions (Anderson-Lewis et al. 2018) who found only 7 of 16 studies in their already-small review had any such theoretical construct.

The nature of digital health technologies should also make it less resource-intensive to generate additional insight into design decisions. Testing the different possible designs for interventions delivered using digital technologies should complement many of the participatory design methods covered above.

Chapter 5

What impact have interventions that use digital health technologies had on health inequalities?

Key messages

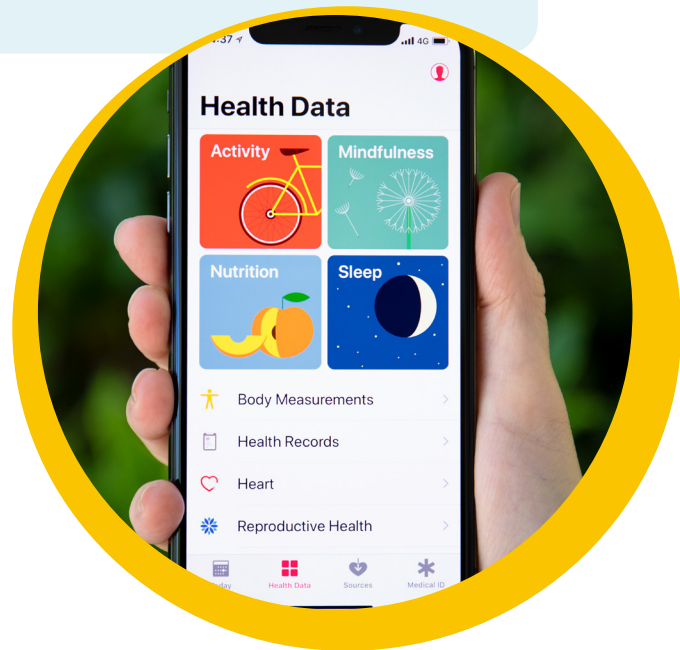
There is no evidence to help us answer the question of how the use of digital health technologies in recent years has affected health inequalities overall.

In the literature that is available, we are only able to draw limited conclusions about the impact of digital technologies on health inequalities and how technology has been effectively applied to the reduction of inequalities.

Far more research in the UK is required to understand the potential impact that the increasing use of digital technology as a medium is having on health inequalities.

We found no evidence to help us answer the central question of this paper: whether the increasing reliance on digital health technologies is affecting health inequalities between social groups.

In this chapter, we instead summarise studies about impact of specific kinds of digital health interventions for disadvantaged groups that our literature search returned.



5.1 Evidence about using specific technologies for disadvantaged groups

Text messaging

Systematic reviews we found elsewhere concluded that in general, text messaging interventions can work for reducing risk factors and have long been used in public health research (Hall et al. 2015; Orr and King 2015). However, the studies we returned about the effectiveness and engagement with text messaging services amongst disadvantaged groups were more equivocal so we would generalise with caution. A high quality randomised control trial (RCT) run in Scotland by Crombie et al (2018) found no reduction in harmful behaviours from a text messaging alcohol reduction intervention specifically targeted to socially disadvantaged men.

Much of the other literature we found were pilots with low power that established the feasibility and acceptance of such interventions amongst their target populations through survey and qualitative work (Herring et al. 2014; Burner et al. 2018; Jones et al. 2018).

Smartphone apps

In recent years, researchers have taken to exploring the potential for using smartphone apps for public health. However, we found only two examples of studies looking at the quantitative impact of smartphone apps on outcomes for disadvantaged groups, both low quality. One saw non-significant changes to childhood obesity for low-income areas. (Smith et al. 2014). Another very small study was of a platform used to support communication between healthcare coaches and low-income patients in the USA, with positive results (reduced blood glucose, weight and BMI) (Wayne and Ritvo 2014).

Online information and social media

The health information on the web has been the subject of study for decades (Eysenbach et al. 2002), and there is a large literature base about the availability, quality and use of it. And we note the availability of this information may have differential impacts for those less able to judge the quality of information for themselves through low health literacy. However, we found that there is less insight into whether there are differences in the level of engagement or action from different disadvantaged groups. Public Health Wales' 2019 survey did find lower engagement on health matters using social media among lower socioeconomic status groups.



