Population-level interventions to improve health in people with diabetes in Nottinghamshire

Supporting document

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Imperial College Health Partners

This document supports the evidence pack, ‘Population-level interventions to improve health in people with diabetes in Nottinghamshire’. It provides further explanation to the slides in the pack followed by an additional appendix.

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Slide 9 Approach

- Our approach
- Methods: literature
- Methods: modelling
- Inclusions

This pack provides a bespoke guide for commissioners of diabetes services to population-based interventions in the new Nottinghamshire Integrated Care Service.

It has a particular focus on:

- Amputations, visual loss and chronic kidney disease as complications
- Markers of control including HbA1c, cholesterol levels, blood pressure and obesity
- Structured education as an intervention
- Admissions and patient satisfaction

Slide 10. Methods: the literature

We have conducted pragmatic reviews of the peer-reviewed and general grey-literature including health technology assessments, reports by the NHS or other health-care organisations, governments, and non-governmental organisations to:

- Identify suitable population-based interventions that may improve the outcomes of interest for diabetic patients
- To identify relevant recommendations from the National Institute of Health and Care Excellence (NICE) relating to such interventions
- Estimate of the effect of these interventions on the outcomes of interest
- Estimate the costs of these interventions
- Estimate the costs of the outcomes of interest

Embase

We searched Embase, a database of the peer-reviewed biomedical literature, using the following search strategy. Search date 14/08/2019.

	Search terms	**Number of hits**
	Using Embase and Medline	
1	'diabetes mellitus'/exp/mj OR 'diabet*':ti	546,617
2	'ambulatory care'/exp/mj OR 'community care'/exp/mj OR 'primary health care'/exp/mj OR 'behavior change'/exp/mj OR 'family therapy'/exp/mj OR 'interpersonal communication'/exp/mj OR 'self care'/exp/mj OR 'social support'/exp/mj OR 'social work'/exp OR 'training'/exp/mj OR 'diabetes educator'/exp/mj OR 'diabetes education'/exp/mj OR 'blood glucose monitoring'/exp/mj OR 'exercise'/exp/mj OR 'health care policy'/exp/mj	619,551
3	'diabetes control'/exp OR 'diagnosis'/exp OR 'screening'/exp OR 'hemoglobin a1c'/exp OR 'glucose'/exp OR 'glucose level'/exp OR 'body mass'/exp OR 'cholesterol'/exp OR 'cholesterol blood level'/exp OR 'amputation'/exp OR 'diabetic foot'/exp OR 'dialysis'/exp OR 'kidney failure'/exp OR 'retinopathy'/exp OR 'visual impairment'/exp OR 'hospital admission' OR 'health care utilization'/exp OR 'remission'/exp OR 'patient satisfaction'/exp OR 'erectile dysfunction'/exp OR 'hypoglycaemia'/exp OR 'health care cost'/exp OR 'treatment outcome'/exp/mj OR 'health care utilization'/exp/mj OR 'health care cost'/exp/mj OR 'health care quality'/exp/mj OR 'outcome assessment'/exp/mj	9,357,701
4	#1 AND #2 AND #3	12,067
5	#4 AND ('meta analysis'/de OR 'randomized controlled trial'/de OR 'systematic review'/de OR 'economic model'/exp)	1,698
6	#5 NOT ('insulin':ti OR 'metformin':ti OR 'recombinant hormone'/exp OR 'oral antidiabetic agent'/exp)	1,248

We counted entries coded as having one of a list of a number of coding occurrences that may be associated with intervention types of interest. The results are shown below.

EMTREE term	Occurrences
exercise	504
blood glucose monitoring	535
self care	361
training	183
diabetes education	128
behavior change	19
social support	48
diabetes educator	8
community care	26
interpersonal communication	8
primary health care	62
ambulatory care	9
health care policy	6
family therapy	15
social work/exp	0

The potential intervention types are ranked by frequency of occurrence.

A searche of the Crystallise HEORO database using the following strategy yielded 380 candidate papers, and a search of the TRIP database yielded 550.

