Healthcare Improvement Scotland | SHTG Advice on health technologies

SHTG Assessment
December 2023

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

Digital prevention programme 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 play an essential role in delivering DDPPs. People were more likely to set goals for themselves and engage with the programme if they received support from a health coach in combination with other tools.
4. DDPPs have the potential to reach a wider population than traditional options and facilitate proportional access across different population groups.
5. In-person programmes to prevent T2D in people at risk are very cost effective. Although yet to formally assessed, the digital implementation and delivery of prevention programmes is expected to be similarly cost effective.

What were we asked to look at?

We were asked by the Accelerated National Innovation Adoption (ANIA) collaborative to assess the evidence for a digitally delivered T2D prevention programme.

T2D prevention programmes are evidence-based interventions aimed at preventing or delaying the onset of T2D in high-risk individuals. This includes offering 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. These prevention programmes 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?

Of all people with diabetes nationally, approximately 88% have T2D. 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. The COVID-19 pandemic caused significant disruption to T2D prevention and weight management services.

Poor diet, lack of physical activity and obesity are known to be the main modifiable factors in the development of T2D. There is a strong evidence base linking T2D prevention with behavioural changes that result in a healthier lifestyle. Prevention programmes can significantly improve outcomes and quality of life for people with a high risk of developing T2D.

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 a value case and subsequent decision making regarding the national implementation of a digital T2D prevention programme.

Key points

1. Evidence about the digital delivery of diabetes prevention interventions in real-world settings is emerging. Findings from recent studies[1-5] suggest that digital diabetes prevention programmes (DDPPs) are effective in reducing glycated haemoglobin (HbA1c), weight, and T2D conversion rates in adults with non-diabetic hyperglycaemia (NDH).

2. The NHS England diabetes prevention programme (NHS-DPP) was initially designed and delivered as an in-person programme. A recent cohort study[1] found that referrals to the NHS-DPP led to a 20% lower risk of people with prediabetes developing T2D.

3. Digital services were found to be as effective as in-person interventions in reducing weight and blood glucose levels. A recent large-scale evaluation[5] 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. The outcomes were comparable to the outcomes for patients receiving the in-person intervention.

4. The results from a non-randomised trial[6] of the United States (US) national 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 sessions during the first year sustained a −2.9% weight loss after 3 years ($p = 0.0024$).

5. A user engagement study[7] examined participant data from three independent NHS-DDPP providers from December 2020 to June 2021. Data from the 1,826 participants enrolled found a decline in app usage over the course of a 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. Health coaches were found to play a crucial role in supporting components of a digital programme.

6. Factors influencing programme uptake and user engagement include ease of access to programmes, motivation, support, and people's perception of their risk of developing T2D.

7. DDPPs have the potential to reach a wider population and facilitate proportional access across different demographic profiles, when offered alongside traditional in-person programmes.

8. Low rates of uptake, retention and completion are known barriers to realising the full impact of DDPPs. Factors contributing to variable uptake and engagement with DDPPs should be considered when developing and implementing sustainable DDPPs.

9. Systematic reviews have generally found lifestyle interventions that prevent T2D in high-risk individuals to be very cost effective. 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.

10. An impact assessment, conducted in advance of the (non-digital) NHS-DPP rollout in England, modelled predicted savings in the region of £35 million over a 20-year time horizon. 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.

11. The most recent economic analysis[8] of the NHS-DPP shows that the programme is cost effective solely based on short-term health gains achieved by participants. Data analysis across a cohort of 384,611 referrals found that the average cost per referral was £119, rising to £286 per referral for those 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 1,542 QALYs were generated for this cohort at a cost of £28,661 per QALY (£34,346 per QALY when including implementation costs).

12. The health economics of the digital pathway (NHS-DDPP) has not been assessed. It is unlikely that digital delivery would have a major impact on cost effectiveness given the evidence on comparative efficacy of the programmes and the likelihood of digital delivery be no more costly than in-person.

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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.

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. 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).[9]

A diagnosis of NDH is associated with an increased risk of developing T2D and other diabetes-related conditions. People with NDH are considered to be at high risk of developing T2D.

Diabetes prevention programmes (DPPs) – evidence-based interventions aimed at preventing or delaying the onset of T2D in high-risk individuals. 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.

