Healthcare Improvement Scotland | SHTG Advice on health technologies

SHTG Assessment
May 2025

In response to enquiry from the Accelerated National Innovation Adoption (ANIA) Collaborative

Digital prevention programmes for people at risk of developing type 2 diabetes

Key messages

1. Evidence suggests that digital diabetes prevention programmes (DDPPs) are as effective as in-person programmes in preventing or delaying the onset of type 2 diabetes (T2D) in people with a high risk of developing T2D.

2. DDPPs are effective in reducing blood glucose levels (HbA1c) and body weight, which together have been proven to reduce the risk of developing T2D.

3. Health coaches and social support from family and friends play an essential role in delivering DDPPs, by helping to sustain participant engagement, building rapport and promoting behavioural changes. People were more likely to set goals for themselves and engage with the programme if they received this support in combination with other tools.

4. People's experiences of online group support are influenced by individual preferences and sociodemographic factors. Careful consideration of user needs is crucial for sustained engagement and achieving meaningful health outcomes.

5. DDPPs have the potential to reach a wider population than traditional options and facilitate proportional access across different population groups.

6. In-person programmes to prevent T2D in people at risk have been shown to be cost effective in the United Kingdom (UK). The digital implementation and delivery of prevention programmes has been shown to be similarly cost effective, in studies carried out in the United States (US). The cost effectiveness of the digital delivery of prevention programmes has yet to be formally assessed in the UK.

7. An SHTG budget impact analysis shows that a DDPP can lead to substantial resource savings for NHSScotland.

What were we asked to look at?

In 2023, we reviewed the evidence for digitally delivered T2D prevention programmes on behalf of the Accelerated National Innovation Adoption (ANIA) collaborative. ANIA has asked us to update our review to ensure any new evidence is captured as part of their decision making.

T2D prevention programmes are evidence-based interventions aimed at preventing or delaying the onset of T2D in high-risk individuals. The programmes provide ongoing tailored advice, support, and encouragement to people through established behaviour change techniques (BCTs) such as information provision, goal setting, action planning, coping plans and relapse prevention. They can be delivered using in-person or digital models. The digital programmes deliver information, advice and support using a combination of digital technologies, such as smartphone apps, websites, videoconferencing, and wearable devices such as smartwatches.

Why is this important?

Approximately 88% of people with diabetes in Scotland, have T2D.[1] Reducing risk factors for developing T2D and delaying or preventing the onset of the condition are key indicators in the Scottish Government's T2D prevention, early detection and intervention framework.[2]

Diet, lack of physical activity and obesity are known to be the main modifiable factors in the development of T2D.[3] There is a strong evidence base linking T2D prevention with behavioural changes that result in a healthier lifestyle.[4, 5, 6] Prevention programmes can significantly improve outcomes and quality of life for people with a high risk of developing T2D.[7-9]

What was our approach?

We conducted a review of the published evidence on national digitally delivered T2D prevention programmes.

More information about SHTG Assessments can be found on our website.

What next?

ANIA will use our assessment to inform its value case and subsequent decision making regarding the national implementation of a digital T2D prevention programme.

Key points

1. Studies suggest that digital diabetes prevention programmes (DDPPs) are effective in reducing HbA1c, weight, and T2D conversion rates in adults with non-diabetic hyperglycaemia (NDH).[4, 5, 10-13]

2. NHSE-DPP digital services were found to be as effective as in-person interventions in reducing weight and blood glucose levels. A recent large-scale evaluation (n=3,623) found that participation in the digital service was associated with clinically significant ($p<0.001$) mean reductions in both HbA1c (−1.6 mmol/mol) and weight (−3.1 kg) at 12 months.[12] The outcomes were comparable to the outcomes for patients receiving the in-person intervention.

3. The results from a non-randomised trial of the United States (US) national DDPP (n=220) demonstrated that participants who engaged in four or more sessions during the first year sustained a −3.0% weight loss after 3 years ($p = 0.0009$).[14] Those who participated in nine or more sessions during the first year sustained a −2.9% weight loss after 3 years ($p=0.0024$).

4. A user engagement study examined participant data from three independent NHSE-DDPP providers from December 2020 to June 2021.[15] Data from the 1,826 participants enrolled found a decline in app usage over the course of a 9-month period. Health coaches were found to play a crucial role in supporting components of a digital programme.

5. Support from social circles (for example, the emotional and practical support from family and friends) is considered a key enabler of engagement. A 2025 study (n=45), found that social support helped with initiating and maintaining behavioural changes.[16]

6. A 2024 qualitative study (n=33) evaluated the role of online group support functions within the NHSE-DDPP.[17] Group chats with active health coach moderation were effective in promoting behavioural changes. Closed group chats, where participants interact and empower each other directly, were effective in supporting changes to diet and physical activity. Health coach moderation was essential in fostering a positive and engaging environment, especially in the early stages of the programme.

7. The Irish NDPP (n=22) reported positive psychosocial outcomes, such as high self-efficacy and strong motivation to manage diabetes risk.[18, 19] Engagement levels were high, with 81% of participants attending at least six sessions.[18] The flexibility and accessibility of the synchronous online group format were particularly effective in engaging working individuals and men. The trust placed in healthcare professionals and the perceived need for structured support were key factors contributing to participation.[19]

8. Factors influencing programme uptake and user engagement include ease of access to programmes, motivation, support, group composition, sociodemographic characteristics, shared interests and people's perception of their risk of developing T2D.[4, 20, 21]

9. DDPPs have the potential to reach a wider population and facilitate proportional access across different demographic profiles, when offered alongside traditional in-person programmes. In a longitudinal, mixed-methods evaluation, all participants (n=26) noted that the introduction of the online digital service (NHSE-DDPP) offered a wider access to patients who either could not or did not want to attend in-person sessions, particularly those living in rural areas and younger people.[22]

10. Systematic reviews have generally found lifestyle interventions that prevent T2D in high-risk individuals to be cost effective.[4-6] Only a small number of studies have evaluated the cost effectiveness of DDPPs and the relative cost effectiveness of digital versus in-person interventions is yet unknown.[18,19]

11. An impact assessment, conducted in advance of the (non-digital) NHSE-DPP rollout in England, modelled predicted savings in the region of £35 million over a 20-year time horizon.[23] It was estimated that 18,000 cases of T2D could be prevented or delayed amongst a 5-year cohort of 390,000 participants at a programme cost of £105 million. Modelling using effectiveness estimates from the literature found that the programme was likely to be cost effective, and that the programme would be cost saving by year 18 (2033/34), based on an intervention cost of £270 per participant.[23]

12. Economic analysis of the NHSE-DPP shows that the programme is cost effective on the basis of short-term health gains achieved by participants as well as over a long term course of 35 years.[24] Across a cohort of 384,611 referrals the average cost per referral was £119, rising to £286 per referral for people who completed at least 60% of programme sessions. Each session attended was associated with a 0.0042 quality-adjusted life year (QALY) increase in utility. A total of 1,772 QALYs were generated for this cohort at a cost of £24,929 per QALY (£29,874 per QALY when including implementation costs). Cost savings of £71.4 million were estimated over a 35-year time horizon with the generation of an additional 21,472 QALYs.[25]

13. The health economics of the digital pathway (NHSE-DDPP) have not been assessed. It is unlikely that digital delivery would have a major negative impact on cost effectiveness given the evidence on comparative efficacy of the programmes and the likelihood of digital delivery being no more costly than in-person. Emerging evidence from the US has found that DDPPs are cost-effective and potentially even cost saving compared with in-person programmes.[26, 27]

14. An SHTG budget impact analysis found that DDPP implementation can lead to a substantial return on investment in terms of cost avoidance. Modelling shows that the

total costs associated with routine healthcare provision, monitoring and prescription medicines over an eight-year horizon were lower compared with no intervention.

Contents

Key messages 1
What were we asked to look at? 2
Why is this important? 2
What was our approach? 2
What next? 2
Key points 3
Contents 6
Definitions 8
Introduction 9
Literature search 10
Health technology description 10
NHS England's Healthier You: Digital Diabetes Prevention Programme 10
Table 1 Variability in features of the NHSE-DDPP provider programmes* 11
NHSE-DDPP – access to provider programmes 12
NHSScotland digital diabetes prevention programmes 13
Epidemiology 13
Clinical effectiveness 14
Diabetes prevention programmes 14
Digital diabetes prevention programmes 14
Patient and social aspects 21
Inequalities/equality considerations 22
Organisational issues and considerations 23
Cost effectiveness 23
Cost effectiveness of the NHSE-DPP 24
Cost effectiveness of digital versus in-person programmes 27
SHTG budget impact analysis 27
Table 2: Base case model parameters and key assumptions 28
Table 3: NDH to T2D conversion rates applied to two arms of the model 29
Table 4: Base case results 29
Conclusion 30
Identified research gaps 31

Acknowledgements....32
Healthcare Improvement Scotland development team....32
Peer reviewers....32
References....34
Appendix 1: abbreviations....38

Definitions

Type 2 diabetes (T2D) – a chronic disease characterised by high levels of sugar in the blood, either because the pancreas does not produce enough insulin or because the body does not respond to insulin. T2D is linked to being overweight or inactive, or having a family history of the disease. Treatment for T2D involves controlling blood sugar levels either through medication or by supporting patients to change their diet and activity levels.[3, 4]

Non-diabetic hyperglycaemia (NDH) or prediabetes – the decreased ability of the body to regulate glucose effectively, through mechanisms such as impaired glucose regulation, impaired glucose tolerance or impaired fasting glucose.[4] In people with NDH, blood glucose levels are above normal but not in the diabetic range (HbA1c 42–47 mmol/mol (6.0–6.4%) or fasting plasma glucose 5.5–6.9 mmol/l).[3]

A diagnosis of NDH is associated with an increased risk of developing T2D and other diabetes-related conditions.[4]

Diabetes prevention programmes (DPPs) – evidence-based intervention programmes aimed at preventing or delaying the onset of T2D in people at high-risk of developing T2D. DPPs provide personalised plans and strategies to help people make behavioural changes that result in healthier lifestyle choices and consequently reduce their risk of developing T2D. Information, advice and support are delivered using in-person (face-to-face) models.[3]