Systematic reviews have tackled the use of social media for health communication, finding that social media can often be part of effective strategies. Welch et al. (2016) authored a Cochrane review of the literature on social media interventions across a range of health issues including weight loss, behaviour change, service usage and mental health. They found evidence that social media interventions were effective among both younger and older adults, people in lower socio-economic areas as well as across ethnicity and rurality. The authors acknowledged the risk of increasing inequalities if issues around access, uptake and information quality weren't considered and mitigated where appropriate. They suggest targeting existing groups on social media sites when developing social media interventions.

...social media can often be part of effective strategies

Other systematic review authors note the opportunities to improve the evidence base about exactly what types of social media are best for health communication through comparative trials (Moorhead et al. 2013).

Digital interventions

We found a small number of individual studies which reported the use of online interventions for disadvantaged groups.

Study	Intervention type	Target group	Summary
(Mustanski et al. 2018)	Multimedia health messages on social media	Men who have sex with men who were predominantly from ethnic minority backgrounds	Reduction in reporting of risk behaviour from intervention and control group drawn from the same population
(Whiteley et al. 2018)	Emailed links to health messages on social media sites	Young people from mainly US ethnic minority backgrounds	Intervention group reported reduced risky behaviour compared to no-treatment control
(Jack et al. 2015)	Chatbot style conversations	Ethnic minority women	Chatbot intervention compared to control of previous routine of letter informing of risks – result was chatbot group statistically significant greater reductions in risky behaviour and higher engagement.
(Love et al. 2016)	Gamification on social media for parenting support intervention	Parents in multiple disadvantaged groups	Significant reduction in some outcomes defined by programme (including child behavioural problems, 'over-reactive' parenting, parental stress), though no impact on others (parental confidence, depression, anxiety)

One study did compare engagement levels between deprivation groups. Edmonds et al (2018) reported older people were more likely to drop out of an internet delivered cognitive behaviour therapy in a USA population - reflecting the evidence about older people being more likely to be digitally excluded from chapter 3.

Targeted use of social media for public health interventions using the relevant information social media companies hold about citizens has recently been mooted, along the lines already frequently used to reach out to potential voters or consumers and influence their behaviour (Dunn et al. 2018). Clearly, if people are not already online, they would not benefit. But this is a worthwhile avenue to explore, given the prevalence of social media use. A recent population survey of engagement with social media in Wales found 77% of the Welsh population aged 16+ years used one or more social media platform, though this decreases with age (Song et al. 2019). It could be used to reach disadvantaged groups, where they are users of these platforms, but would require appropriate governance and approaches to privacy.

5.2 Summary

We found no evidence to help us answer the overall question of whether the use of digital health technologies is widening or closing the health outcome gaps between groups.

What we found were some examples of specific technologies (text messaging, smartphone apps, online information and social media) used within disadvantaged groups, but many were from initial trials and feasibility studies with small sample sizes, and of limited quality and applicability to the Welsh and UK contexts. Most of the examples of individual interventions for disadvantaged groups were based in the USA with a considerably different health and social support system.

Chapter 6

Conclusion

6.1 Key findings

This scoping review brings together evidence about the relationship between digital health technology and health inequalities to inform a theoretical framework for considering how lack of access, skills and motivation for using digital technologies (digital exclusion) could affect health outcomes.

Our theoretical model considers the way that digital exclusion may affect health outcomes, and therefore how systematic digital exclusion of groups could exacerbate health inequalities. We hope that this can organise and inform future strategic policymaking and research on digital health technologies.

We found evidence to suggest that some of the divides in access and use have narrowed in recent years, for example between ethnic groups in the UK, giving some cause for optimism. However, some gaps between age and income groups, for example, persist.

To mitigate this risk, there is a need for greater participatory practices when designing digital services, and an expansion of research on digital health inequalities.

While we found no evidence that conclusively establishes that digital exclusion is leading to worsening health inequalities, health services seeking to make best use of digital technologies must take into account both:

- the remaining barriers to using digital technologies that some groups face
- new opportunities to improve health for some groups because of the way they use digital technologies.

... there is a need for greater participatory practices when designing digital services...

They should consider the access, use and engagement patterns in their local populations. They should design interventions by involving users, designing and developing them in partnership with people from the groups in question, using a process underpinned and structured by formal models of behaviour change and health improvement.

6.2 Opportunities for future research

Key limitations of our scoping review include the complexity of factors contributing to digital exclusion and health inequalities.

