

How people with type two diabetes in England learn about digital health technologies, and what are the barriers to access and motivators for use? A qualitative study

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Abstract

Background

Type 2 Diabetes (T2D) is a common chronic disease, with socially patterned incidence and severity. Digital self-care interventions have the potential to reduce health disparities, by providing personalised low-cost reusable resources that can increase access to health interventions. However, if under-served groups are unable to access or use digital technologies, digital health interventions might make no difference, or worse, exacerbate health inequity.

Study aims

To gain insights into how and why people with T2D access and use web-based self-care technology and how experiences vary between individuals and social groups.

Methods

A purposive sample of people with experience of using a web-based intervention to help them self-care for T2D were recruited through diabetes and community groups. Semi-structured interviews were conducted in person and over the phone. Data were analysed thematically.

Results

A diverse sample of 21 participants were interviewed. Health care practitioners were not viewed as a good source of information about Digital Health Technology (DHT) that could support T2D. Instead participants relied on their digital skills and social networks to learn about what DHT are available and helpful. The main barriers to accessing and using DHT described by the participants were availability of DHT from the NHS, cost and technical proficiency. However, some participants described how they were able to draw on social resources such as their social networks and social status to overcome these barriers. Participants were motivated to use DHT because they provided self-care support, a feeling of control over T2D, and personalised advice or feedback. The selection of technology was also guided by participants' preferences and what they valued in relation to technology and self-care support, and these in turn were influenced by age and gender.

Conclusion

This research indicates that low levels of digital skills and high cost of digital health interventions can create barriers to the access and use of DHT to support the self-care of T2D. However, social networks and social status can be leveraged to overcome some of these challenges. If digital interventions are to decrease rather than exacerbate health inequalities, these barriers and facilitators to access and use must be considered when interventions are developed and implemented.

Background

Type 2 Diabetes (T2D) is a common chronic disease that creates a considerable burden to patients and health services [1–6]. A diagnosis of T2D results in widespread changes in the lives of the person with the condition as well as their families [1]. By their nature, chronic conditions cause illness over long periods and their management is complex and costly [3]. 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 those with higher SES [3, 7]. It has been proposed that this gradient is created by unequal access to resources, such as: knowledge, power, advantageous social connections, money, status and good quality healthcare [8–11]. People in more privileged social positions have greater access to these key resources that they can leverage to avoid risks to health and minimise the consequence of illness once it occurs [8–11]. Those in less privileged positions have fewer resources, which means they are less likely to have good control over their health and that there are greater barriers to managing illness [8–10, 12].

Digital self-care interventions are a resource that people with chronic conditions, like T2D, can use to help them to manage their condition. These interventions have the potential to reduce health disparities, by increasing access to personalised, low-cost health interventions, whilst reducing demand on an overstretched healthcare system [13–15]. The digital divide in terms of unequal internet access has narrowed across socio-economic and cultural groups, largely due to increased Smartphone ownership and the reduction in the cost of technology [16–19]. There is some evidence that digital self-care interventions can be acceptable and feasible in populations that are traditionally viewed as underserved by health services [20–22]. These interventions may also redress power imbalances between patients and Health Care Professionals (HCPs), by providing access to health information that was previously only available to clinicians [23].

However, there is some evidence that people from lower SES groups with fewer resources are less likely to access and use digital self-care interventions [24, 25]. Web-based health information has been found to be variable in quality, challenging to navigate and has mostly been developed to be used for people with high-school or greater reading ability [26, 27]. A qualitative study based in Australia found that people from lower Socio-Economic (SE) groups with less economic, cultural and social capital faced greater challenges accessing and using digital technology, which reinforced or increased existing disadvantage [28]. Participants with lower SES could not afford to purchase new technology (economic capital), found technology challenging use because of lower levels of education (cultural capital), and they did not have the social connections (social capital) to support the use of the technology [28]. Baum et al.'s (2014) study [30] 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, specifically T2D.

This study was designed to explore: how and why people with T2D access and use web-based self-care technology and how experiences vary between individuals and social groups.

Methods

The methodological orientation underpinning the study was an inductive approach drawing on aspects of grounded theory [29, 30]. Ethical approval was granted from University of Bristol Faculty of Health Sciences Research Ethics Committee 27th April 2017.