Digital diabetes prevention programme (DDPPs) – DPPs that are delivered digitally. Information, advice and support are delivered using a combination of digital technologies, such as smartphone apps, websites, videoconferencing and wearable devices such as smartwatches.[3]

Introduction

T2D occurs when the body no longer produces enough insulin to regulate blood glucose levels or has developed resistance to the insulin that is produced. T2D is no longer seen as a progressive and irreversible disease. Prevention and remission are possible with clinically effective interventions, notably weight loss. This provides a powerful tool to address the rising trajectory of T2D incidence and related ill health in Scotland.[28]

T2D does not affect our population equally. In Scotland, people living in the most deprived communities have a 77% greater chance of developing diabetes than those in the most affluent areas. Many of the factors that drive T2D risk cannot be controlled by the individual. These social determinants of health are the social, cultural, political, economic and environmental conditions into which people are born, grow up, live, work and age, and their access to power, decision making, money and resources that shape the conditions of their daily life. These have a significant impact on the ability to prevent and manage T2D effectively.[28]

At the individual level, non-modifiable risk markers such as increased age, ethnicity and genetic predisposition contribute to a person's overall likelihood of developing T2D. Even though some people may feel healthy, they can still be at risk of developing the condition. At the time of diagnosis, people from minority ethnic populations, particularly those of South Asian ethnicity, in the UK are, on average, younger, have a lower body mass index (BMI), and higher HbA1c levels than white or European populations.[28]

People with NDH or prediabetes have a higher risk of developing T2D though they may have no symptoms.[29] The asymptomatic nature of NDH means that people may go undiagnosed and untreated, remaining at a higher risk of developing T2D.[30] About 11% of people with obesity and NDH progress to T2D every year.[21] The NDH population is an important group to target in T2D prevention.[2]

Behavioural interventions that focus on healthy eating, weight loss and increased physical activity, can prevent or delay the onset of T2D.[4-6] These interventions can be delivered to individuals or groups either in-person or via digital models. Traditional in-person methods have been shown to be effective in preventing or delaying the onset of T2D.[7-9] In-person interventions have limitations in reaching and engaging some at-risk populations, for example, younger people, people who are averse to group interactions, and those with work or caring commitments.[3]

The digital delivery of behavioural interventions can improve the reach, access and overall uptake of preventive interventions.[31]

Research question

What is the clinical and cost effectiveness of DDPPs?

Literature search

In 2023, we carried out a systematic search of secondary literature to identify systematic reviews, health technology assessments and other evidence-based reports. Medline, Medline in process, Embase and Cochrane databases were also searched for systematic reviews and meta-analyses. Results were limited to English language publications from 2013 onwards. Key websites were also searched for guidelines, policy documents, clinical summaries, economic studies and ongoing trials.

We carried out an updated search, across the same databases and websites, from 13–18 November 2024. Additional studies were identified from the peer review process carried out in February 2025.

Concepts used in all searches included: type 2 diabetes/prevention/app, web, digital, online/coach, clinician, dietitian. A full list of resources searched, and terms used is available on request.

Health technology description

A DDPP uses digital technologies, such as smartphone apps, websites, telehealth services and wearable devices (smartwatches), to deliver evidence-based behavioural and lifestyle interventions aimed at preventing or delaying the onset of T2D in people at risk.

The DDPP being considered by ANIA for NHSScotland is a nine-month integrated intensive lifestyle modification programme delivered via bespoke digital technology. The DDPP will comply with the recommendations set out in the National Institute for Health and Care Excellence (NICE).public health guidelines, on T2D prevention in people at high risk and the Scottish Intercollegiate Guidelines Network (SIGN) guidelines on prevention and remission of T2D.[28, 32] This includes offering ongoing tailored advice, support and encouragement to people through established BCTs.

This assessment is focused on programmes which meet the NICE criteria for DDPPs and focuses on the NHS England DDPP.

NHS England's Healthier You: Digital Diabetes Prevention Programme

In 2016, the Healthier You: NHS Diabetes Prevention Programme (NHSE-DPP) was established which aimed to prevent or delay the onset of T2D in adults with prediabetes. The NHSE-DPP is based on specifications in the NICE guidelines on the prevention of T2D in people who are high risk. It sets out BCTs such as information provision, goal setting, action planning, coping plans and relapse prevention.[32] These BCTs are considered the active ingredients that produce the required behaviour change to facilitate improvements in diet and physical activity. The programme is a group-based model delivered predominantly in-person over a minimum of 9 months, with at least 16 hours of contact time.[6] The various aspects of the NHSE-DPP such as uptake and retention, implementation considerations, programme outcomes and stakeholder experiences have been evaluated.[33]

The digital service (NHSE-DDPP) was introduced in 2019 to address age-related inequalities in the uptake of the NHSE-DPP. With the introduction of digital tools, patients can be offered a tailored combination of in-person and digital interventions. This includes support from health coaches (ranging from brief onboarding calls to weekly coaching phone calls), using apps for accessing peer support groups and goal setting/monitoring, and using wearable technologies for tracking physical activity. Educational materials are provided through websites, emails and smartphone apps.[3]

Between 2019 and 2022, four independent providers were commissioned to deliver the NHSE-DDPP on behalf of NHS England. Participants were assigned to service providers based on their local geographical area. Although all four services were based on a common NHS England service specification, there was variation in how the interventions were delivered across the providers (*Table 1*). Variability included the inclusion of wearable technologies (such as accelerometers and wireless weighing scales), the level of human support provided, type of delivery platform (smartphone app and website), and the format and degree of educational materials provided.[3]

Eligible participants were identified from primary care lists or during NHS Health Checks offered to people aged 40 to 74 years. Participants were informed of their high risk of developing T2D and offered referral to the programme.[3]

Adults aged 18 years and above, having at least one glycated haemoglobin reading of 42 to 47 mmol/mol or at least one fasting blood glucose reading of 5.5 to 6.9 mmol/L in the 24 months before referral are eligible for the programme. Women with a history of gestational diabetes were eligible from 2024. Pregnant women and people already diagnosed with diabetes are not eligible for the programme.[3]

Table 1 Variability in features of the NHSE-DDPP provider programmes*

NHSE-DDPP features	Provider A	Provider B	Provider C	Provider D
Materials provided to service user	Programme app	Programme app and programme handbook	Programme app	Programme app, programme handbook, recipe book, wireless scales and activity tracker
Educational content	42 web-based articles	Weekly articles (available via app and website) on a weekly topic	Bite-sized videos and written modules to supplement participant learnings—these are assigned by the health coach	Web-based articles that are unlocked daily and 8 optional 4-week web-based courses

Professional input	Health coaching via series of scheduled telephone calls and web-based chat	Access to health coaches via chat function	Health coaching via an initial telephone call, then regular video messages and web-based chat	Health coaching in a web-based message service with a group of approximately 10 people (access to health coach in group or one-on-one chat)
Peer support	None[ǂ]	Optional web-based discussion forum	Optional web-based discussion forum	Optional web-based discussion forum Peer support via closed group chats during the first 12-weeks, consisting of 10-15 people per group and moderated by a health coach

*Based on the evaluation of the NHSE-DDPP in 2019-2022. The programme has since been re-commissioned resulting in different providers or adaptations to programmes.

[ǂ]At the time of the evaluation, Provider A did not offer group support. A 'group support pathway' was introduced later.

NHSE-DDPP – access to provider programmes

When the NHSE-DDPP contractual framework was introduced in 2019, results from the pilot were emerging. A cap of 20% was placed on the number of digital referrals. Individuals had to have been offered in-person sessions, and subsequently decline them, before being referred to the digital programme. In response to the COVID-19 pandemic, all in-person group sessions were suspended from March 2020. Participants were offered remote group sessions via telephone or video consultations, or they could choose to pause the programme until in-person sessions resumed. New participants were given the option to participate in the remote group sessions or the online digital programme, and the 20% cap on digital referrals was removed.[22]

Due to limited access to blood tests during the pandemic, eligibility for the programmes was expanded to include people with glycaemic test results from the last 24 months, instead of 12 months. In July 2020, a national self-referral option was introduced, allowing people to assess their risk of T2D using the 'Know Your Risk' tool on the Diabetes UK website. People could refer themselves directly to the digital programme if they were eligible.[22]

NHSScotland digital diabetes prevention programmes

There is currently limited and variable provision of T2D prevention programmes for patients with NDH across Scotland. Three health boards offer digital prevention programmes that meet the SIGN and NICE criteria. A total of 5,700 patients with prediabetes were referred to Health Board Adult Weight Management teams for some type of support, with slightly over 50% taking up this offer in 2023/24.

Ten health boards offer a range of prevention programmes delivered by local professional staff using either in-person or video groups (synchronous online group sessions delivered via videoconferencing platforms). These programmes do not meet the SIGN and NICE criteria. Approximately 695 people with prediabetes in Scotland have accessed a SIGN compliant DDPP within the past 12 months, which until April 2025 has only been available in four Health Boards.

For most parts of the country, there appears to be limited provision of T2D prevention programmes. A national DDPP would address this variation in availability and access for NDH patients.