Search category	Search terms	Number of hits
Disease	Diabetes Mellitus	
AND Location	United Kingdom, Europe, United States, Canada, Australia, New Zealand	
AND Intervention	Integrated disease management, Education interventions, Resistance training, Exercise therapy, Diet – Mediterranean, Diet therapy, Low-energy diets, Diet – reducing, Cognitive behavioural therapy, Internet or computer CBT, Therapist-guided CBT, Ambulatory care, Computer and mobile health interventions, Healthy lifestyle promotion, Holistic Health, Mobile health, Blood glucose self-monitoring, Insulin infusion or injection systems	
AND Study methodology	RCT, Systematic Review	
AND Publication dates	2000-2019	
Total		380

	Search terms	Number of hits 14/08/19
	(title:diabetics)(title:"integrated disease management" OR education OR "physical training" OR exercise OR "resistance training" OR "aerobic exercise" OR diet OR CBT OR "cognitive behavioural therapy" OR "Ambulatory care" OR "mobile phone apps" OR "smartphone apps" OR "computer interventions" OR "self management" OR "self monitoring" OR "continuous blood sugar monitoring" OR "insulin infusion" OR lifestyle OR)(title:costs OR admissions OR utilisation OR control OR amputation OR retinopathy OR cardiovascular OR neuropathy OR nephropathy OR satisfaction OR "patient reported outcomes")(title:random OR trial OR controlled OR RCT OR "systematic review" OR "meta-analysis" OR "metanalysis") NOT insulin NOT metformin not drug not medication	550

Abstracts were filtered by the coding occurrence and examined for Intervention themes.

An analysis of NICE guidance was conducted to identify intervention, the supporting evidence and associated economic analyses.

After eliminating interventions that were under clinical control rather than commissioned at a population level, the following categories of intervention emerged.

1. Structure education,
2. Specific weight and exercise interventions,
3. Retinopathy screening,
4. Multidisciplinary foot care services, and
5. Bariatric surgery.

Structured education interventions were generally a heterogeneous and comprehensive mix of elements including:

- a mix of face-to-face teaching or training on a one-to-one or group level;
- information about diabetes, its complications, screening and monitoring;
- advice and support on lifestyle, smoking cessation, exercise and weight management;
- peer support or lay mentoring.

These could be targeted at specific groups like people with pre-diabetes, those with type 1 or type 2 diabetes.

A separate group were considered incorporating digital elements like use of the internet or smart-phone apps.

Slide 11. Methods: modelling

To estimate the impact of these interventions and their potential return on investment, we have built a stochastic model of diabetes outcomes based on the UKPDS outcomes models[2]. The model uses intermediate markers of risk including measures of control, co-morbidities and demographic variables to identify risks. A description of the model is given in **appendix A**.

Predictors:

Age, sex, smoking status, ethnicity, and age at diagnosis of diabetes.

Measures of control including body mass index (BMI), serum glycosylated haemoglobin (HbA1c), systolic blood pressure, low-density and high-density lipoprotein levels, the electronic glomerular filtration rate (eGFR) and macro-albuminuria.

Co-morbidities including all the outcomes listed below.

Outcomes:

Diabetic ulcers, amputations, visual loss, renal failure, myocardial infection, congestive heart failure, strokes, other ischaemic heart disease, or remission from diabetes.

1. Hayes, A.J., Leal, J., Gray, A.M., Holman, R.R., Clarke, P.M., 2013. UKPDS Outcomes Model 2: a new version of a model to simulate lifetime health outcomes of patients with type 2 diabetes mellitus using data from the 30 year United Kingdom Prospective Diabetes Study: UKPDS 82. Diabetologia 56, 1925–1933. https://doi.org/10.1007/s00125-013-2940-y

Slide 12. Inclusions

The population-based interventions fell into one of the following groups:

- **Structured education**
    - **Diabetes prevention programme** for people at high risk of developing diabetes. (Diabetes Prevention Programme)
    - **Educational interventions –** where people with diabetes or people at risk are taught about diabetes, its treatment, risks, self-care and monitoring, healthy lifestyles and the importance of screening. (DESOMND, DAFNE, X-PERT)
    - **Web-based structured education tools**
- **Other specific lifestyle interventions –** including weight loss and exercise.
- **Multidisciplinary foot care services** – organisational reconfigurations to optimise the delivery of foot care reduce the risk of amputation.
- **Retinopathy screening –** organised nationally but delivered locally.
- **Bariatric surgery –** bariatric surgery can be used to reduce the risk of type 2 diabetes and to treat type 2 diabetes by reducing obesity.

Slide 13. Executive summary

This section summarises:

1. The geographic variation in demographics and selected outcomes within the Nottinghamshire Integrated Care Service area.
2. The populations that our identified interventions apply to, and the sub-populations who may benefit the most from these interventions based either on their degree of modifiable risk or their ability to participate in the service in comparison with alternatives.
3. The expected return on investment in these services.