An overarching gap was the lack of research that addresses the relationship between digital technology and the use and outcomes amongst different population groups, and underlying factors. To start addressing this gap, we would hope to see comparisons between groups in terms of the levels of digital exclusion and health outcomes that they experience.

Across all the sections in this report, there is a concerning lack of evidence specific to the UK, and in local and regional measures of digital exclusion and inequalities. Much of the evidence in this report was drawn from the USA, which is different in important ways on the generation and expression of inequality. This should concern population health systems seeking to understand and meet the needs of their communities. There is much to learn internationally, but all unequal societies are unequal in their own way.

Finally, digital exclusion would not have been a plausible factor that has a major influence on groups' health even a decade ago. But as technologies and society changes, what is required to be meaningfully included now will change. Accounting for this requires constant monitoring. For example, our review covered how gaps in access and use might be falling for the communications technologies that have become more established and widespread like the internet and smartphones. However, the use of other emerging technologies like wearables for health purposes and other devices might well see new divides developing between disadvantaged groups and the rest of the population.

In terms of the wider imperative to improve outcomes for disadvantaged groups, the work sketched above to fill the evidence gaps is important to convince senior decisionmakers that digital inclusion ought to be taken seriously. Funding and priority afforded to digital inclusion for health purposes has been subject to variation over time and the different nations within the UK. A stronger evidence base in this area will help to both establish its importance and improve understanding about where to direct resources.



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Appendix 1

Methodology

This review was conducted in a manner inspired by the flexible framework to complete a restricted review, set out by Plüddemann et al (2018). However, the nature of the literature we were seeking to review included substantial amounts of qualitative evidence that did not lend itself to review by risk of bias assessment tools as that method recommends. This means the review is not a systematic review of the literature that we found. We refer to our review as a 'scoping review' instead.

We set out to answer the research question:

- What does the published literature tell us about the relationship between health inequalities and the use of digital health technologies, and how might interventions be designed to reduce or mitigate risks of worsening inequality⁶⁵

In consultation with Public Health Wales, and reviewing some of the important existing reviews of the literature, we decided to break the process of answering this question down into three constituent parts, summarising the evidence about:

1. Digital exclusion and inequalities in use of and access to digital technologies by different disadvantaged groups;
2. Approaches to the design of technology and the public health interventions they are used in that mitigate the impact of inequality;
3. Health systems' previous use of digital health technology in public health interventions and their impact on health inequalities to date.

We conducted a literature search in collaboration with staff in The King's Fund Information and Knowledge Services. We made the decision to include grey literature, as The Fund's library has access to significant amounts as they maintain a database of grey literature relating to health and care policy. This proved essential; this literature being the source of key national survey data, when the evidence we found in the peer-reviewed literature was not particularly helpful to answering our research question.

The main databases that we searched were:

- EMBASE
- PubMed
- The King's Fund database
- PsycINFO

Given the pace of technological change, and the developments in prevalence among different population groups explored in our introduction, we judged that imposing a date limit would both keep the review relatively manageable and rapid and ensure the research would remain relevant. Unless explicitly stated in the search terms written out below, the date range set includes papers since 2012.

Below are the individual searches conducted and the number of references returned before they were processed from each database. Since MeSH terms are not frequently updated, a second search was done on the most recent years for EMBASE and PubMed using a single search term of the 'digital divide'. The references returned from the PsycINFO database search were deduplicated of papers that were returned in the searches from the other databases, as this search was conducted at a later date than the others after suggestions from external reviewers to improve an earlier version of this work.

EMBASE

EMBASE Search 1 - 362 references

Subject heading: (Health care disparity OR Socioeconomics OR Health care access OR Health equity OR Social justice)

AND

Subject heading: (Artificial intelligence OR Mobile phone OR Smartphone OR Mobile phone usage OR Mobile phone use OR Mobile phone utilization OR Personal digital assistant OR Information technology OR Internet OR Medical informatics OR Mobile application OR Ambulatory monitoring OR Social networking OR technology OR Telemedicine OR telehealth OR Electronic device)

AND

Title/Abstract: (population health OR public health or wider determinant or wider determinants or social determinant or social determinants or health surveillance or health promotion or health protection or behaviour or behaviours or behavior or behaviors or nudge)