Epidemiology

The Scottish Diabetes Survey 2023 is the most recent source of national diabetes epidemiology, based on registry data.[34] According to the survey, there were 310,541 people living with T2D in Scotland at the end of 2023, with 25,606 people newly diagnosed that year.[34] This represents an increase from 287,606 people living with T2D, with 22,221 people newly diagnosed at the end of 2021.[1] T2D accounts for around 88% of all people with diabetes nationally.[1, 34]

In terms of diabetes complications 9.4% of people with T2D were recorded as having had a previous myocardial infarction, 7.3% recorded as having cardiac revascularisation, 21.1% recorded as having diabetic retinopathy, 3.8% recorded as having had a foot ulcer, 0.6% with end stage renal failure,[34] 5.4% recorded as having had a stroke, 0.5% with lower limb amputation[1] and 3.7% recorded deaths.[34]

The incidence of diabetes is related to the prevalence of health inequalities in Scotland. In 2021, the proportions of people aged 35 to 84 years with T2D in Scotland were approximately twice as high among people in the most deprived areas compared with those in the least deprived areas.[35] The impact of diabetes on disability adjusted life years is 2.5 times greater in the most deprived areas compared with those living in the least deprived areas.[36, 37]

The average age at which people are diagnosed is changing. T2D is now affecting greater numbers of young people.[38] In 2023, 31,748 cases of T2D were in people aged between 20 and 49 years, and 9,010 were aged between 20 and 39 years.[34] In 2021, 27,911 cases of T2D were in people aged between 20 and 49 years, and 7,737 were aged between 20 and 39 years.[39]

Compared with women, more men are overweight or obese and as a result are at a higher risk of developing T2D.[40] In Scotland, 56.2% of people with T2D are male and 43.8% are female.[34] Men are less likely to perceive their weight as being a problem and less likely to engage with weight management programmes.[40]

Younger people, men and people living in more deprived areas are target populations for use of DDPPs where the aim is to reach the wider population that do not traditionally engage with in-person programmes.[22]

Clinical effectiveness

Diabetes prevention programmes

The clinical effectiveness of diabetes prevention is supported by a large body of published evidence on in-person, group-based, behaviour change programmes.[7-9] Studies have shown that people with prediabetes or NDH have been prevented or delayed from progression to T2D, having benefitted from reductions in body weight and blood glucose levels.[5,6]

A cohort study investigating the impact of referral to the NHSE-DPP (from April 2016 to March 2020) reported a 20% lower risk of developing T2D for those referred to the programme compared with those who were not referred.[4] A total of 18,470 patients referred to DPP were matched to 51,331 patients not referred to DPP. Mean follow-up from referral was 482 and 472 days, for referred to DPP and not referred to DPP, respectively. The study observed smaller associations with risk reduction compared with observations from randomised controlled trials (RCTs).[41-43] This was deemed to be due to the study examining the impact of the referral, rather than solely the attendance or completion of the intervention.[4]

Digital diabetes prevention programmes

NHSE-DDPP effectiveness

Several systematic reviews conclude that patients who are at risk of diabetes can be offered technology-assisted DPP and weight loss interventions to lower their risk of incident diabetes.[44-47] These weight loss interventions are outwith the scope of this assessment due to the heterogeneity in DPP programme structures and types of technology implemented.

We identified five studies[5, 10-12 13] that investigated the clinical effectiveness of NHSE-DDPP. Three studies, including a 6-year evaluation, concluded that the NHSE-DDPP can achieve broadly equivalent results to the traditional in-person model (NHSE-DPP).[5, 10, 13] The studies compared weight change between in-person, digital-only and digital-choice cohorts of the NHSE-DPP. The 6-year Diabetes Prevention Long Term Multimethod Assessment programme (DIPLOMA) evaluation was commissioned by the National Institute for Health and Care Research, to evaluate the implementation and impact of the NHSE-DPP.[5]

A complete case analysis of participants recruited to the NHSE-DPP in 2017-18 found that weight change in the digital pilot was similar to in-person delivery. Mean weight loss was greater among those who were offered a choice and selected the digital option, compared with in-person delivery (difference in weight change: −1.165 kg (95% confidence interval (CI): −1.841, −0.489). The weight change was similar among participants who were not given a choice (−0.284 kg, 95% CI: −0.712, 0.144).[10]

Due to a substantial amount of missing data in the complete case analysis, a second analysis was conducted to estimate the average effect in everyone who enrolled in the digital or in-person cohorts. Enrollment in the digital cohorts was associated with clinically significant weight loss, which was at least equivalent to the weight loss achieved in the in-person programme. The authors concluded that patients should be offered the choice between in-person and digital delivery.[10]

Another service evaluation of the NHSE-DDPP found that during the COVID-19 pandemic, weight loss achieved using remote and digital interventions was greater than losses previously achieved through group-based in-person interventions, and was greater for people using digital compared with remote interventions.[11] Data from three groups of participants was analysed: participants who attended at least one remote intervention session (n=131,100); participants who engaged with at least one digital intervention session (n=26,169); and participants who attended in-person intervention session (n=119,367).[11]

People who completed the programme remotely had mean weight changes of −3.24 (−3.30 to −3.19) kg. This was −4.76 (−4.92 to −4.60) kg for people taking part digitally and −3.04 (−3.07 to −3.00) kg for those taking part in-person. Linear regression analysis showed that after adjusting for age, sex, ethnicity and deprivation, remote participants lost 0.31 (0.25–0.37) kg more weight, and digital participants lost 2.26 (2.11–2.41) kg more weight, compared with in-person participants. Remote and digital participants were younger (60 and 56 versus 65 years) and heavier (86.1 kg and 91.0 kg versus 84.1 kg) compared with in-person participants.[11]

A large-scale pilot evaluation of nine areas across England found that participation in the NHSE-DDPP was associated with clinically significant reductions in weight and HbA1c.[12] Data from adults with NDH in the 12-months prior to referral were collected prospectively. The digital interventions offered included a website, telephone service, peer support and monitoring tools. HbA1c and weight readings were recorded at referral (baseline) by general practices and then at 12-months after registration. Demographic data and service variables were collected from the providers. About 75% (n=2,734) of the participants (n=3,623) with NDH that registered for the DDPP were included in the analyses. Final (12-month) follow-up data were available for 50% of the registered participants for HbA1c (n=1,799) and weight (n=1,817).

Participation in the digital service was associated with clinically significant mean reductions in both HbA1c (−1.6 mmol/mol, $p<0.001$) and weight (−3.1 kg, $p<0.001$) at 12 months. These outcomes were comparable with those for patients receiving the in-person intervention. Access to a website, telephone service and peer support was associated with significantly ($p<0.001$) greater reductions in HbA1c and weight. Demographic characteristics associated with greater weight loss include being

older, having a degree and being from the second least deprived socioeconomic group. Greater reductions in HbA1c were associated with people living in mainly rural areas. The study concluded that DDPPs can be implemented at a national scale across NHS England.[12]

These studies illustrate that DDPPs can achieve at least equivalent results to the traditional in-person DPP model.

NHSE-DDPP uptake and engagement

We identified seven studies that examined factors influencing uptake and engagement of the NHSE-DDPP. [3-6, 15, 20, 21]

The DIPLOMA evaluation found that of those referred to the programme, 50% started it and 20% completed it.[5] Different providers and practices experienced different levels of participation. Both digital and in-person models faced similar issues regarding the factors that influence an individual's decision to join and engage with the programme. Uptake was found to depend on people's sense of personal control over their health (self-efficacy), as well as their perception of their risk of developing T2D and the potential benefits of the programme. The importance of receiving support from a professional remained vital in both models. The evaluation concluded that group support may not be needed for a digital service as there was low engagement with group support forums and more engagement with closed peer group chats (10–15 people). Outcome-based payments (paying practices based on the number of referrals they generate) were found to be the only effective way to support practices to make referral and encourage uptake.[5]

The extent to which the intervention was implemented as intended varied across providers. There was also evidence of a drift away from the NICE criteria. This included how providers planned to deliver the intervention, how staff were trained and what was offered to participants.[5]

One study reported high rates of patient engagement with apps within the first 30 days of programme enrollment.[20] Overall, 94.37% (12,133/12,857) of patients used the apps in the first 30 days, with the number of engagement days ranging between 2 and 25 days (median=11 days). The most engaged features related to tracking events, while the least engaged features related to peer support. There were differences in how patients engaged with app features across providers. The results support the importance of health coaches, the provision of regular content and use of reminders to improve early engagement.

Three studies highlighted the importance of understanding referral processes, self-belief, motivation, support, and ease of access in users' decisions to start and stay engaged with DDPPs.[3, 4, 21] Ease of access and the presence of health coaches and monitoring tools were essential for participant engagement. Psychosocial perceptions, such as beliefs about T2D risk and self-efficacy, also play a role in uptake.[21]

A qualitative study of the NHSE-DDPP exploring participants' perceptions and use of the BCTs specified by NICE also highlighted the importance of health coaches.[6] The study interviewed 45

service users twice during the programme. The emotional support and assistance with specific BCTs provided by health coaches were essential in supporting participants. Participants expressed frustration regarding the lack of monitoring and feedback on their T2D risk. Variations in how the interventions were delivered were observed among different providers. The study noted that health coaches play a crucial role in delivering key programme components and emphasised the need for additional human support even in digital interventions.

A user engagement study analysed usage data from 1,826 participants enrolled with three independent NHSE-DDPP providers from December 2020 to June 2021.[15] Key findings include a decline in app usage over the 9-month period, with variations among individuals and providers. Users frequently engaged in self-monitoring behaviours but rarely used group discussion forums. Features like goal setting had higher engagement when linked to health coach support. The study further suggests that health coach support may enhance engagement with specific features.

We identified three qualitative studies evaluating people's experiences from the rollout of the NHSE-DDPP.[16, 17, 22]

The give year study explored how service users engaged with and experienced the NHSE-DDPP, and how variations across four provider programmes might impact experience or engagement.[16] One provider did not offer proactive health coach support.[16] Semi-structured interviews were conducted with 45 service users, who were 2–4 months into the programme. Participants ranged in age from 21 to 78 years, with a median of 59 years. The majority of participants (n=31, 69%) were from socioeconomic deprived areas.

Service users valued the personalised support from health coaches, which helped tailor the programme to their individual needs and facilitated behaviour change. Health coaches provided specific guidance based on participants' logged behaviours, such as offering dietary suggestions. All participants used the app regularly. They engaged with different features based on their preferences. Goal setting and tracking features were reported as the most frequently used functions.[16] Support from social circles (for example, family and friends offering both practical and emotional support) was cited as being a key enabler of behaviour change. Participants noted that this type of social support helped with initiating and maintaining behavioural changes.[16] This reinforces the importance of including non-digital elements, particularly human contact, as part of the programme.

The results suggest that DDPPs should incorporate human elements, such as health coaches and support from social circles, to enhance user experience. The study recommended that future research should explore the experiences of participants later in the programme and investigate why some users disengage. Understanding these factors could help tailor DDPPs to a wider population and improve their effectiveness.