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

Introduction

T2D is an impairment in the way the body controls and regulates blood sugar levels.[1] The condition is associated with poor diet, insufficient or lack of physical activity and obesity.[9] Genetic risk factors are also associated with an increased risk of developing T2D. Research has shown that having a close relative with T2D and people from African-Caribbean, Black-African or South-Asian (Indian, Pakistani and Bangladesh) backgrounds are at higher risk of developing T2D.[10] With poor control, people with T2D have a higher risk of developing other cardiovascular health complications and in severe cases, limb amputation.[11]

People with NDH or prediabetes have a higher risk of developing T2D though they often have no symptoms.[12] The asymptomatic nature of NDH means that people may go undiagnosed and untreated, and remain at a higher risk of developing T2D.[13] About 11% of people with obesity and NDH progress to T2D every year.[10] The NDH population is an important group to target in T2D prevention.

Behavioural interventions that focus on healthy eating, weight loss, and increased physical activity, can prevent or delay the onset of T2D. 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. 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.[9]

The digital delivery of behavioural interventions can improve the reach, access and overall uptake of preventive interventions.[14]

Research question

What is the clinical and cost effectiveness of DDPPs?

Literature search

A systematic search of the secondary literature was carried out from 14th – 18th August 2023 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.

The primary literature was systematically searched from 14th – 18th August 2023 using the following databases: Medline, Medline in process and Embase.

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.

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 (smart watches), to deliver evidence-based behavioural and lifestyle interventions aimed at preventing or delaying the onset of T2D in people at risk.

The proposed DDPP for NHSScotland is a 9-month integrated intensive lifestyle modification programme delivered via bespoke digital technology. The DDPP will comply with the recommendations set out in the NICE public health guidelines, on type 2 diabetes: prevention in people at high risk. 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, such as the NHS England DDPP.

NHS England's Healthier You: Digital Diabetes Prevention Programme

In 2016, the Healthier You: NHS Diabetes Prevention Programme (NHS-DPP) was established which aimed to prevent or delay the onset of T2D in adults with prediabetes. The NHS-DPP is based on specifications in the NICE guidelines on the prevention of T2D in people who are high risk, which set out BCTs such as information provision, goal setting, action planning, coping plans and relapse prevention. 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.[15]

The digital service (NHS-DDPP) was introduced in 2019 to address age-related inequalities in uptake of the NHS-DPP. With the introduction of the digital tools, patients can be offered a combination of in-person and digital interventions tailored to individual needs. This includes personalised coaching and 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 also provided through various channels including websites, emails and smartphone apps.[9]

Between 2019 and 2022, four independent providers were commissioned to deliver the NHS-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.[9]

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.[9]

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. From 2024, women with a history of gestational diabetes will also be eligible. Pregnant women and people already diagnosed with diabetes are not eligible for the programme.[9]

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

NHS-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 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[†]	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

*Information in Table 1 is based on the evaluation of the NHS-DDPP in 2019-2022. The programme has since been re-commissioned resulting in different providers or adaptations to programmes.

[†]At the time of the evaluation, Provider A did not offer group support. A 'group support pathway' was later implemented by the provider.

NHSScotland digital diabetes prevention programmes

There is currently limited and variable provision of T2D prevention programmes for NDH patients across Scotland. Three health boards offer digital prevention programmes that meet NICE guidelines. A total of 590 people have been offered a place on these programmes, with 343 taking up a place over the last 2 years.

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 NICE specifications, mainly because they are far less intensive. Approximately 4,500 people were referred to these programmes, with 1,900 taking up a place over the last 2 years.

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

Epidemiology

The Scottish Diabetes Survey 2021 is the most recent source of national diabetes epidemiology, based on registry data.[16] According to the survey, there were 287,606 people living with T2D in Scotland at the end of 2021, with 22,221 people newly diagnosed that year. T2D accounts for around 88% of all people with diabetes nationally.[16]

In terms of diabetes complications, 9.6% of people with T2D were recorded as having had a previous myocardial infarction; 7.5% recorded as having cardiac revascularisation; 5.4% recorded as having had a stroke; 4% recorded as having had a foot ulcer; 0.6% with end stage renal failure and 0.5% with lower limb amputation.[11]

Diabetes is a consequence of health inequalities in Scotland. In 2021, the proportions of people aged 35-84 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.[17] 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.[18, 19]