Participants

Participants were recruited from diabetes and community groups, including groups that served Black, Asian and Minority Ethnic and lower income neighbourhoods. Participants were recruited in person, via circulated email and through adverts in Diabetes UK magazine. Adults were invited to take part if they had a diagnosis of T2D, spoke and understood English, and had ever used a web-based intervention to help them self-care for their condition. The screening questionnaire is available in the Appendix, which was used to support the purposive sampling of participants. Participants were selected from different social groups and to capture a range of experiences of the use of different types of digital interventions.

Procedure

Semi-structured interviews were conducted by telephone, in participants' homes and in a diabetes unit in a hospital. The participants received both written and verbal information about the research and provided consent before the interview. The interviews were conducted by one researcher (ST) and ranged from 35 minutes to two hours 13 minutes and were transcribed verbatim.

The first 10 minutes of one telephone interview was lost because the recording device did not pick up the audio. There were no further issues with lost data. In three phone interviews family members (children and partners) were around the person being interviewed, which may have affected the content of the interview. 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. There were three iterations of the topic guide, with minor changes around challenges of conducting self-care activities in the context of social gatherings (version 1.0 and the final version 1.3 available in Appendix). Field notes were taken during and after interviews.

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. Interviewing continued until data saturation was reached and no new data was arising in relations to the key themes. The interviews were recorded 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). Transcripts were anonymised, checked for accuracy and imported into NVivo for analysis. The data were analysed using the Thematic approach [31]. Some major themes were derived from theory prior

to coding and further themes were derived from the data as they emerged. Three transcripts were coded by ST and were independently coded by two other authors (CC and PL). The lists of codes were reviewed in a meeting and ST, CC and PL 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 (coding tree available in Table 3 in Appendix). Participants were provided with a summary of the findings.

Research team and reflexivity

Personal characteristics

This study was conducted as part of ST's PhD, during which she received formal and informal training in qualitative methods and was supervised by senior academics with specialism in qualitative research (CC and PL). ST's previous qualifications were a BSc in psychology and an MSc in neuropsychology and most of her training and experience is in quantitative methods, which may have had a bearing on the conduct and the interpretation of the interviews.

Relationship with participants

There was no prior relationship with the study participants before the study commenced. Participants interviewed in person would be aware that the interviewer (ST) was a white woman, in her thirties, who is relatively affluent, with no visible disabilities and a healthy weight. All would have known that the author was a student researcher at the University of Bristol. 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.

The position taken by the ST was 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.

Results

Sample description

Twenty-seven people with T2D were eligible to enter the study, and data saturation was reached after 21 interviews. 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. The sample was diverse in terms of age (median 60 years, range 29-74), gender (11 men), socioeconomic situation and household income. Two thirds had a University degree or equivalent and 17 participants identified as White British. The sample overview is in Table 1 and the individual participant profile in in Table 2 in the Appendix.

The sample was self-selecting for those who had tried using digital technology to support the management of their condition. However, not all people in the sample were technophiles. Participants ranged from those who used one intervention to those who used multiple digital interventions (up to 7), and in one case the participant had tried digital interventions but had stopped using them because she did not find them helpful (ID 24). Twelve participants were light users (≤ 2 intervention) and nine were heavier users (> 2 interventions) of digital technology (Table 1).

Digital interventions used

Digital health interventions used included: Blood Glucose Monitors (BGMs) with apps, wearable technology (e.g. Fitbits), online access to electronic health records, diabetic specific and general health websites and apps. Most people did not use interventions designed specifically for people with diabetes, but rather used technology designed to support healthy living and social connectivity. Wearable fitness trackers were the most commonly used intervention (16 participants) and apps that tracked nutrition or fitness (11 participants). The diabetes specific interventions were the BGMs (Dario meter, Freestyle Libre, Trueyou mini) used by ten participants (five supplied by HCPs and five purchased privately), and three different apps each used by one participant (Diabetes diary, IBG star app and Habits- South Asian specific diabetes app).

How people learned about digital interventions

Few participants described 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 who “*don’t get the technology*” (ID 10, white female, Low Ed) about what is available to the public and their benefits. Only one person mentioned that the Food Smart app had been recommended to them the “*first [NHS] health visit that [he] had from this wellbeing thing*” (ID 22, white male, Low Ed).

Instead, 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 how they ‘googled’ interventions, navigated apps stores and products and sought out expert advice. Many participants initially found out about technology through friends and family. Participants took advice on digital interventions 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. One man described how he learnt about the Change for Life app through “*very knowledgeable*” people in the diabetes research focus group he attends:

...they have a much more in-depth, 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, White male, Low Ed)

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. They also had 'professionals' representing digital health companies like Abbott attend their meetings. Online communities and forums fulfilled a similar purpose to physical support groups in spreading information about innovations in technology.