The second study examined service user engagement and experience of using online group support features within the NHSE-DDPP.[17] Support features offered by the four service providers included health coach moderation, group discussion forums and group chats. A total of 33 participants were

recruited to the qualitative interview study. Of these, 55% were female, median age was 57 years, 48% were from less deprived areas and 79% were reported as being White British.[17]

Participants taking part in the digital programme were interviewed via telephone at the beginning (2–4 months, n=33) and end (8–10 months, n=26) of the programme. Providers offered weekly contact during weeks 1–12 and gradually reduced the support offered during weeks 13–40, the maintenance phase. Data was analysed for three of the four service providers who offered group support as part of their service provision. One provider did not offer an online support group function at the time of the evaluation.[17] One provider offered a group chat function (similar to WhatsApp group chats) and the other two providers offered discussion forums.

The study did not report specific numbers associated with some of the findings. Almost all findings were based on experiences of participants from a single provider. Participants reported greater engagement with group chats during the first three months, especially when these were moderated weekly by a health coach. Engagement tended to decline in the maintenance phase as contact reduced. Participants from one provider emphasised the importance of health coach moderation in encouraging participation and maintaining momentum, noting that group discussions became less active without coach involvement.

Only one provider offered a leaderboard feature, which tracked the cumulative steps of the group. While exact numbers were not provided, the feature was noted as being especially motivating for male participants, fostering competition and a sense of achievement. In contrast, some female participants found it discouraging and felt it added pressure, negatively impacting their confidence.[17]

The third study was a longitudinal, mixed-methods evaluation of the NHSE-DDPP, which explored how local processes were implemented and adapted across sites over time.[22] Between October 2019 and January 2020, 24 semi-structured interviews were conducted by telephone with 26 local implementation leads from selected case sites. Subsequently, 13 interviews were held with local leads between July and August 2020. The interviews were designed to capture reflections on the implementation process and examine how implementation evolved over time.

The introduction of the digital service in August 2019 was met with positive reactions by all 26 respondents. They viewed the digital expansion as a way of offering access to patients who either could not or did not want to attend in-person sessions, particularly younger, working-age people and those living in rural areas.[22] During the first round of interviews, concerns were raised about the delivery of the digital service. Respondents were apprehensive about the requirement for patients to decline in-person sessions before being offered the digital option. They felt that this could risk disengagement due to someone having to reject the programme initially. Another concern was that the 20% cap on digital referrals was seen as too low to meet demand, especially in areas with high referral targets.[22]

By the time of the second interviews, and after in-person sessions had been paused due to the COVID-19 pandemic, the digital service delivery was viewed in further positive light. The local implementation leads praised the providers for quickly transitioning to remote options and offering

technological support to participants. The shift to remote delivery was also perceived as improving accessibility for people with mobility issues and people living in rural areas.[22] The study recommended that policy makers should consider maintaining the option for the digital programme to run alongside in-person sessions to enhance access for a wider range of participants.[22]

The results from the studies on NHSE-DDPP are generalisable to Scotland as they have been conducted in similar health settings and policy contexts.[3-6, 10-12, 13, 15-17, 20-22]

Evidence from the pilot phase of the Irish National Diabetes Prevention Programme (Irish NDPP).

The Irish NDPP pilot was launched by the Health Service Executive (HSE) between June 2021 and September 2022. The programme was aimed at achieving 5%–7% weight loss, 150 minutes of physical activity per week (including two sessions of resistance exercise) and dietary goals (increased dietary fibre, less than 30% total fat and less than 10% saturated fat).[19]

Participants were primarily recruited from community dietetic waiting lists and through referrals from GPs and clinical nurse specialists. People with HbA1c levels of 42–47 mmol/mol (6%–6.5%) or fasting plasma glucose of 6.1–6.9 mmol/L and people with a history of gestational diabetes were enrolled into the programme. Pregnant women and individuals with T2D, severe physical or intellectual disabilities, or moderate-to-severe psychological issues were excluded.[19]

We identified two studies of the Irish NDPP and a related systematic review.[18, 19, 48] The first study was a survey describing the demographic and psychosocial characteristics of the NDPP participants.[18] The second was a qualitative study that examined the factors influencing participation.[19]

The first study invited individuals who had attended the initial assessment of the pilot NDPP (n=73) to complete a survey. A total of 22 people responded, aged between 36 and 82 years (mean age=62 years). More than half were men (n=12, 57.1%). Most of the participants had family members or friends with diabetes (n=19, 90.5%) and high quality of life scores (n=15, 71.4%). The majority of participants attended six or more sessions (n=17, 81%) and most believed it was crucial to manage their diabetes risk (n=20, 95.2%). Although the study had a low response rate (30.5%), more than half of the participants were confident about participating in the online programme (n=12, 57.2%). Almost all of the participants (n=20, 95.2%) believed it was important to manage their risk of T2D.[18]

The second qualitative study gathered data from 13 participants and educators, and identified four key themes that influenced participation in the Irish NDPP.[19] First, a lack of awareness about prediabetes, combined with a fear of diabetes, motivated participants to join the programme. Second, both participants and educators recognised the need for structured support to help individuals change their health behaviours. Third, trust in healthcare professionals was crucial, as participants relied on them to convey the seriousness of prediabetes and the benefits of the programme. Finally, the online format encouraged engagement from groups like working individuals and men.[19]

The systematic review explored the facilitators and barriers to DPPs. The review highlighted the need for clear communication and resource allocation to improve referral pathways and processes. Healthcare workers were found to play a pivotal role in the referral process. Some of the barriers identified in the review included limited awareness and understanding of the effectiveness and availability of DPPs. Raising awareness of programme benefits was also considered essential to overcome barriers and improve uptake.[48]

Despite limitations in generalisability of the studies of the Irish NDPP (for example due to small sample sizes, absence of clinical effectiveness data, and differences in healthcare systems), the experiences gathered may help to guide the use of online programmes in Scotland, for example when considering the value of services for remote or rural areas of Scotland where in-person services are less feasible.

Evidence from the United States Digital Diabetes Prevention Programme (US-DDPP)

Evidence from the US-DDPP demonstrates that digitally delivered interventions can improve and sustain health outcomes.[49] Five studies assessing the impact of the national US-DDPP were identified.[14, 50-53]

One study concluded that the US-DDPP resulted in health benefits regardless of the specific programme.[50] The study examined 776 adults with prediabetes who enrolled in either a variation of in-person programmes (led by certified diabetes educators, trained peer instructors or trained lifestyle coaches) or an online digital programme led by personal health coaches with virtual group meetings. Regardless of the type of programme, individuals achieved health benefits. Blood pressure, lipid and HbA1c levels improved across all programmes, with no significant differences among the programmes at 1 year or 2 years. There were no significant differences among the programmes in the incidence of T2D at 1 year (8%) and at 2 years (11%).[50]

In a 2-year study of the US-DDPP, participants (n=155) who completed the programme experienced a 4.9% loss in mean baseline body weight after 1 year ($p<0.001$) and a 4.3% loss after 2 years ($p<0.001$). HbA1c levels improved with reductions of 0.40% after 1 year and 0.46% after 2 years. Each participant received a wireless scale, had an assigned health coach and was part of a 10 to 15 person virtual group.[51]

The results from a non-randomised trial (n=220) of the US-DDPP demonstrated that participants who engaged in four or more sessions during the first year sustained a −3.0% weight loss after 3 years ($p = 0.0009$). Those who participated in nine or more lessons during the first year sustained a −2.9% weight loss after 3 years ($p = 0.0024$).[14]

Feasibility studies adapted the US-DDPP for low-income, Hispanic and older adult populations. Adaptations included simplifying the curriculum to a fifth grade reading level, cultural appropriateness and a Spanish version. These adaptations led to high engagement and satisfaction rates, particularly among low-income and Hispanic populations (people from South and Central America including Mexico).[52] An observational study among older adults (mean age=68.8 years)

reported meaningful engagement and a 7.5% loss in mean body weight at 12 months (p=0.001) for participants who used the US-DDPP.[53]

The results from US-DDPPs provide evidence that national DDPPs can be successful in promoting sustainable weight loss, improving glycemic control and making effective interventions accessible to diverse populations. Adaptations to the US-DDPP (such as simplifying content for readability, ensuring cultural relevance and offering a Spanish version) offer valuable insights for the development of a more inclusive and accessible DDPP for use in NHSScotland.

Patient and social aspects

SIGN guidelines noted that sensitive and person-centred communication is central to improving health outcomes and supporting behaviour change. Healthcare professionals are encouraged to adopt a collaborative, tailored and trauma-informed approach that considers each person's individual and social context and resources.[28]

While lifestyle changes, especially weight loss, are a core part of the recommendations for diabetes prevention, it is important to consider when additional caution may be required in providing advice to minimise the risk of unintended harm. It is essential to ask permission before starting any discussions linked to overweight and obesity. The stigma associated with living with obesity can be distressing for many people and can impact outcomes. It is essential that all healthcare professionals have an awareness and understanding of this and undertake suitable training on how to practice in a non-stigmatising way. Weight stigma, bias and discrimination can cause considerable harm including compromised psychosocial wellbeing, depressed mood, increased metabolic risk factors and lower self-esteem.[28]

Additional caution is recommended in conversations with those who have, have had, or are suspected of having, an eating disorder of any kind. Weight-loss attempts may be contraindicated and may exacerbate or maintain the condition.[28]

NICE guidance states that the delivery of DPPs should take into account the local social and cultural contexts to ensure relevance and effectiveness.[54] The equality and diversity considerations for patients with prediabetes, outlined by NICE, involve ensuring that information shared is:

- easy to read and understand
- tailored to the unique needs of the prediabetic population, including older individuals, people from different socioeconomic backgrounds, people who are socially disadvantaged and people with disabilities
- culturally sensitive and appropriate to the needs of adults from different ethnic backgrounds
- age-appropriate
- accessible to adults who do not speak or read English, possibly through translations or interpretation services.

Adequate consideration should be given to individuals with hearing or visual impairments or learning disabilities. Alternative provision should be made for adults who may have difficulty accessing services in traditional healthcare settings.