Ethnic heritage is not recorded for about one fifth (20%) of people with a diagnosis of T2D in Scotland. In 2021, 72.3% (207,994) of those recorded as having T2D were described as being of 'white ethnicity', 4.0% (11,577) were described as being of 'Asian', 'Asian Scottish' or 'Asian British' ethnicities, 2.3% (6,604) were described as being of 'mixed' or 'multiple' ethnic groups and 0.6% (1,729) were described as being of 'African', 'Caribbean', or 'Black' ethnicities.[11] These ethnic groups were self-reported in the Scottish diabetes survey. Some of the groups are too broad (for example 'Asian', 'mixed', 'multiple') and may not be an accurate reflection of the differences among the various nationalities belonging to that ethnic group in Scotland.

The average age at which people are diagnosed is changing. T2D is now affecting greater numbers of young people.[20] In 2021, 20.5% of new cases of T2D (22,221) were in people aged between 20 and 49 years, and 7% aged between 20 and 39 years.[11]

Compared with women, more men are overweight or obese and as a result are at a higher risk of developing T2D.[21] In Scotland, 55.5% of people with T2D are male and 44.5% are female.[17] Men are less likely to engage with weight management programmes as they are less likely to perceive their weight as being a problem.[21]

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.

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. Studies have shown that people with prediabetes or NDH have been prevented or delayed from progression to T2D,[2] having benefitted from reductions in body weight and blood glucose levels.[15]

A cohort study[1] investigating the impact of referral to the NHS-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. 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 observations from randomised controlled trials (RCTs).[22-24] 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.[1]

Digital diabetes prevention programmes

NHS-DDPP effectiveness

Four studies[2-5] were identified that investigated the clinical effectiveness of NHS-DDPP. Two studies,[2, 3] including a 6-year evaluation, concluded that the NHS-DDPP can achieve broadly equivalent results to the traditional in-person model (NHS-DPP). The studies compared weight change between in-person, digital-only and digital-choice cohorts of the NHS-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 NHS-DPP.[2]

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. There were fewer males than females in the in-person (males 45.5%; females 54.5%) and digital-only (males 46%; females 54%) cohorts. The digital-choice cohort had equal numbers of males and females. The authors concluded that patients should be offered the choice between in-person and digital delivery.[3]

Another service evaluation of the NHS-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.[4] 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).

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. [4]

A large-scale pilot evaluation of nine areas across England found that participation in the NHS-DDPP was associated with clinically significant reductions in weight and HbA1c.[5] Data from adults with NDH in the 12 months prior to referral were prospectively collected. 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 were associated with significantly (p<0.001) greater reductions in HbA1c and weight. Demographic characteristics associated with greater weight loss included being older, having a higher education 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.[5]

The findings from these studies illustrate that DDPPs can achieve at least equivalent results to the traditional in-person DPP model, with no evidence of adverse impacts on health inequalities.

NHS-DDPP uptake and engagement

We identified seven studies[1, 2, 7, 9, 10, 15, 25] that examined factors influencing uptake and engagement of the NHS-DDPP.

The DIPLOMA evaluation[2] found that of those referred to the programme 50% started it and 20% completed it. 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 even with the digital delivery model. 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.[2]

The extent to which the intervention was implemented as intended varied across providers. There was also evidence of a drift away from the NICE specifications. This included how providers planned to deliver the intervention, how staff were trained and what was offered to participants.[2]

One study[25] reported high rates of patient engagement with apps within the first 30 days of programme enrollment. 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 of events, while the least engaged features related to peer support. There were differences in how patients engaged with app features across providers. The findings of the study support the importance of health coaches, as well as the provision of regular content and reminders to improve early engagement.

Other studies[1, 10] 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. 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 significant role in uptake.[10]

A qualitative study of the NHS-DDPP exploring participants' perceptions and use of the BCTs specified by NICE also highlighted the importance of health coaches.[15] The study interviewed 45 service users twice during the programme. Health coaches were essential in supporting participants through offering emotional support and assistance with specific BCTs. Participants expressed frustration regarding the lack of monitoring and feedback on their T2D risk. Variations in understanding and use of BCTs 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 NHS-DDPP providers from December 2020 to June 2021.[7] 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 findings further suggest that health coach support may enhance engagement with specific features.