I'm sort of active in the diabetes online world (...) there are always people there talking about new innovations. (ID 33, white female, High Ed)

How people acquire technology

In context with health services

Many participants believed 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 described how the NHS "*refused to give [them] a meter*" (ID 27, white male, Low Ed). 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.

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 (...) 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, white female, High Ed)

Some participants privately bought BGM and additional test strips because they were not supplied by their HCP or because they felt that the equipment provided was not adequate for their needs.

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, white, female, High Ed)

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. (ID 42, white male, High Ed)

Participants described having negative reactions from HCPs about their use of BGMs when they had bought one for themselves, rather than being supplied or prescribed one on the NHS. One woman talked about being frustrated with the critical response from her doctor about Freestyle Libre, who was critical because "*it doesn't meet with any approval in this neck of the woods.*" (ID 41, white female, High Ed). One participant described not being provided with a BGM because the nurse felt having access to a BGM may

mean he ended up “*in an even deeper hole*” with his health-related anxiety (ID 27, white male, Low Ed). However, other technology (such as digital dietary and activity aids) used to support self-care behaviours appeared to elicit more positive reactions: “*I showed them [Diabetes Diary app] to a doctor (...) he thought it was an excellent idea*” (ID 20, white male, Low Ed).

Barriers and facilitators to access

The main reported barriers to privately accessing Digital Health Technology (DHT) were cost and technical proficiency. However, some participants described how they were able to draw on social resources to overcome these barriers.

The cost of DHT was prohibitive for some participants. Participants described how they had considered buying expensive technology like the Freestyle Libre, but the high cost meant it was “*a no-go*” (ID 40, white female, low income). One woman talked about how Fitbits had become less affordable “*This one was £60, that’s the cheapest. Now they’ve gone up to about £90 I think*” (ID 10, white female, low income). Some used expensive technology (such as the Freestyle Libre) but limited its use to minimise expense, only using it “*when things were going to be changing*” (ID 42, white male). Others described using DHT that were free to download onto their smartphones.

Participants described how access to DHT was facilitated by people in their personal networks. They talked about having access to technology such as smartphones and watches through being given “*a very generous gift*” (ID 41, white female, highest income) and through perks from work such as company phones that are free to use. One participant described how her personal trainer got her to use an app (MyFitnessPal) to keep a track of what she was eating to “*really understand the diabetes more*” (ID 37, white female, High Ed, low income).

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.

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, white male, High Ed)

Some people self-identified as early adopters and technophiles, while other people felt less able to navigate new innovations but were still using DHTs. There was a suggestion that limitations in the individual’s knowledge of and skill to use 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... (ID 10, White Female, Low Ed)

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, Asian British-Indian Male, Low Ed)

Social capital seemed to help some participants be able to gain better access to technology. A man talked about how his work as “a Microsoft partner” meant he was able to negotiate getting replacement technology when his failed because he felt confident with technology companies (ID 36, Male, 57yrs, White, High Ed, lowest income). Another man used his role as lead of a South Asian diabetes support group to gain pre-launch access to a culturally sensitive app for himself: “it hadn’t reached the iPhone yet. (...) I said to the company [making the app], “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, Asian British-Indian male, Low Ed and income)

Why people select and use technology

Participants were motivated to use DHT because they provided self-care support, a feeling of control over T2D, and personalised advice or feedback. The selection of technology was also guided by participants’ preferences and what they valued in relation to technology and self-care support, and these in turn were influenced by age and gender.

Participants described how DHTs gave them a sense of being in control of their condition by providing self-care support and feedback. They talked about how BGMs kept them on “the straight and narrow” with the diabetic diet by providing personalised feedback, meaning “you have nowhere to hide from that evidence” of how food impacts blood glucose levels. (ID 33, white female, High Ed). Others talked about how the feedback from wearables like Fitbits had “driven” them to increase their activity levels and “change my lifestyle as a result of trying to get that 7000 steps.” (ID 27, white male, Low Ed) Access to BGMs was particularly important to the participants because many felt that this technology gave them greater control over their blood glucose levels or diabetes in general.

without those two things [blood glucose meter and Freestyle Libre], I wouldn’t be in control of my blood glucose. (...) 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, white female, High Ed, highest income)

Digital interventions were valued by many participants because they felt that the personalised information provided was more beneficial than “one fits all” (ID 27) guidelines issued by HCPs and in structured education courses. 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 in community-based education courses and leaflets from HCPs they had experienced.