The learning from the DIPLOMA evaluation[5] supports the considerations outlined by NICE. The evaluation recommended ways to improve patient uptake and consistency with the NICE specifications, including:

- adequate discussions about attendance, NDH and the risk of T2D from trained healthcare professionals
- tailored messages with clear information about diabetes risk, what the programme involves and its value
- local champions or leads to support practices to make referrals
- offering payments based on the number of referrals practices generate
- undertaking equality impact assessments to understand local demographics and identify at-risk populations to target.

Inequalities/equality considerations

A citizens' panel third survey report highlighted several equality considerations relevant to the implementation of digital diabetes prevention programmes. The report identified that certain groups (such as older adults, individuals from lower socioeconomic backgrounds and those with limited digital literacy) may face barriers to accessing and benefiting from digital health interventions. These barriers include lack of access to digital devices, unreliable internet connectivity and limited confidence or skills in using digital technologies. These disparities can lead to unequal participation and outcomes.[55]

A review of the NHSE-DPP identified inequalities in service provision or uptake relating to the areas, organisations and patient populations most likely to engage with the programme. Areas of concern included how people from more deprived communities are included, in terms of selection into and completion of the programme.[5]

There is a potential for some population groups to experience exclusion arising from a digital delivery model. The factors that influence this "digital divide" include age, region, socioeconomic status and whether a person has a disability. Older individuals might not be familiar with, or have access to, a smart device to access the web app.

Service evaluations of the remote and digital models of the NHSE-DPP did not observe any effects of the digital divide with regard to age, and found no association with exacerbation of health inequalities compared with an in-person approach.[11, 12]

Organisational issues and considerations

A mixed methods study, involving a review of NHSE-DDPP providers' design and delivery documentation as well as interviews with 12 health coaches and six programme developers, reported a relatively high adherence to the NHS service specification in terms of structural design.[56] There was variation in how providers delivered certain elements of the NHSE-DDPP, especially in terms of inclusion of health coaches and/or group support and the extent of support offered to participants.

The study found that:

- health coaches enhance service user engagement, experience and understanding of intervention content, even in DDPPs
- all health coaches, regardless of professional background, receive in-depth training in BCTs and how to deliver behaviour change support, prior to programme implementation
- consideration of the type and extent of digital group or peer support provided is important, as service users tend to value closed group chats moderated by a health coach.[56]

A cross-sectional analysis of BCT content in the NHSE-DDPP noted that DDPPs are complementary to in-person services, and their effectiveness depends on their content in terms of self-management and behaviour change, and how users engage with the different modes of delivery. In practice, a combination of delivery methods, such as educational materials, health coaching, online peer support, access to messaging platforms and apps with ability to set and monitor goals will help maximise user engagement.[57]

More research is required to investigate whether a variation in delivery has implications for the effectiveness of DDPPs.[6]

Cost effectiveness

The published economic evidence for T2D prevention programmes generally relates to interventions delivered in-person. As digitally delivered programmes have been shown to be equally effective as in-person interventions, the cost effectiveness conclusions might be considered generalisable provided the pricing or reimbursement structures associated with DDPPs are not significantly different from that of in-person delivery.[5, 10, 11]

A 2020 systematic review reporting on the cost effectiveness of T2D prevention interventions among high-risk individuals and whole populations included 28 studies on targeted interventions, of which six involved a choice of in-person or digital mode of delivery.[58] Most of the studies were based on simulation modelling. Eight studies assessed prevention strategies using RCTs. Screening for prediabetes and providing either lifestyle or pharmacologic interventions, were cost effective from a US health care system or a societal perspective, with median incremental cost-effectiveness ratios (ICERs) of $12,510/QALY and $17,089/QALY (equivalent to £12,100/QALY and £16,500/QALY at 2022

levels), respectively, compared with no intervention. Lifestyle programmes using the translational DPP curriculum (used in the US national DPP) were more cost effective than those interventions which did not follow the DPP curriculum.

A second systematic review included 27 economic evaluations of lifestyle interventions, either alone or in combination with a screening programme to identify high-risk individuals.[59] The majority of studies evaluated intensive trial-based interventions, although there was substantial heterogeneity in the type of lifestyle interventions evaluated (for example, frequency of contact, duration, staff providing intervention and individual versus group interventions). Lifestyle interventions were found to be cost effective but not cost saving in the short term. Screening plus intervention studies tended to be less cost effective than intervention only studies.

Another systematic review of economic evaluations of lifestyle interventions for T2D prevention published in 2016, reported that 15 of 20 included studies found that interventions based on lifestyle modifications were cost effective compared with usual care, metformin or placebo.[60] The review concluded that lifestyle interventions through physical activity or diet or combining both were generally cost effective, with a few exceptions.

Cost effectiveness of the NHSE-DPP

NHS England conducted an impact analysis, prior to the rollout of the NHSE-DPP, to estimate the resource implications of implementing the programme over the first 5 years (2016–21). It was estimated that the NHSE-DPP would cost approximately £105 million (£115 million including implementation and support costs), but yield net positive economic returns from year 8, and be cost saving from year 14 onwards (year 18 with discounting).[23]

It was predicted that 18,000 cases of T2D would be prevented or delayed in a cohort of 390,000 participants over 5 years. The financial impact of prevented cases over a 20-year horizon was net cumulative savings in the region of £35 million. The model estimated that 1,000–1,500 cumulative cases of CVD could be avoided in the first 5 years, with the peak annual reduction in CVD cases occurring in the fifth year of the programme.[23] These model projections were based on several key assumptions:

- the average cost of the NHSE-DPP was assumed to be £270 per participant enrolled (or £435 per participant who completes the programme) based on assumed retention rates at different milestones and the profiling of staged payments to providers
- assumed uptake rate of 37%
- the NHSE-DPP was implemented with full roll out achieved by end of year 3 and sustained for a further 2 years as follows: Year 1, 30,000 enrolled; Year 2, 60,000 enrolled; Year 3–5, 100,000 enrolled each year
- a validated and peer-reviewed patient simulation model of individual risk of developing T2D and disease progression where the full effectiveness of the DPP was applied to the first year only and assumed to decline linearly, reaching zero effect after 5 years.[23]

Analysis reports of the short-term costs and benefits of the NHSE-DPP have been published using data from 384,611 referrals between June 2016 and March 2019.[24] This study analysed data on provider payments supplied by NHS England to calculate the costs of all referrals received. Providers were paid based on session attendance and reaching milestones. It estimated the benefits of the NHSE-DPP in terms of the QALYs experienced by referred individuals, from initial assessment up to programme completion. The data used in the analyses relates to in-person delivery of the DPP rather than the digital pathway that has been rolled out in recent years.

From the cohort analysed, 52.4% of people referred went on to attend an initial assessment and 19.3% completed the DPP. Across the total cohort, people attended three sessions on average, increasing to 5.6 sessions when considering only those people who attended the initial assessment after being referred. Where recorded, people lost on average 3.3 kg between their initial assessment and final session.

The total cost of all referrals was approximately £44.19 million. The average cost per referral received was £119, rising to £286 per referral for people who completed the DPP (defined as completing at least 60% of programme sessions). Total implementation costs were £8.76 million, equivalent to an additional cost of £22.79 per referral.

Each session attended was associated with a 0.0042 increase in utility (95% CI 0.0025–0.0059). This generated 1,773 QALYs across all referrals (95% CI 889–2,656) attributed to the DPP. When weight change was included as a covariate in the regression analysis, session attendance was linked to a utility increase of 0.0034 (95% CI 0.0016–0.0051). Each kg lost was associated with a utility increase of 0.0025 (95% CI 0.0020–0.0031).

The results of the evaluation found that the DPP was associated with a cost per QALY of £24,929 excluding implementation costs (£29,874 including implementation costs). These cost per QALY estimates fall within the £20,000–£30,000 per QALY range that is commonly considered for an intervention to be cost effective by NHS England.

There were some key differences between the projections of the impact assessment, conducted prior to the NHSE-DPP rollout, and the observed estimates from this study.

For people who attended at least one session, the observed retention at the final milestone of the DPP was higher in reality than originally predicted (34.7% versus 20%), although this can be partly explained by the impact assessment not accounting for people who dropped out between referral and initial assessment.

The observed average cost per referral (£119) was substantially lower than predicted by the impact assessment (£270). The low levels of retention from referral to initial assessment (52.4%) could explain this lower cost as payments to providers on ‘activity only’ contracts were only reimbursed at the initial assessment stage.

The impact assessment estimated an additional 700–1,000 QALYs being generated within the first 5 years of the programme, while the observed analyses suggest an additional 1,541–1,773 QALYs within the first 3 years of the NHSE-DPP.

The results of the retrospective observational analysis show that the NHSE-DPP is associated with health gains even over a short time horizon, with the QALY gains being large enough to suggest that the programme could be cost effective even prior to including the longer-term benefits associated with diabetes prevention. The comparison of observed data to earlier predictions suggests that returns on investment for the NHSE-DPP may occur earlier than predicted.

The long-term cost effectiveness of the NHSE-DPP compared with usual care has been evaluated via a cost utility analysis conducted from the NHS England perspective.[25] A Markov cohort state transition model was used, with a 35-year time horizon. The comparator of usual care was specified as an annual blood test and BMI assessment.

The cost per referral to the NHSE-DPP and utility gains for programme participants were sourced from the 3-year analysis of the programme.[24] The long-term effect of delaying or preventing T2D was based on a previous matched analysis, which estimated the effect of being referred to the NHSE-DPP compared with not being referred.[4] This analysis found an adjusted hazard ratio of 0.80 (95% CI 0.73–0.87) for developing T2D within 36 months. This hazard ratio was applied to the transition probability of moving from the NDH state to the T2D health state and, in the base case, was maintained for three years.