The findings from the studies on NHS-DDPP are generalisable to Scotland as they have been conducted in similar health settings and policy contexts. As highlighted in the health technology description section, there were differences in delivery across the service providers.

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.[26] Five studies assessing the impact of the national US-DDP were identified.[6, 27-30]

One study concluded that the US-DDPP resulted in health benefits regardless of the specific programme [27] 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%).[27]

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.[28]

The results from a non-randomised trial 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 ($p = 0.0024$).[6]

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).[29] 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.[30]

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. The findings are not directly generalisable to the UK population because of differences in populations, health settings and policy context.

Patient and social aspects

NICE guidance states that the delivery of DPPs should take into account the local social and cultural contexts to ensure relevance and effectiveness.[31] 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[2] 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 recent review[2] of the NHS-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.

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 NHS-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.[4, 5]

Organisational issues and considerations

A mixed methods study, involving a review of NHS-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.[32] There was variation in how providers delivered certain elements of the NHS-DDPP, especially in terms of inclusion of health coaches and/or group support and the extent of support offered to participants.

Health coaches enhance service user engagement, experience and understanding of intervention content, even in DDPPs. It is important that all health coaches, regardless of professional background, receive in-depth training in BCTs and how to deliver behaviour change support, prior to programme implementation.

A 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.

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.[33]

Future research is required to investigate whether a variation in delivery has implications for the effectiveness of DDPPs.[15]

Cost effectiveness

The 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,[2-4] 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.

The most recent 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.[34] 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 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.[35] 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. 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.[36] 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 NHS-DPP

NHS England conducted an impact analysis, prior to the rollout of the NHS-DPP, to estimate the resource implications of implementing the programme over the first 5 years (2016–21). It was estimated that the NHS-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).

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 cardiovascular disease (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. These model projections were based on several key assumptions:

- the average cost of the NHS-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 NHS-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.

Analysis reports of the short-term costs and benefits of the NHS-DPP have been published using data from 384,611 referrals between June 2016 and March 2019.[8] This study analysed data on provider payments supplied by NHS England to calculate the costs of all referrals received. It estimated the benefits of the NHS-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 QALY 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 QALY (95% CI 0.0016–0.0051). Each kg lost was associated with a utility increase of 0.0025 QALY (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 NHS-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 initiated 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 NHS-DPP.

The results of the retrospective observational analysis show that the NHS-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 NHS-DPP may occur earlier than predicted.

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.

Digital versions of DPPs, when offered alongside traditional options, have the potential to reach a wider population and facilitate proportional access across different demographic profiles.

Although there is evidence to support the effectiveness of DDPPs, there are still challenges associated with the scale and spread of DDPPs, including concerns around the digital divide and impact on health inequalities, and a lack of understanding of the most effective digital components of these interventions.

Low rates of uptake, retention and completion remain a major 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 high-risk individuals have generally been found to be very cost effective. The health economics of the digital pathway has not been assessed at this time. However, the latest findings regarding the cost effectiveness of the NHS-DPP are positive and demonstrate good value for money.

Identified research gaps

Further work is needed to investigate the longer-term outcomes of DDPPs, the relative cost effectiveness of DDPPs vs in-person programmes and to confirm if DDPPs delay or prevent progression to T2D.

A better understanding of the reasons for high dropout rates between referral and initial assessment and exploring the extent to which service users engage with the different features offered within DDPPs will help establish the most effective digital components of DDPPs.

More understanding of the relative impacts of the DDPPs on health outcomes, service user experience and behaviour change is needed to determine whether certain population groups benefit more from the programme and provide further insight into developing the optimal delivery mode for behaviour change content for DDPPs.

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.

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Appendix 1: abbreviations

ANIA	Accelerated National Innovation Adoption
BCTs	behaviour change techniques
CVD	cardiovascular disease
DPPs	diabetes prevention programmes
DDPPs	digital diabetes prevention programmes
HbA1c	glycated haemoglobin
ICERs	incremental cost-effectiveness ratios
NHS-DPP	National Health Service Healthier You: Diabetes Prevention Programme
NHS-DDPP	National Health Service Healthier You: Digital Diabetes Prevention Programme
NDH	non-diabetic hyperglycaemia
RCTs	randomised controlled trials
T2D	type 2 diabetes
UK	United Kingdom
US	United States
US-DDPP	United States Digital Diabetes Prevention Programme
QALY	quality-adjusted life year