Slide 14. CCG summary rankings

Levels	IMD[1]	Proportion BME[2]	Diabetes prevalence	% age 65 and over	Amputation rate	Type 2 achieving 3 targets
1. Highest	Nott' City	Nott' City	Mansfield & Ashfield	Newark & Sherwood	Nott' City	Nott' West
2	Mansfield & Ashfield	Nott' West	Newark & Sherwood	Nott' West / Rushcliffe	Mansfield & Ashfield	Rushcliffe
3	Newark & Sherwood	Rushcliffe	Nott' West	Nott' West / Rushcliffe	Newark & Sherwood	Nott' North & East
4	Nott' North & East	Mansfield & Ashfield	Nott' North & East	Nott' North & East	Nott' North & East	Newark & Sherwood
5	Nott' West	Nott' North & East	Nott' City	Mansfield & Ashfield	Rushcliffe	Nott' City
6. Lowest	Rushcliffe	Newark & Sherwood	Rushcliffe	Nott' City	Nott' West	Mansfield & Ashfield

Source: Public Health England 'Fingertips'. www.fingertips.phe.org.uk (Accessed December 2019)

In this table, the CCG are ranked according to each of the properties in the column headings. The top row has the highest score, and the bottom row, the lowest. So for deprivation, Nottingham City has the highest levels of deprivation, and Rushcliffe, the lowest.The **ranking for the rate of amputation** (penultimate column) is almost the **reverse** of the **ranking of the proportion of people with type 2 diabetes achieving all three treatment targets** (final column). The degree of control is known to influence the risk of amputation.[3]

At the CCG level, only **deprivation** and **not having an HbA1c between 6.5% and 7.5%** were significant **predictors of major amputation**. For excess **risk of renal replacement**, prevalence of **ethnic minorities**, poor control of **HbA1c**, uncontrolled **BP**, not being on **statins** and the proportion **failing to meet all three treatment targets** were significant predictors.

1. Index of Multiple Deprivation.
2. Black and Minority Ethnicity.
3. Hayes, A.J., Leal, J., Gray, A.M., Holman, R.R., Clarke, P.M., 2013. UKPDS Outcomes Model 2: a new version of a model to simulate lifetime health outcomes of patients with type 2 diabetes mellitus using data from the 30 year United Kingdom Prospective Diabetes Study: UKPDS 82. Diabetologia 56, 1925–1933.

Slide 15. Interventions summary

Intervention	Applicable population	Population likely to gain the most.
Structured education: Diabetes Prevention Programme (DPP)	All people with **pre-diabetes**	**Retired** or **not in work**.
Traditional structured education	**All** people newly diagnosed with diabetes. Type 2 – **DESMOND** Type 1 – **DAFNE** Either – **X-PERT** Existing people with diabetes who are poorly controlled.	**Retired** or **not in work**.
Structured education: web-based	**All** people newly diagnosed with diabetes Existing people with diabetes who are poorly controlled or have a history of non-adherence to medication or non-attendance at clinics.	**Working age** people with diabetes, those **living remotely** or with **transport difficulties**.
Multidisciplinary foot care teams	**All** people with diabetes	Poorly controlled, people with type 1 diabetes with a **history of ulcers** or **'diabetic foot'**.
Retinal screening	**All** people with diabetes	**Poorly controlled people with diabetes** from **deprived areas**, **BME** populations or a **history of non-attendance or non-adherence** to treatment.
Bariatric surgery	**People with type 2 diabetes** with a **BMI over 35** who are engaged with multidisciplinary weight management services. **People without diabetes** with a **BMI over 40** who are engaged with a multidisciplinary weight management service.	**Morbidly obese people with diabetes** with **poor control** or **additional risk** factors and who are **free of significant psychological illness**.

Structured education that is based on face-to-face contact typically has **low uptake rates**. Factors that affect the ability of invitees to attend include competing demands on time such as **work or caring commitments**, **distance from the teaching centres**. **Web-based structured education** addresses some of these issues as well as having unique benefits such as the **ability to easily tailor content** or **gamify control**.

People with diabetes with a **history of non-attendance** or non-adherence are at **higher risk of retinopathy** and visual loss. Steps taken to increase participation in this group may be relatively effective.

The potential **gains from bariatric surgery increase with risk**. People with **significant psychological illness** have **worse outcomes** than those who don't. These issues should be addressed before participation.

Slide 16. Return on investment

Web-based structured education (SE) intervention offer the highest returns on investment.