While T2D-related complications were not included as discrete health state(s) in the model, the costs attributed to people being in a T2D state incorporated a range of disease severities, including those experiencing diabetes related complications. The costs associated with complications were therefore assumed to be captured within the cost distribution used in this model. The base case applied an average healthcare resource use cost of £3,717 (inflated to £4,421 in 2020 prices) per annum for individuals developing T2D.[25]

The results of a simulated cohort of 1,000 cases were applied to the number of actual referrals received by the NHSE-DPP (526,283 referrals by 31 March 2020) to estimate the total incremental costs and benefits incurred. The NHSE-DPP was found to 'dominate' usual care by generating an additional 40.8 QALYs and saving £135,755 in costs for a cohort of 1000, over the course of three years. The cost savings increased to £71.4 million over the course of 35 years and an additional 21,472 QALYs were generated when the results were scaled up to actual number of referrals (n) received by the NHSE-DPP.[25]

The dominance of NHSE-DPP was robust across a range of sensitivity analyses considering different effectiveness estimates of DPP, different cost and utility scores for model states, as well as different transition probabilities. Continued investment in the NHSE-DPP is predicted to lead to substantial cost savings in the future along with quality-of-life improvements.[25]

Cost effectiveness of digital versus in-person programmes

We identified two studies that assessed the relative cost effectiveness of DDPPs versus in-person programmes based on evidence from the US.[26, 27]

A retrospective cost effectiveness analysis compared a DDPP with small group education (SGE) over a 1-year time horizon, using data from a 12-month diabetes prevention RCT.[27] The DDPP was delivered entirely digitally and consisted of small group support, personalised health coaching, digital tracking tools, and a weekly behaviour change curriculum. Participants who were assigned to the SGE arm received a one-time, 2 hour-long, in-person diabetes prevention education class led by a health educator or graduate student with training in behavioural nutrition and physical activity interventions. The SGE in this study would be more reflective of usual care in the absence of a DPP in the UK context. The study does therefore not help inform the relative cost effectiveness of the NHSE-DDPP compared with the NHSE-DPP.[27]

A more comprehensive model compared the cost effectiveness of digital and in-person DPPs by using a meta-analysis of trial results and parametrising the onset of T2D complications, T2D-to-prediabetes remission rates, long-term effect attrition and incorporating adherence.[26]

The DDPP included 12-months of lessons on maintaining weight loss, with users able to access various health-promotion tools online. The in-person DPP was a lifestyle intervention programme that focused on achieving and maintaining weight loss, accompanied by a 16-lesson core curriculum on behavioural change. Adherence was modelled through full completion, partial completion and dropouts. Pooled treatment effects on HbA1c reduction for both DDPP and in-person DPP were derived through separate meta-analyses. Microsimulations were used to estimate the incidence of a T2D complication.[26]

In the base case, DDPP was the dominant option resulting in better outcomes at a lower cost compared with the in-person DPP. The DDPP generated an additional 0.08 QALYs and was less costly by $3,671 (£2,934) from a societal perspective and $2,989 (£2,389) from a healthcare perspective. By the end of the final model cycle, the DDPP had a lower share of patients with T2D and T2D complications (15.56%; 3.93%) compared with the in-person DPP (15.71%; 6.57%).[26]

The authors concluded that by mitigating access barriers and reducing costs in the USA, DDPPs are a better option for policymakers and payers, facilitating greater adoption of lifestyle interventions for T2D prevention at a lower implementation cost.[26]

SHTG budget impact analysis

We applied the most up-to-date information available from the NHSE-DPP in England to develop a budget impact model for the proposed Scottish DDPP.

The base case analysis estimated the net difference in health state costs between a targeted cohort of people with NDH starting a DDPP compared with them experiencing no intervention. Results are presented for a planned intake of 5,000 people annually for three consecutive years.

The model applied annual conversion rates from the NHSE-DPP analysis to estimate the number of individuals belonging to one of three health states: Normal glycaemic control (GC); NDH; T2D.[3] The costs associated with someone being in any particular health state over the course of a year was obtained from the cost effectiveness analysis of the NHSE-DPP.[25] Health state costs were lowest in GC and highest in T2D.

Health state costs were based on NHS England-specific resource use costs applied to resource use estimates. This includes activities such GP appointments, monitoring, prescriptions and in/out-patient hospital visits.

It was assumed that people completing the DDPP (defined as more than 60% attendance of sessions)[24] would move from a state of NDH to normal glycaemic control for the duration of the model. People only completing part of the DDPP (less than 60% session attendance) were assumed to remain in NDH initially but subsequently transition to T2D at observed conversion rates.[3]

Key parameters and assumptions informing the model are detailed in *Tables 2 and 3.*

Table 2: Base case model parameters and key assumptions

Parameter	Value	Source/Assumption
Cohort size	5,000 per year	Based on proposed Scotland wide 3-year pilot programme
Time Horizon	8 years	To capture health benefits for up to 5 years after commencement of DDPP for each annual cohort intake.
DDPP Completion rate	37%	NHSE-DPP analysis[24]
Utility gain (per session)	0.0042	NHSE-DPP analysis[24]
Annual conversion rates (NDH to T2D)	See *Table 3*	Matched cohort analysis of referrals to NHS-DPP [3]
Annual conversion rates (NDH to normal glycaemic control)	100% or 5%	DDPP arm: all programme completers convert from NDH to normal control for duration of model No-intervention arm: 5% of cohort convert from NDH to normal control
Health state costs (annual)	GC - £2,005 NDH - £2,224 T2D - £4,420	Long term cost effectiveness analysis of NHSE-DPP[17]
Cost of DDPP	£250	Estimated supplier cost of DDPP program is expected to be in the range of £180 - £250 per person

Table 3: NDH to T2D conversion rates applied to two arms of the model

Timepoint	DDPP	No intervention
12 months	6 %	8 %
24 months	8.2%	10.1%
36 months	12.7%	15.4%
48 months*	18%	23%
60 months*	25%	30%

** extrapolated from observed data up to 36 months*

The net financial impact of DDPP implementation was calculated as the difference in total health state costs over an eight-year period between the two arms of the model. Results of the base analysis are presented in *Table 4.* The model estimated that DDPP implementation for 15,000 people would lead to net savings of £19.87 million in health state costs over the span of 8 years. The majority of resource saving stems from people completing the DDPP who transition from NDH to the lower cost GC state. The numbers of people progressing from NDH to T2D or remaining in NDH were greater in the no intervention arm which led to higher overall NDH and T2D health state costs.

Table 4: Base case results

		DDPP	No Intervention
No. of people in health state at end of 8-year time horizon	NDH	1900	2750
	T2D	7550	11,500
	GC	5550	750
Total health state costs	NDH	£115,125,360	£161,295,600
	T2D	£88,112,700	£123,649,500
	GC	£66,766,500	£9,022,500
Total resource costs		£270,004,560	£293,967,600
Programme costs		£4,091,850	0
Net resource savings		£19,871,190	

The two key drivers of net savings were the DDPP completion rate and the cost per person of the program. Table 5 below shows results of a joint sensitivity analysis examining the impact of varying these two parameters.

Nearly all combinations of cost and completion rates result in net savings which suggests that the DDPP is a worthwhile intervention likely to lead to both short- and long-term savings even under the highly conservative assumption that no DDPP participants are able to return to normal glycaemic control but remain in the NDH state.

Table 5: Estimated net savings (£) DDPP vs no intervention

	DDPP Cost per person					
Completion Rate	**£150**	**£180**	**£200**	**£220**	**£250**	**£300**
0%	1,89m	1,44m	1,14m	840,690	390,690	-359,310
10%	7,16m	6,71m	6,41m	6,11m	5.65m	4.91m
20%	12.42m	11.97m	11.67m	11.37m	10.92m	10.17m
30%	17.66m	17.24m	16.94m	16.64m	16.19m	15.44m
37%	21.37m	20.92m	20.62m	20.32m	19,87m (base case)	19.12m
50%	28.22m	27.77m	27.46m	27.16 m	26.72m	25.97m
60%	33.48m	33.03m	32.73m	32.43m	31.98m	31.23m
70%	38.75m	38.29m	37.95m	37.69m	37.25m	36.49m
80%	44.01m	43.56m	43.26m	42.96m	42.51m	41.76m

Our budget impact analysis shows that a targeted DDPP has the potential to achieve savings from displaced healthcare resource utilisation as a result of fewer people progressing from NDH to T2D, with consequential lower T2D related comorbidities and lower expenditure on prescription medicines.

Projected net savings are likely to be an overestimate of actual realised savings as they do not include DDPP service implementation costs and are not based on health state costs derived from Scottish source(s) which tend to be higher than equivalent costs in England.

While the precise financial impact of DDPP implementation in Scotland cannot be quantified due to local data limitations, the results of this analysis provide an estimate of indicative savings and avoided resource costs.

Conclusion

Evidence suggests that DDPPs are effective in reducing HbA1c, weight and T2D conversion rates in adults with NDH. Factors influencing user engagement include ease of access, support and psychosocial perceptions. Health coach moderation, social support from family and friends, and

adequate consideration of user needs and composition are important for sustaining engagement and achieving meaningful health outcomes.

Digital versions of DPPs have the potential to reach a wider population and facilitate proportional access across different demographic profiles, particularly people living in rural areas and younger people.

Despite the evidence to support the effectiveness of DDPPs, there are challenges associated with the scale and spread of DDPPs, including dispelling perceptions around the digital divide and impact on health inequalities, and the understanding needed to ensure incorporation of the most effective digital components of these interventions.

Low rates of uptake, retention and completion have been a barrier to effective implementation and impact of DDPPs. An understanding of why people take up and engage with DDPPs is important and should be adequately considered when developing and implementing DDPPs to facilitate a successful and sustainable widespread impact.

Lifestyle interventions which prevent T2D in people at high-risk have generally been found to be very cost effective. The health economics of the digital pathway in the UK has not yet been assessed. The latest findings regarding the cost effectiveness of the NHSE-DPP are positive and demonstrate good value for money.

Identified research gaps

Further work is needed to investigate the longer-term outcomes for people using DDPPs and the relative cost effectiveness of DDPPs versus in-person programmes in the UK.

Future work is needed to provide a better understanding of the relative impacts of DDPPs on health outcomes, service user experience, behaviour change and the reasons for high dropout rates between referral and initial assessment.