EMBASE Search 2 - 471 references

Title/Abstract: (eHealth OR digital* OR "machine learning" OR "artificial intelligence" OR Web-based OR Internet OR interactive health communication* OR health communication* OR telehealth OR telecare OR computer communication network* OR "computer-assisted therapy" OR "computer assisted" OR software OR "communications media" OR "communication media" OR telecommunication* OR multimedia OR medical information technolog* OR computing OR health information technolog* OR patient-facing technology OR wearable* OR World Wide Web OR computer-assisted instruction* OR interactive technolog* OR "online learning" OR "social media" OR "new media" OR participatory media* OR user-generated content OR smartphone OR tablet OR iPad OR iPhone OR Facebook OR Twitter OR YouTube OR Instagram OR wiki* OR blog* OR online social network OR social networking OR app OR apps OR self-tracking OR activity tracking OR location tracking OR purchasing activit* OR online habits OR health application* OR Internet OR social media)

AND

Title/Abstract: (underprivileged OR health inequalit* OR inequalit* in health OR poverty OR

digital exclusion OR inequalit* OR social inequalit* OR socioeconomic inequalit* OR "health for all" OR health-related exclusion OR health disparit* OR health equit* OR equit* OR vulnerable group* OR inequalit* OR low-income OR homeless* OR disab* OR ethnic* OR rural* OR poverty)

AND

Title/Abstract: (population health OR public health OR wider determinant OR wider determinants OR social determinant OR social determinants OR health surveillance OR health promotion OR health protection OR behaviour OR behaviours OR behavior OR behaviors OR nudge)

EMBASE Digital divide category - 109 references

Subject heading: digital divide [years 2014-2018] OR Title/Abstract: digital divide [years 2018-2019]

PubMed

PubMed Search 1 - 982 references

"Healthcare Disparities"[Mesh] OR "Health Status Disparities"[Mesh] OR "Socioeconomic Factors"[Mesh] OR "Health Services Accessibility"[Mesh:NoExp] OR "Health Equity"[Mesh] OR "Social Justice"[Mesh]

AND

"Artificial Intelligence"[Mesh] OR "Cell Phone"[Mesh] OR "Cell Phone Use"[Mesh] OR "Computers, Handheld"[Mesh] OR "Information Technology"[Mesh] OR "Internet"[Mesh] OR "Medical Informatics"[Mesh] OR "Mobile Applications"[Mesh] OR "Monitoring, Ambulatory"[Mesh] OR "Social Networking"[Mesh] OR "Technology"[Mesh:NoExp] OR "Telemedicine"[Mesh] OR "Wearable Electronic Devices"[Mesh]

AND

Title/Abstract: (population health or public health OR wider determinant or wider determinants or social determinant or social determinants or health surveillance or health promotion or health protection or behaviour or behaviours or behavior or behaviors or nudge)

PubMed Search - 506 references

[Title/Abstract]: (eHealth OR digital* OR "machine learning" OR "artificial intelligence" OR Web-based OR Internet OR interactive health communication* OR health communication* OR telehealth OR telecare OR computer communication network* OR "computer-assisted therapy" OR "computer assisted" OR software OR "communications media" OR "communication media" OR telecommunication* OR multimedia OR medical information technolog* OR computing OR health information technolog* OR patient-facing technology OR wearable* OR World Wide Web OR computer-assisted instruction* OR interactive technolog* OR "online learning" OR "social media" OR "new media" OR participatory media* OR user-generated content OR smartphone OR tablet OR iPad OR iPhone OR (Facebook OR Twitter OR YouTube OR Instagram OR wiki* OR blog* OR online social network OR social networking OR app OR apps OR self-tracking OR activity tracking OR location tracking OR purchasing activit* OR online habits OR health application* OR Internet OR social media)

AND

[Title/Abstract]: (underprivileged OR health inequalit* OR inequalit* AND in health OR poverty OR digital exclusion OR inequalit* OR social inequalit* OR socioeconomic inequalit* OR "health for all" OR health-related exclusion OR health disparit* OR health equit* OR equit* OR vulnerable group* OR inequalit* OR low-income OR homeless* OR disab* OR ethnic* OR rural* OR poverty)

AND

Title/Abstract: (population health or public health or wider determinant or wider determinants or social determinant or social determinants or health surveillance or health promotion or health protection or behaviour or behaviours or behavior or behaviors or nudge)