With the exception of the DPP, these values are calculated in relation to a standard user defined as a 60 year-old, male, obese diabetic.

Intervention	Initial cost	Years to recover initial cost	Ratio[2] 5-years	Cost effectiveness Cost per QALY
SE: DPP	**£270** per user	12 years	-	£2,336
Traditional SE[1]	**DESMOND – £203** **DAFNE – £359** **X-PERT - £180**	15 years	0.14	**DESMOND** - £2,920 **DAFNE** - £14,400 **X-PERT** - £6,800
Web-based SE[1]	**HeLP** - **£226** per user. **DDM** - **£90 for 3 years** for **Low-carb** app (NHS). **£100 p.a. for the testing app**. Annual cost of **£170 per user per year** used for modelling.	2 year	2.35	£5,550
Multidisciplinary foot care teams[1]	**£330** per referral per year	4 years	1.38	No information
Bariatric surgery[1]	**£6,235** per procedure	18 years	0.14	£7,129
Retinopathy screening	**£40** per year per person	10 year	0.62	£2,469

1. Obese 60 year-old male.
2. Ratio represent the number of pounds returned for every pound invested.

Slide 17. Recommendations

All of the interventions described here are cost-effective and are therefore **worth doing**.

To maximise return on investment and cost-effectiveness, **prioritize the following**:

- **Web-based structured education**. This offers the highest return on investment and are very cost-effective. This is in part because they have completion rates are much higher than traditional structured education. They can also utilize other features of the Internet or smartphone apps such as tools for self-monitoring, rapid tailoring of information to a user's needs, and gamification of diabetic control.[1]
- **Multidisciplinary foot-care services**. They have a rapid return on investment, and whilst a comprehensive UK cost-effectiveness analysis is lacking, it is very likely to be very cost-effective given the observed savings when implemented at pilot sites.
- **Take steps to improve uptake rates** for **structured education** everywhere, and **retinopathy screening** in Nottingham City in particular by:
    - **Addressing competing time pressures**. Consider running services out-of-hours or at weekends to make it easier for those in work or with caring commitments to attend. Promoting the use of web-based structured education for these groups may increase overall uptake. This is particularly important for those who are **economically disadvantaged**, who have less control of their working day, and greater need to prioritise income generation over education and health.
    - **Addressing travel and transport difficulties**. **Consider locating service provision closer to users**, particularly in the less densely populated areas. Again, **web-based applications** may be particularly useful for those with difficulty travelling to sites of service provision. Many **frail, elderly people** find it difficult to travel and may struggle with using the Internet or smartphone apps. Consider running traditional structured education services with staff in **elderly care homes or sheltered housing** where there is a high concentration of people with type 2 diabetes. Consider **mobile screening units** for retinopathy screening.
    - **Culturally adapt service provision**. In Nottingham City, there is a relatively high black and ethnic minority population. Review the provision of tr**anslation services**, select **web applications that are available in locally used languages**, and consult with **community representatives** on **potential barriers**.

- For **retinopathy screening,** identify and target those people with diabetes who have **missed two consecutive years of screening** for more **intensive reminders and engagement**. The most cost-effective interval for screening is three years, so cost-effectiveness falls for screening intervals longer than this.

1. Johnson, D., Deterding, S., Kuhn, K.-A., Staneva, A., Stoyanov, S., Hides, L., 2016. Gamification for health and wellbeing: A systematic review of the literature. Internet Interv 6, 89–106. https://doi.org/10.1016/j.invent.2016.10.002
2. Scanlon, P.H., Aldington, S.J., Leal, J., Luengo-Fernandez, R., Oke, J., Sivaprasad, S., Gazis, A., Stratton, I.M., 2015. Development of a cost-effectiveness model for optimisation of the screening interval in diabetic retinopathy screening. Health Technology Assessment 19, 1–116. https://doi.org/10.3310/hta19740