Future studies should focus on optimising group support formats, tailoring interventions to participant characteristics and obtaining representative samples to better capture generalisable patient experience.

When developing or rolling out a DDPP, it is important to consider how behaviour-related issues like disordered eating will be recognised and managed by trained professionals. There should be a clear and defined process for patients to access further support to support them to adequately engage with the programme.

Acknowledgements

Healthcare Improvement Scotland development team

- Mr Edward Clifton, Head SHTG, Healthcare Improvement Scotland
- Dr Rohan Deogaonkar, Senior Health Economist, Health Improvement Scotland
- Ms Hilda Emengo, Lead Author/Health Services Researcher, Health Improvement Scotland
- Mr Paul Herbert, Health Information Scientist, Healthcare Improvement Scotland
- Ms Mary Michael, Project Officer, Healthcare Improvement Scotland
- Mr James Stewart, Programme Manager, Healthcare Improvement Scotland

Peer reviewers

We would like to thank the following individuals who took part in the peer review and provided comments on the draft document.

- Dr Karen Adamson, Associate Medical Director/Consultant Diabetologist, NHS Forth Valley
- Dr Kashif Ali, GP Partner and Primary Care Lead Diabetes Managed Clinical Network, NHS Greater Glasgow and Clyde
- Dr Sarah Cotterill, Reader in Health Services Research and Statistics, University of Manchester
- Ms Alison Grant, Healthcare Engagement and Systems Change Manager, Diabetes Scotland
- Dr Rhiannon Hawkes, Research Fellow in Health Psychology, University of Manchester
- Dr Nauman Jadoon, Consultant Physician and Endocrinologist, NHS Greater Glasgow & Clyde / SIGN Council Member
- Dr Emma McManus, Research Fellow in Health Economics, University of Manchester

Declarations of interest were obtained from all reviewers and are published alongside the review on our website. Reviewers had no role in authorship or editorial control and the views expressed are those of Healthcare Improvement Scotland and the SHTG Council.

Published 2025

References

1. Public Health Scotland. Scottish Burden of Disease (SBoD) study. 2022 [cited 2023 Oct 10]; Available from: https://scotland.shinyapps.io/phs-local-trends-scottish-burden-diseases/.
2. Scottish Government. A Healthier Future: type 2 Diabetes prevention, early detection and intervention: framework. 2018 [cited 2025 Feb 03]; Available from: https://www.gov.scot/publications/healthier-future-framework-prevention-early-detection-early-intervention-type-2/pages/11/.
3. Ross J, Cotterill S, Bower P, Murray E. Influences on patient uptake of and engagement with the national health service digital diabetes prevention programme:Qualitative interview study. Journal of Medical Internet Research. 2023;25:e40961. https://dx.doi.org/10.2196/40961
4. Ravindrarajah R, Sutton M, Reeves D, Cotterill S, McManus E, Meacock R*, et al.* Referral to the NHS Diabetes Prevention Programme and conversion from nondiabetic hyperglycaemia to type 2 diabetes mellitus in England: A matched cohort analysis. PLOS Medicine. 2023;20(2):e1004177. 10.1371/journal.pmed.1004177
5. Bower P S-RC, Heller S, Wilson P, Cotterill S, French D, Sutton M. Diabetes prevention at scale: Narrative review of findings and lessons from the DIPLOMA evaluation of the NHS Diabetes Prevention Programme in England. Diabetic Medicine. 2023;40:e15209.
6. Miles LM, Hawkes RE, French DP. How the behavior change content of a nationally implemented digital diabetes prevention program is understood and used by participants: Qualitative study of fidelity of receipt and enactment. Journal of Medical Internet Research. 2023;25:e41214. https://dx.doi.org/10.2196/41214
7. Public Health England. A systematic review and metaanalysis assessing the effectiveness of pragmatic lifestyle interventions for the prevention of type 2 diabetes mellitus in routine practice. 2015 [cited 2025 Mar 03]; Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/733053/PHE_Evidence_Review_of_diabetes_prevention_programmes-_FINAL.pdf.
8. Galaviz KI, Weber MB, Straus A, Haw JS, Narayan KMV, Ali MK. Global Diabetes Prevention Interventions: A Systematic Review and Network Meta-analysis of the Real-World Impact on Incidence, Weight, and Glucose. Diabetes Care. 2018;41(7):1526-34. 10.2337/dc17-2222
9. Dunkley AJ, Bodicoat DH, Greaves CJ, Russell C, Yates T, Davies MJ*, et al.* Diabetes prevention in the real world: effectiveness of pragmatic lifestyle interventions for the prevention of type 2 diabetes and of the impact of adherence to guideline recommendations: a systematic review and meta-analysis. Diabetes Care. 2014;37(4):922-33. 10.2337/dc13-2195
10. Marsden AM, Hann M, Barron E, Ross J, Valabhji J, Murray E*, et al.* Comparison of weight change between face-to-face and digital delivery of the English National Health service diabetes prevention programme: An exploratory non-inferiority study with imputation of plausible weight outcomes. Prev Med Rep. 2023;32:102161. Epub 20230220. 10.1016/j.pmedr.2023.102161
11. Barron E BD, Safazdeh S, McGough B, Bakhai C, Young B, et al. . Effectiveness of digital and remote provision of the Healthier You: NHS Diabetes Prevention Programme during the COVID-19 pandemic. Diabetic Medicine. 2023;4(5).
12. Ross JAD BE, McGough B, Valabhji J, Daff K, Irwin J, et al. Uptake and impact of the English National Health Service digital diabetes prevention programme: observational study. BMJ Open Diabetes Research Care. 2022;10:e002736.
13. Marsden AM, Hann M, Barron E, McGough B, Murray E, Valabhji J*, et al.* The effectiveness of digital delivery versus group-based face-to-face delivery of the English National Health Service Type 2 Diabetes Prevention Programme: a non-inferiority retrospective cohort comparison study. BMC Health Serv Res. 2023;23(1):1434. Epub 20231218. 10.1186/s12913-023-10365-2
14. Sepah SC, Jiang L, Ellis RJ, McDermott K, Peters AL. Engagement and outcomes in a digital Diabetes Prevention Program: 3-year update. BMJ Open Diabetes Research & Care. 2017;5(1):e000422. 10.1136/bmjdrc-2017-000422

15. Hawkes RE, Miles LM, Ainsworth B, Ross J, Meacock R, French DP. Engagement with a nationally-implemented digital behaviour change intervention: Usage patterns over the 9-month duration of the National Health Service Digital Diabetes Prevention Programme. Internet Interventions. 2023;33:100647. https://dx.doi.org/10.1016/j.invent.2023.100647
16. Moussas-Alvarez D, Hawkes RE, Miles LM, Dack C, French DP. Service users' experiences of, and engagement with, a nationally implemented digital diabetes prevention programme. British Journal of Health Psychology. 2025;30(1):e12787. https://doi.org/10.1111/bjhp.12787
17. Cheung WC, Miles LM, Hawkes RE, French DP. Experiences of online group support for engaging and supporting participants in the National Health Service Digital Diabetes Prevention Programme: A qualitative interview study. J Health Serv Res Policy. 2024;29(2):100-10. https://dx.doi.org/10.1177/13558196231212846
18. Haseldine C, O'Donoghue G, Kearney PM, Riordan F, Humphreys M, Kirby L*, et al.* Characteristics of participants in the first fully online National Diabetes Prevention Programme: A quantitative survey. HRB Open Res. 2023;6:61. Epub 20241217. 10.12688/hrbopenres.13807.2
19. Haseldine C, O'Donoghue G, Kearney PM, Riordan F, Kerins C, Kirby L*, et al.* Factors influencing participation in an online national diabetes prevention programme: A qualitative study with attenders and educators. Diabet Med. 2024;41(6):e15277. Epub 20231227. 10.1111/dme.15277
20. Ross J HR, Miles LM, Cotterill S, Bower P, Murray E. Design and Early Use of the Nationally Implemented Healthier You National Health Service Digital Diabetes Prevention Programme: Mixed Methods Study. J Med Internet Res. 2023;25:e47436.
21. McManus E, Meacock R, Parkinson B, Sutton M. Population level impact of the NHS Diabetes Prevention Programme on incidence of type 2 diabetes in England: An observational study. Lancet Reg Health Eur. 2022;19:100420. Epub 20220529. 10.1016/j.lanepe.2022.100420
22. Brunton L, Soiland-Reyes C, Wilson P. A qualitative evaluation of the national rollout of a diabetes prevention programme in England. BMC Health Services Research. 2023;23(1):1043. 10.1186/s12913-023-10002-y
23. NHS England. NHS England Impact Analysis of implementing NHS Diabetes Prevention Programme, 2016 to 2021. 2016 [cited 2025 May 13]; Available from: https://www.england.nhs.uk/wp-content/uploads/2016/08/impact-assessment-ndpp.pdf.
24. McManus E, Meacock R, Parkinson B, Sutton M. Evaluating the Short-Term Costs and Benefits of a Nationwide Diabetes Prevention Programme in England: Retrospective Observational Study. Appl Health Econ Health Policy. 2023. Epub 20231003. 10.1007/s40258-023-00830-8
25. McManus E. Evaluating the Long-Term Cost-Effectiveness of the English NHS Diabetes Prevention Programme using a Markov Model. PharmacoEconomics - Open. 2024;8(4):569-83. 10.1007/s41669-024-00487-6
26. Park S, Ballreich J, Ward T, Shi L. Cost-effectiveness analysis of a digital diabetes-prevention programme versus an in-person diabetes-prevention programme in people with prediabetes in the United States. Diabetes, Obesity and Metabolism. 2024;26(10):4522-34. https://doi.org/10.1111/dom.15807
27. Michaud TL, Wilson KE, Katula JA, You W, Estabrooks PA. Cost and cost-effectiveness analysis of a digital diabetes prevention program: results from the PREDICTS trial. Translational Behavioral Medicine. 2023;13(7):501-10. 10.1093/tbm/ibad008
28. SIGN. Prevention and remission of type 2 diabetes. 2025 [cited 2025 May 13]; Available from: https://www.sign.ac.uk/media/2323/20250311type-2-diabetes-prevention-gl-publication-v2.pdf.
29. Cosentino F, Grant PJ, Aboyans V, Bailey CJ, Ceriello A, Delgado V*, et al.* 2019 ESC Guidelines on diabetes, pre-diabetes, and cardiovascular diseases developed in collaboration with the EASD: The Task Force for diabetes, pre-diabetes, and cardiovascular diseases of the European Society of Cardiology (ESC) and the European Association for the Study of Diabetes (EASD). European Heart Journal. 2020;41(2):255-323. 10.1093/eurheartj/ehz486.
30. Sutton M, Bower P, Chandola T, Cotterill S, French D, Kontopantelis E*, et al.* Evaluating the NHS Diabetes Prevention Programme (NHS DPP): the DIPLOMA research programme (Diabetes Prevention Long term Multimethod Assessment). 2017 [cited 2023 Oct 10]; Available from: https://njl-admin.nihr.ac.uk/document/download/2035302.