PubMed digital divide category - 75 references

MeSH heading: digital divide [years 2014-2018] OR Title/Abstract: digital divide [years 2018-2019]

The King's Fund

The King's Fund library database search 1 - 136 references

su: (access or deprivation or disabled or equity or ethnic or health inequalities or homelessness or poverty or social exclusion or social inclusion or social inequality or sociocultural factors or socioeconomic factors or vulnerability) and su: (artificial intelligence or computer applications or digital information or health technology or information technology or internet or mobile devices or mobile telephones or online or social media or social networks or technological innovations or technology or telehealth or telecare)

PsycINFO

PsycINFO Search 1 - 712 references

Title/Abstract: (eHealth OR digital* OR "machine learning" OR "artificial intelligence" OR Web-based OR Internet OR interactive health communication* OR health communication* OR telehealth OR telecare OR computer communication network* OR "computer-assisted therapy" OR "computer assisted" OR software OR "communications media" OR "communication media" OR telecommunication* OR multimedia OR medical information technolog* OR computing OR health inf OR information technolog* OR patient-facing technology OR wearable* OR World Wide Web OR computer-assisted instruction* OR interactive technolog* OR "online learning" OR "social media" OR "new media" OR participatory media* OR user-generated content OR smartphone OR tablet OR iPad OR iPhone OR Facebook OR Twitter OR YouTube OR Instagram OR wiki* OR blog* OR online social network OR social networking OR app OR apps OR self-tracking OR activity tracking OR location tracking OR purchasing activit* OR online habits OR health application* OR Internet OR social media)

AND

Title/Abstract: (underprivileged OR health inequalit* OR inequalit* AND in health OR poverty

OR digital exclusion OR inequalit* OR social inequalit* OR socioeconomic inequalit* OR "health for all" OR health-related exclusion OR health disparit* OR health equit* OR equit* OR vulnerable group* OR inequalit* OR low-income OR homeless* OR disab* OR ethnic* OR rural* OR poverty)

PsycINFO search 2 - 224 references

Subject headings: (Health disparities OR health services accessibility OR health status disparities OR socioeconomic factors OR socioeconomic status OR treatment barriers OR social equality OR social justice)

AND

Subject headings: (Artificial intelligence OR computer applications OR computer peripheral devices OR digital technology OR electronic communication OR electronic health services OR health information technology OR information systems OR minicomputers OR mobile applications OR mobile devices OR mobile phones OR monitoring OR monitoring, ambulatory OR online community OR online social networks OR online therapy OR smartphones OR smartphone use OR social networking OR social networks OR technology OR teleconsultation OR telemedicine OR text messaging OR wearable devices OR wireless technologies)

AND

Title/Abstract: (population health or public health or health surveillance or health promotion or health protection)

PsycINFO digital divide category – 278 references

Subject heading: digital divide [years 2012-2019]

Three reviewers (MH, DM, HE) were tasked with checking the titles and abstracts of peer reviewed literature to determine whether they were relevant to the subject at hand.

The project team applied the following exclusion criteria:

- Uses of digital health technologies only involving health care rather than the activities in public health like promotion and prevention;
- Studies conducted in the context of low- and middle-income countries;
- Irrelevant to the research question (not involving digital health technology or public health intervention or health inequality);
- Study protocols or MSc/PhD theses;

Subsequent to full reviews and further snowball literature searching, 84 papers were included to be cited in this review.

MH, DM, HE divided the peer reviewed literature evenly and read each paper in full. A fourth team member (SD) reviewed all of the grey literature. For each paper, we summarised and noted the technology involved, disadvantaged groups relevant to the study, outcome measure (if any). Peer reviewed studies' quality was appraised according to relevant ROBIS, CASP tools and given descriptions of 'low/medium/high' quality. The grey literature was appraised with the Authority, Accuracy, Coverage, Objectivity, Date, Significance tool (AACODS checklist). The

results of applying these appraisal tools were not used to exclude papers, but we report by exception where studies were of high quality and given high weight in our synthesis of themes of the literature's findings.

After being reviewed and summarised, the papers were categorised according to their findings and the evidence they provide about use and access for different groups, risk mitigation strategies, and the impact of the technology used in interventions. The summaries and the full papers were used in the thematic analysis, where we summarised papers and grouped them under relevant themes for answering the research question posed.



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