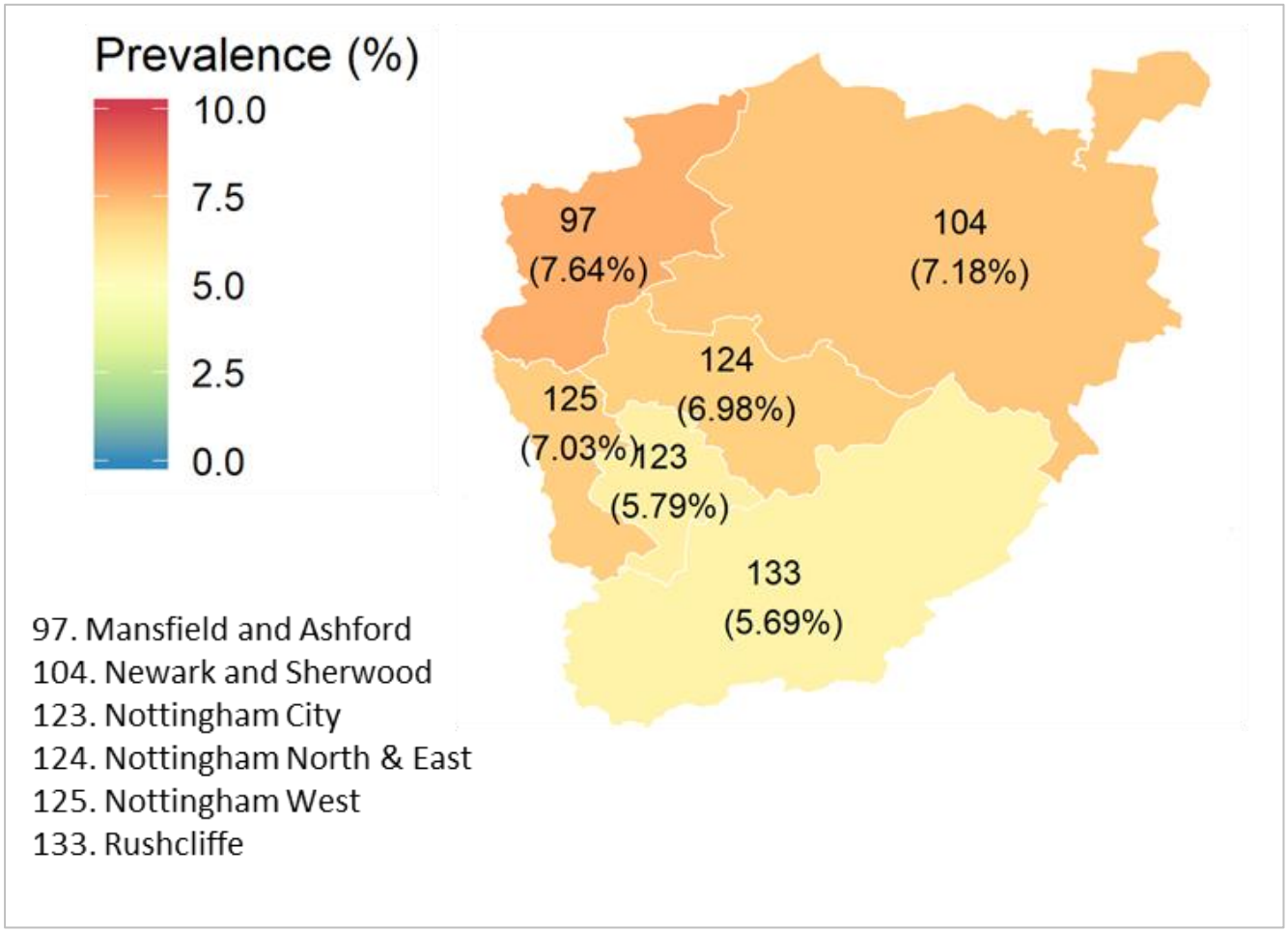
Slide 18. Context

The wider determinants that could affect patients' use of services and therefore how services could be commissioned:

- Diabetes prevalence
- CCG-level predictors of outcomes

Slide 19. Diabetes prevalence

Diabetes Prevalence (%) in 2017/18 by CCG2



This chart shows the prevalence of diabetes across the CCG areas of Nottingham. For each area the CCG number and the prevalence percentage is displayed. In 2017/18, diabetes prevalence was highest in Mansfield and Ashfield (7.64%), and lowest in Rushcliffe (5.69%).

Snapshot of ICPs 23 October 2019

Integrated Care Provider	% Pre-Diabetic (Range) [1]	% Type 2 (Range) [1]
Mid Nottingham	7.4 (7.0 – 7.8)	7.1 (6.2 – 7.6)
Nottingham City	3.2 (0.3 – 4.3)	5.4 (0.2 – 7.5)
South Nottingham	4.4 (3.2 – 6.0)	5.9 (4.5 – 7.3)

Shows % diagnosis rate of the age 15+ registered population in each ICP and range of the primary care network (PCN) neighbourhoods:
Mid Nottingham ICP - 6 PCN Neighbourhoods;
Nottingham City - 8 PCN Neighbourhoods;
South Nottingham - 10 PCN Neighbourhoods.