“I thought, “Wow this is something I’ve been looking for, for a while” [Habits South Asian specific diabetes app] And it’s now here, so we have to take advantage (ID 26, Asian British-Indian male, Low

Ed)

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, white female, High Ed)

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 be suboptimal because (...) people aren't gonna get the same things out of it. Some will get m-much more than others...(ID 33, white female, High Ed)

Some participants felt that physical and digital interventions were complementary, fulfilling different roles in relation to education and practical support.

whatever you get from a sort of structured education programme (...) I think those can only be the principles and brushstrokes(...) what you get from the self-stuff is, like, colouring it in, getting, getting the detail. (ID 33, white female, High Ed)

There was a perception from some participants that technology could not replace current effective non-digital interventions. A few of the interviewees talked about the benefits of a physical courses over a digital intervention, including having someone to “show people how” to do an activity (ID 26, Asian British-Indian male). One man felt the physical prompts he used for taking medication in pill form (e.g. medicine dosset boxes) could not be easily replaced by technology, but found apps helpful for tracking his intake of insulin where no physical prompts were available.

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, white male, 74yrs)

There were mixed preferences with regard to digital forums for social support. Several participants described receiving all the support they needed from online forums.

I've made quite a few friends on there [Diabetes.co.uk], erm, and we, we interact separately from the forum. (ID 41, white female, 50yrs, High Ed)

Other participants talked about how people would miss out emotional support and learning from other people with diabetes, which they felt “an app doesn't replicate” (ID 29, white male, 64yrs). A few were very negative about sharing their experiences and seeking support on digital social platforms.

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. (ID 29, white male, 64yrs, High Ed)

Technology was described by many of the (older) participants as something that young people use and older people resist: *"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, white male, 58yrs). For some participants, differences in use of technology between older and younger people had been observed as well as perceived. There was 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 such as *"chat, er, forums and things like that"* (ID 37, white female, 68yrs).

In contrast the two younger participants in the sample (female aged 29 and male aged 31 years old) talked about the benefits of physical interventions over digital. The younger man felt that non-digital interventions increased his opportunities to make social connections and used the discussion of health apps as a conversation starter with people at the gym:

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 ideas, on what works for them, and what's been quite useful (ID 23, Asian British-Indian male, 31yrs, High Ed, lowest income)

The younger woman felt apps were not very good compared to in-person courses like LEAP and Weightwatchers *"Cause the whole point is you got to be physical"* (ID 24). She was the only participant that felt none of the digital interventions she had tried had been helpful for the management of diabetes. She characterised digital interventions as being for people who were already *"independent in their own exercise"* (ID 24). She did express the feeling that she had different requirements than others on the diabetes support course because they were much older, but she found the quick progress she made relative to the older attendees motivating:

I found it [LEAP] 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, Asian British-Indian female, 29yrs, High Ed, low income)

Male and female participants emphasised different concerns about technology. Many of the men in the group had concerns about data security and with what companies were doing with their personal details or whether *"nasty people"* (ID 36) could hack and used their data maliciously. Male participants also talked about some technology feeling insidious, *"like you are being watched"* (ID 22, white male, Low Ed). 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.

Discussion

Summary of main findings

Participants described how they: learnt about, acquired, and used technology to support the self-management of their T2D. Participants rarely learned about digital interventions from HCPs and did not

perceive HCPs as knowledgeable about self-care technology. Instead they sought information from their personal social networks and diabetes support groups (in person and online). The main barriers to accessing and using DHT described by the participants were availability of digital innovations from the NHS, cost and technical proficiency. However social resources such as social networks and social capital could be leveraged to overcome some of these barriers. Participants gained access to technology through their personal networks through gifts and work perks. Group membership provided benefits which included access to discounts off expensive digital interventions and being offered free samples. Social capital was used to negotiate getting replacement technology and to gain pre-launch access to apps. Participants described how a lack of digital skills could be barrier to the use of DHT, but could be overcome by drawing on support from tech buddies in their social network. Participants were motivated to use DHT because they provided self-care support and a feeling of control over T2D. They selected DHT because they provided personalised information that could be tailored to culturally specific needs, diet preferences and learning styles, and could provide social support. Some participants felt that non-digital interventions were better at providing some aspects of support for T2D management, such as 'how to' training and emotion support. Although technology was constructed by many participants as something that young people use and older people resisted, the younger participants in the sample valued the face to face support and networking available from non-digital interventions. Men and women expressed different concerns about technology: most of the men brought up worries about data security, which was never mentioned by women.