31. McGough B, Murray E, Brownlee L, Barron E, Smith J, Valabhji J. The Healthier You: NHS Diabetes Prevention Programme: digital modes of delivery engage younger people. Diabet Med. 2019;36(11):1510-1. Epub 20190725. 10.1111/dme.14083
32. NICE. Type 2 diabetes: prevention in people at high risk. 2017 [cited 2024 Oct 03]; Available from: https://www.nice.org.uk/guidance/ph38.
33. Whelan M, Bell L. The English national health service diabetes prevention programme (NHS DPP): A scoping review of existing evidence. Diabet Med. 2022;39(7):e14855. Epub 20220426. 10.1111/dme.14855
34. NHS Scotland, Scottish Diabetes Group. Scottish Diabetes Survey 2023. 2024 [cited 2025 Feb 04]; Available from: https://www.diabetesinscotland.org.uk/wp-content/uploads/2024/11/Scottish-Diabetes-Survey-2023.pdf.
35. Jack W, Sarah HW. Marked and widening socioeconomic inequalities in type 2 diabetes prevalence in Scotland. Journal of Epidemiology and Community Health. 2022;76(5):482. 10.1136/jech-2021-217747
36. Grant I, Chalmers N, Fletcher E, Lakha F, McCartney G, Stockton DL*, et al.* Pre-pandemic inequalities in the burden of disease: a Scottish Burden of Disease study. medRxiv. 2023:2023.03.15.23286907. 10.1101/2023.03.15.23286907
37. Wyper GMA, Fletcher E, Grant I, Harding O, de Haro Moro MT, Stockton DL*, et al.* COVID-19 and prepandemic all-cause inequalities in disability-adjusted life-years due to multiple deprivation: a Scottish Burden of Disease study. The Lancet. 2021;398:S94. 10.1016/S0140-6736(21)02637-4
38. Xie J, Wang M, Long Z, Ning H, Li J, Cao Y*, et al.* Global burden of type 2 diabetes in adolescents and young adults, 1990-2019: systematic analysis of the Global Burden of Disease Study 2019. BMJ. 2022;379:e072385. 10.1136/bmj-2022-072385
39. NHS Scotland, Scottish Diabetes Group. Scottish Diabetes Survey 2021 2021 [cited 2023 Oct 10]; Available from: https://www.diabetesinscotland.org.uk/wp-content/uploads/2023/02/Diabetes-Scottish-Diabetes-Survey-2021-final-version.pdf.
40. Robertson C AD, Avenell A, Douglas F, Hoddinott P, van Teijlingen E, et al. Systematic reviews of and integrated report on the quantitative, qualitative and economic evidence base for the management of obesity in men. Health Technol Assess. 2014;18(35):v-vi, xxiii-xxix, 1-424.
41. Pan XR LG, Hu YH, Wang JX, Yang WY, An ZX, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The Da Qing IGT and Diabetes Study. Diabetes Care. 1997;20(4):537–44. https://doi.org/10.2337/diacare.20.4.537
42. Tuomilehto J LmJ, Eriksson JG, Valle TT, Ha¨ma¨la¨inen H, Ilanne-Parikka P, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. . N Engl J Med. 2001;344(18):1343–50. https://doi.org/10.1056/NEJM200105033441801
43. Knowler WC B-CE, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. . N Engl J Med. 2002;346(6):393–403. https://doi.org/10.1056/NEJMoa012512
44. Grock S, Ku JH, Kim J, Moin T. A Review of Technology-Assisted Interventions for Diabetes Prevention. Curr Diab Rep. 2017;17(11):107. Epub 20170923. 10.1007/s11892-017-0948-2
45. Bian RR, Piatt GA, Sen A, Plegue MA, De Michele ML, Hafez D*, et al.* The Effect of Technology-Mediated Diabetes Prevention Interventions on Weight: A Meta-Analysis. J Med Internet Res. 2017;19(3):e76. Epub 20170327. 10.2196/jmir.4709
46. Joiner KL, Nam S, Whittemore R. Lifestyle interventions based on the diabetes prevention program delivered via eHealth: A systematic review and meta-analysis. Prev Med. 2017;100:194-207. Epub 20170427. 10.1016/j.ypmed.2017.04.033
47. Van Rhoon L, Byrne M, Morrissey E, Murphy J, McSharry J. A systematic review of the behaviour change techniques and digital features in technology-driven type 2 diabetes prevention interventions. Digit Health. 2020;6:2055207620914427. Epub 20200324. 10.1177/2055207620914427
48. Haseldine C, Pallin JA, Kearney PM, Mc Hugh SM, Riordan F, Cotterill S*, et al.* Healthcare workers' perspectives on barriers and facilitators to referral to type 2 diabetes prevention programmes: a systematic review. BMJ Open. 2025;15(3):e090105. 10.1136/bmjopen-2024-090105

49. National Association of Chronic Disease Directors (NACDD), Division of Diabetes Translation at the Centers for Disease Control and Prevention (CDC). National Diabetes Prevention Program Coverage Toolkit 2023 [cited 2023 Oct 10]; Available from: https://coveragetoolkit.org/about-national-dpp/evidence/.
50. Herman WH, Villatoro C, Joiner KL, McEwen LN. Uptake, retention, and outcomes of the National Diabetes Prevention Program by enrollee characteristics and program type. Diabetes Research and Clinical Practice. 2023;203:110835. https://dx.doi.org/10.1016/j.diabres.2023.110835
51. Sepah SC, Jiang L, Peters AL. Long-term outcomes of a web-based diabetes prevention program: 2-year results of a single-arm longitudinal study. J Med Internet Res. 2015;17(4):e92. Epub 20150410. 10.2196/jmir.4052
52. Fontil V, McDermott K, Tieu L, Rios C, Gibson E, Sweet CC*, et al.* Adaptation and feasibility study of a digital health program to prevent diabetes among low-income patients: Results from a partnership between a digital health company and an academic research team. J Diabetes Res. 2016;2016:8472391. Epub 20161027. 10.1155/2016/8472391
53. Castro Sweet CM, Chiguluri V, Gumpina R, Abbott P, Madero EN, Payne M*, et al.* Outcomes of a Digital Health Program With Human Coaching for Diabetes Risk Reduction in a Medicare Population. Journal of Aging and Health. 2018;30(5):692-710. 10.1177/0898264316688791
54. National Institute for Health and Care Excellence (NICE). Type 2 diabetes in adults [QS209]. 2023 [cited 2023 Aug 15]; Available from: https://www.nice.org.uk/guidance/qs209.
55. Healthcare Improvement Scotland. Our Voice Citizens' Panel Third Survey Report. 2018 [cited 2025 May 13]; Available from: https://hisengage.scot/informing-policy/citizens-panel/third-panel-report/.
56. Miles LM, Hawkes RE, French DP. Description of the nationally implemented National Health Service digital diabetes prevention programme and rationale for its development: mixed methods study. BMC health services research. 2023;23(1):373. https://dx.doi.org/10.1186/s12913-023-09210-3
57. Hawkes RE, Miles LM, French DP. What behaviour change technique content is offered to service users of the nationally implemented English NHS Digital Diabetes Prevention Programme: Analysis of multiple sources of intervention content. Preventive Medicine Reports. 2023;32:102112. https://dx.doi.org/10.1016/j.pmedr.2023.102112
58. Zhou X, Siegel KR, Ng BP, Jawanda S, Proia KK, Zhang X*, et al.* Cost-effectiveness of Diabetes Prevention Interventions Targeting High-risk Individuals and Whole Populations: A Systematic Review. Diabetes Care. 2020;43(7):1593-616. 10.2337/dci20-0018
59. Roberts S, Craig D, Adler A, McPherson K, Greenhalgh T. Economic evaluation of type 2 diabetes prevention programmes: Markov model of low- and high-intensity lifestyle programmes and metformin in participants with different categories of intermediate hyperglycaemia. BMC Medicine. 2018;16(1):16. 10.1186/s12916-017-0984-4
60. Alouki K, Delisle H, Bermúdez-Tamayo C, Johri M. Lifestyle Interventions to Prevent Type 2 Diabetes: A Systematic Review of Economic Evaluation Studies. J Diabetes Res. 2016;2016:2159890. Epub 20160113. 10.1155/2016/2159890

Appendix 1: abbreviations

ANIA	Accelerated National Innovation Adoption
BCTs	behaviour change techniques
BMI	body mass index
CVD	cardiovascular disease
CI	confidence interval
DPPs	diabetes prevention programmes
DDPPs	digital diabetes prevention programmes
HbA1c	glycated haemoglobin
ICERs	incremental cost-effectiveness ratios
NHSE-DPP	National Health Service England Healthier You: Diabetes Prevention Programme
NHSE-DDPP	National Health Service England Healthier You: Digital Diabetes Prevention Programme
NDH	non-diabetic hyperglycaemia
NICE	National Institute for Health and Care Excellence
RCTs	randomised controlled trials
SGE	small group education
SIGN	Scottish Intercollegiate Guidelines Network
T2D	type 2 diabetes
UK	United Kingdom
US	United States
US-DDPP	United States Digital Diabetes Prevention Programme
QALY	quality-adjusted life year