This table shows the percentage rate of diagnosis of pre-diabetes and type 2 diabetes across the three Integrated Care Partnership (ICP) areas, along with the range of values across the Primary Care Network (PCN) neighbourhoods within the ICP area. **Type 1** diabetic diagnosis rate is **below 1%** and is similar across Nottingham Integrated Care Partnerships (ICPs).

1) Nottinghamshire PCN Diabetes Profiles, GPRCC.
2) Quality and Outcomes Framework, Achievement, prevalence and exceptions data – 2017/18 (qof-1718-prev-all-lev).

Slide 20. Predictors of outcomes at the CCG level

The effects of CCG level factors on the outcomes in patients with diabetes was investigated by performing multiple linear regression of **age categories**, **gender**, **ethnic minority prevalence**, **deprivation**, **treatment target categories** and the **achievement of all of the eight process targets** or **all of the three treatment targets** obtained from the Public Health England indicators[1].

Major amputation

The only statistically significant predictors of major amputation were the **dominant deprivation quintile** and not having an **HbA1c** between 6.5% and 7.5%.

Additional risk of renal replacement therapy

The significant predictors of excess risk of renal replacement therapy were prevalence of **ethnic minorities**, proportion of **HbA1cs less than 7.5%**, proportion of **BPs below 140/80**, being **on statins** and **achieving all three treatment targets.**

Age category, **gender** and **process target achievement** were **not significant** predictors for either outcome. Only **~16% of the variation** between CCGs was accounted, so most of the variation is driven by factors not included in the CCG indicators, individual variation or the random play of chance.