In the context of other literature

This study has shown how economic, educational (digital skills) and social resources (social networks and social capital) can influence the access and use of technology for self-care by people with T2D. This agrees with previous evidence has indicated that people with fewer resources are less likely to access and use digital self-care interventions [24, 25, 28]. As with this study, Baum et al. (2014) found that those with fewer economic, educational and social resources encountered more challenges accessing and using digital technology and that social networks facilitated access [28]. They also found evidence of digital exclusion being amplified by social exclusion [28], which was not reported by participants in this study.

The finding in this study that difference in resources influenced how people learnt about and accessed health technology, 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 [8-10]. The resources include: power, advantageous social connections, money, knowledge and prestige [8-10]. This study provided examples of how each of these resources were drawn on to overcome barriers to accessing digital innovations that were used by participants to gain a feeling of control over their diabetes. Social capital theory addresses inequities at a community level, and proposes there is a social hierarchy in 'the ability of actors to secure benefits by virtue of membership in social networks and other social structures' [32]. This theory suggests that belonging to a social network, provides access to

resources and benefits that individuals would not have on their own [33]. This study highlighted the role of membership to social groups (e.g. diabetes groups, research groups and online forums) in providing knowledge about technology and shortcuts to accessing new and helpful innovations. This demonstrates that traditional measures of deprivation such as education, occupation and household income, are not sufficient to encapsulate the resources people had available to them.

There was also some evidence of 'bridging social capital' through memberships to these groups. Bridging is the connections that link people across different networks or social groupings (such as ethnicity, occupational class, or religion), which are responsible for the transmission of information and resources [33-36]. 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.

Strengths and limitations

To the authors knowledge, this is the first study to explore how people with T2D choose technology to support to the self-care and their experiences using digital technology. Double coding of a subset of interviews by two members of the team and ongoing discussion about coding structure ensured the coding scheme was robust. Multiple views of the data promote confidence in the credibility of the findings [37]. A diverse range of experiences and opposing sides of arguments were identified and presented.

Some caution should be exercised in the transferability of the findings to other settings or populations. Despite targeted efforts made to recruit a diverse sample in terms of ethnicity and religion most of the participants identified as White-British and Christian and had tertiary degrees. Consequently, thematic analysis may not capture the range of experiences of those from minority ethnic groups. The decision to restrict interviews to English were due to a lack of resources for interpreting, and in response to challenges with conducting cross-language qualitative research [38]. However, this may have created a barrier to study entry for some groups. 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. 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. 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. 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 [39, 40].

Implications for future research, policy and clinical practice

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. These measures did 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) [33-36, 41]. Research into health inequalities should consider the important role of social and community assets in the access and use of health interventions.

The training and availability of tech buddies may reduce barriers to accessing health technology caused by a lack of knowledge about available digital interventions, and how to access and use them. As NHS policy begins to encourage greater adoption of digital interventions, primary care HCPs with oversight of those with chronic conditions are likely to play a role in supporting people to access and use these interventions. However, in the context of growing financial and workforce pressures and considering the views of those in this study that this is not within HCP knowledge or skills, this role may be to signpost to trained 'tech buddies' in community services. People diagnosed with chronic conditions could be linked with trained 'tech buddies' 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 [42, 43].

Conclusion

This research indicates that low levels of digital skills and high cost of some digital innovations can create barriers to the access and use of DHT to support the self-care of T2D. However, social networks and social status can be leveraged to overcome some of these challenges. If digital interventions are to decrease rather than exacerbate health inequalities, these barriers and facilitators to access and use must be considered when interventions are developed and implemented. The training and availability of tech buddies may reduce barriers to accessing health technology caused by a lack of knowledge about available digital interventions, and how to access and use them.