1) www.fingertips.phe.org.uk

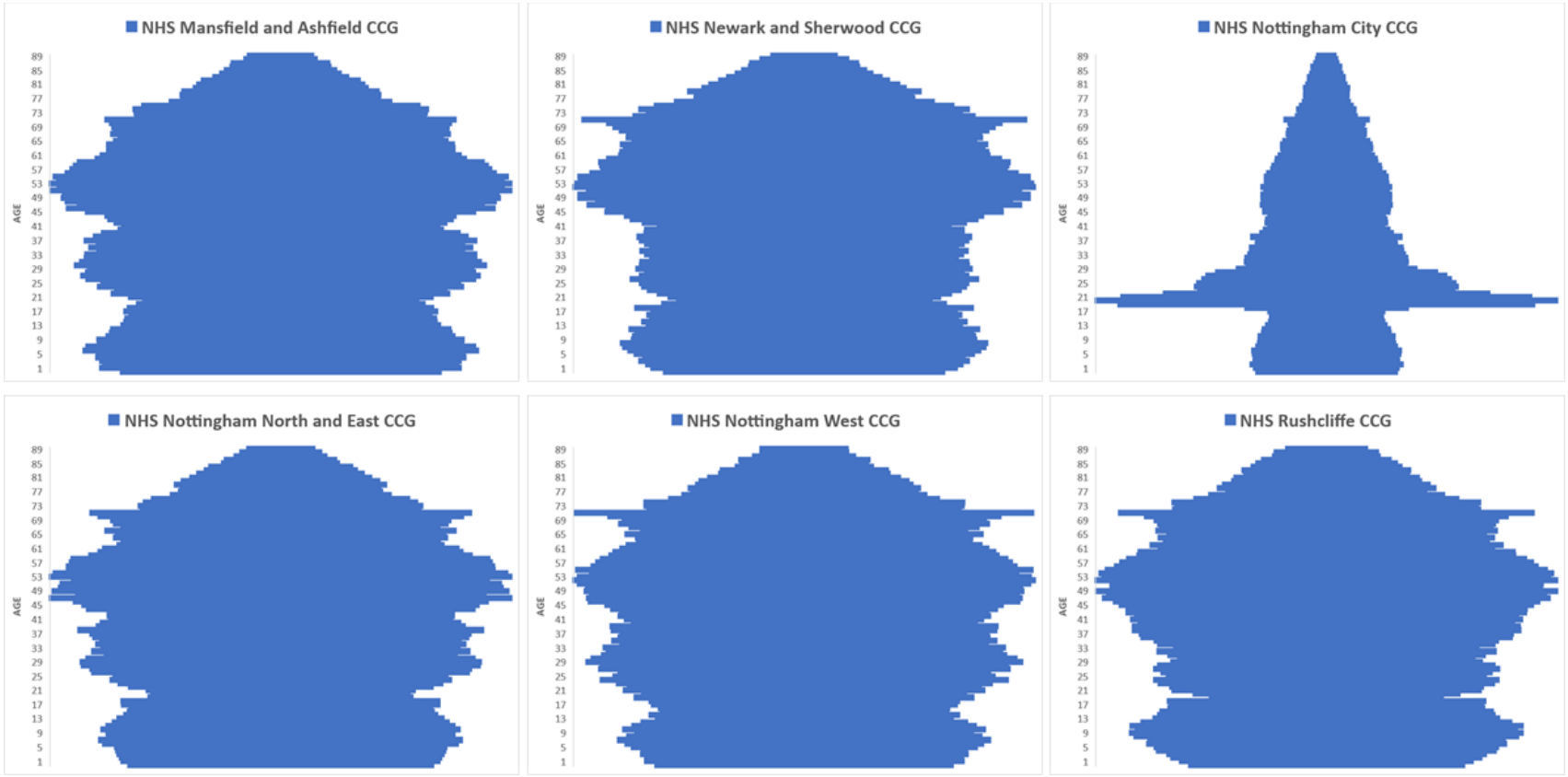
Slide 21. Wider determinants of health

The socio-demographic and lifestyle factors relevant to delivering care to people with diabetes:

- Population
- Deprivation
- Impactability and health inequalities
- Distances
- Weight and obesity
- Smoking

Slide 22. Population: age demographics by CCG

These population pyramid charts show the age distribution in each of the constituent CCG areas of the Nottinghamshire ICS area. Nottingham City stands out as having a large proportion of 18 to 25-year-olds reflecting the presence of a major university.



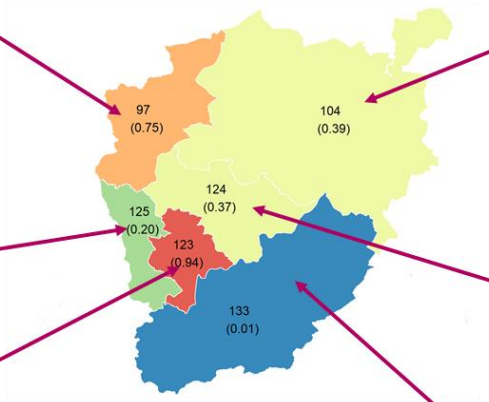
Source: Office for National Statistics (ONS), Mid 2018 population estimates

The proportion of the population **over the age of 65** is only **12%** in Nottingham City compared to **19-21%** across all the **other CCGs**.

Slide 23. Demographics and Deprivation

Mansfield and Ashfield
Urban area with a history of mining and textile industry. Moderately deprived (on the 25th percentile for England). Part of the **Mid-Nottinghamshire Integrated Care Provider.**

Newark and Sherwood
An ancient market town, with lower levels of deprivation than the national average (39th percentile for England).
It is less densely populated than most of the rest of Nottingham, with rural areas to the West. Part of the **Mid-Nottinghamshire Integrated Care Provider.**



Nottingham West
Is a reasonably well-off suburb to the West of Nottingham (on the 20th percentile for England). Part of the **South Nottinghamshire Integrated Care Provider.**

Nottingham North and East
Urban area to the East of the city centre with lower levels of deprivation than the national average (37th percentile for England). Part of the **South Nottinghamshire Integrated Care Provider.**

Nottingham City
Densely populated and very deprived (94th percentile in England).
Over a quarter of the population are from ethnic minorities.
A large body of students in their late teens and early 20s. Forms the **Nottingham City Integrated Care Provider.**