Abbreviations

BGM	Blood Glucose Monitors
DESMOND	Diabetes Education and Self-Management for Ongoing and Newly Diagnosed
DHT	Digital Health Technology
DTA	Digital Technology Access Model
HCP	Health Care Practitioners
NHS	National Health System
NICE	National Institute For Health And Care Excellence
LEAP	Let's Empower and Prepare
PIS	Participant Information Sheet
SDH	Social Determinants Of Health
SE	Socio-Economic
SES	Socio-Economic Status
T2D	Type 2 Diabetes
UK	United Kingdom

Declarations

Ethics approval and consent to participate

Ethical approval was granted from University of Bristol Faculty of Health Sciences Research Ethics Committee 27th April 2017. The participants received both written and verbal information about the research and provided consent before the interview.

Consent for publication

Not applicable

Competing interests

None declared.

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Authors contributions

ST had primary responsibility for conducting this study as part of her the National Institute for Health Research (NIHR) School for Primary Care Research (SPCR) PhD and drafted the manuscript. CC and PL contributed to the conception, study design, analysis, and interpretation. All authors reviewed and contributed to revisions of the manuscript and approved the final version.

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Availability of data and materials

Anonymised interview transcripts are available from the corresponding author on reasonable request.

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Tables

Table 1: 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)^a		
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 (Low Ed)	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)		
Lowest income <£16,000 and/or eligible for means tested benefits	3	0
Low income £16,000-£24,999	1	4
Mid income £25,000-£34,999	3	0
High income £35,000-£44,999	0	2
Highest income >£45,000	2	2
Prefer not to say	2	2
Use of digital interventions		
Lighter (≤ 2 interventions)	7	5
Heavier (> 2 interventions)	4	5
<p>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</p>		

Table 2: Profile of individual participants

ID	Gender	Age	Ethnicity	Religion	Highest level of education	Estimated household income last year(before tax and not including benefits)	IMD quintile
10	Female	61	White-British	No religion	Intermediate between secondary level and university (e.g. NVQ3-5, diploma, apprenticeship)	£16,000 to £24,999	1
11	Female	59	White-British	Christian	University degree or equivalent	£35,000 to £44,999	5
20	Male	74	White-British	Christian	Intermediate between secondary level and university (e.g. NVQ3-5, diploma, apprenticeship)	£25,000 to £34,999	2
22	Male	67	White-British	Christian	Secondary school or equivalent	£25,000 to £34,999	5
23	Male	31	Asian or Asian British-Indian	Muslim	University degree or equivalent	<£16,000 and/or eligible for means tested benefits	3
24	Female	29	Asian or Asian British-Indian	Sikh	University degree or equivalent	£16,000 to £24,999	2
26	Male	48	Asian or Asian British-Indian	Hindu	Intermediate between secondary level and university (e.g. NVQ3-5, diploma, apprenticeship)	£16,000 to £24,999	2
27	Male	58	White-British	Prefer not to say	Intermediate between secondary level and university (e.g. NVQ3-5, diploma, apprenticeship)	Prefer not to say	5
28	Male	66	White-British	Christian	Intermediate between secondary level and university (e.g. NVQ3-5, diploma, apprenticeship)	>£45,000	3
29	Male	64	White-British	Christian	University degree or equivalent	>£45,000	5
30	Female	56	White-British	No religion	University degree or equivalent	>£45,000	NA

31	Female	58	White-British	Christian	Intermediate between secondary level and university (e.g. NVQ3-5, diploma, apprenticeship)	Prefer not to say	5
33	Female	60	White-British	Christian	University degree or equivalent	Prefer not to say	5
34	Male	55	White-British	No religion	Intermediate between secondary level and university (e.g. NVQ3-5, diploma, apprenticeship)	£25,000 to £34,999	1
35	Female	63	Other-White European, with mixed racial ancestry	Christian	University degree or equivalent	£35,000 to £44,999	3
36	Male	57	White-British	No religion	University degree or equivalent	<£16,000 and/or eligible for means tested benefits	4
37	Female	68	White-British	Christian	University degree or equivalent	£16,000 to £24,999	4
38	Male	65	White-British	Christian	University degree or equivalent	<£16,000 and/or eligible for means tested benefits	5
40	Female	72	White-British	Christian	University degree or equivalent	£16,000 to £24,999	4
41	Female	50	White-British	No religion	University degree or equivalent	>£45,000	1
42	Male	72	White-British	Christian	University degree or equivalent	Prefer not to say	3

Table 3: 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 calcs 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 exercise 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 24/7
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
Convenience 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
Forgo 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 unconsciously
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 feedback on physiology
Feel like an athlete
Indication of fitness
Interest in data
Link to trends in blood glucose
Understand how body responds to food

Supplementary Files

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