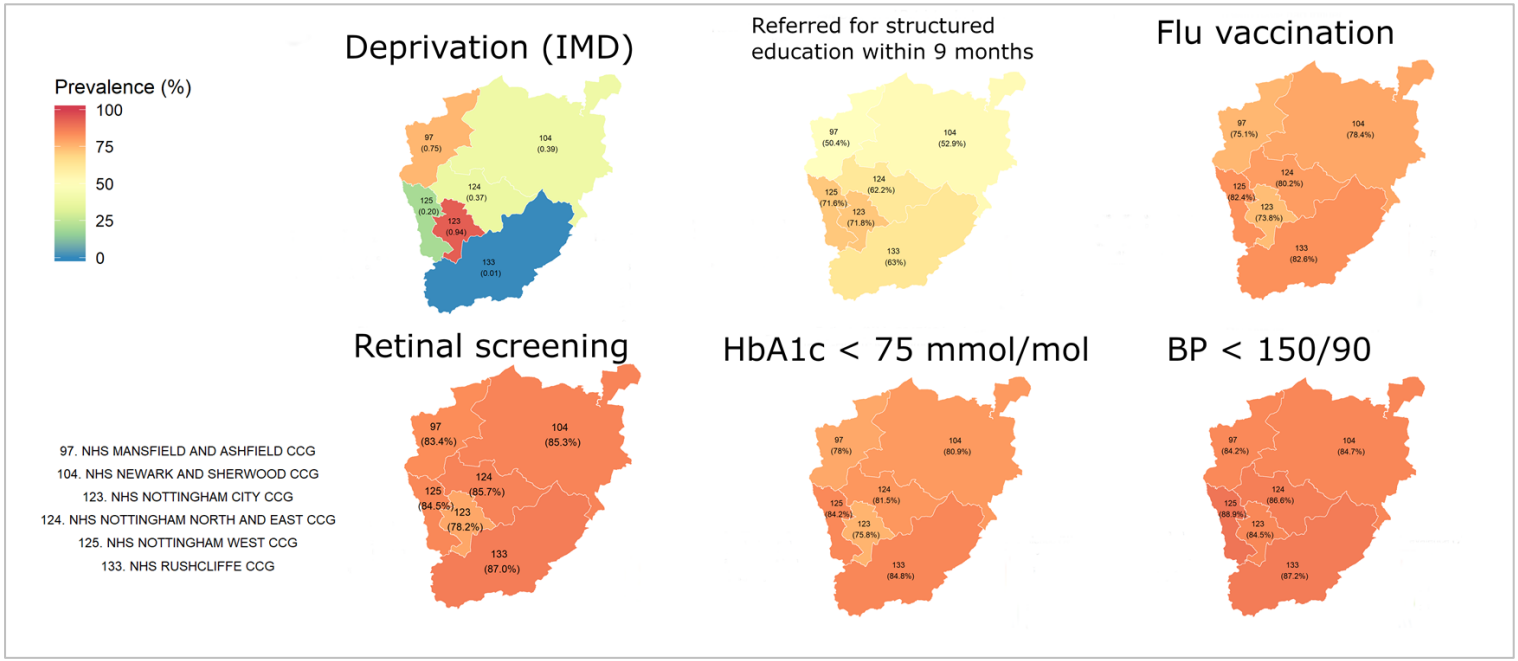
Rushcliffe
This is one of the least deprived parts of England (1st percentile).
It is less densely populated than most of the rest of Nottingham and has rural areas. Part of the **South Nottinghamshire Integrated Care Provider.**

Social deprivation may affect service provision and patient outcomes. This chart displays the deprivation indices across CCG areas of Nottinghamshire. Deprivation percentiles are calculated using the Index of Multiple Deprivation (IMD) statistic for each area. In each map area the CCG number and IMD deprivation value are displayed. While Rushcliffe is one of the least deprived areas in England, the neighbouring CCG of Nottingham City is one of the most deprived. Nottingham city is the most deprived area in Nottinghamshire, which would be expected to correlate with a high prevalence of diabetes. However, it also has a much younger population, which mitigates for this effect and results in a diabetes prevalence only 0.1% higher than Rushcliffe.

Source: Nottinghamshire PCN Diabetes Profiles, GOV.CO.UK

Slide 24. Deprivation and achievement

Each chart displays the percentage of patients with diabetes that fall into each title category, sub-divided into each CCG. The exception is the Deprivation chart, where deprivation is shown as a percentile for each CCG relative to all CCG areas in England. A colour gradient has been applied across the range of 0%-100% to avoid biasing perception of the variation between CCGs. In each map area the CCG number and associated percentage value are displayed.



1) Quality and Outcomes Framework, Achievement, prevalence and exceptions data – 2017/18 (qof-1718-prev-all-lev).
2) Public Health England, NHS Diabetic Eye Screening Programme 2016-17.

It can be seen that the proportion of people with diabetes referred for structured education is about **20% lower** in the **sparsely populated** northern CCGs compared to the densely populated Nottingham City and Nottingham West. Distance may be important factor in non-attendance rates at screening clinics or structured education.

25. Impactability and health inequalities

On the whole, the results suggest that those at the highest risk offer the highest return on investment in services such as the elderly, the morbidly obese and those with co-morbidities.

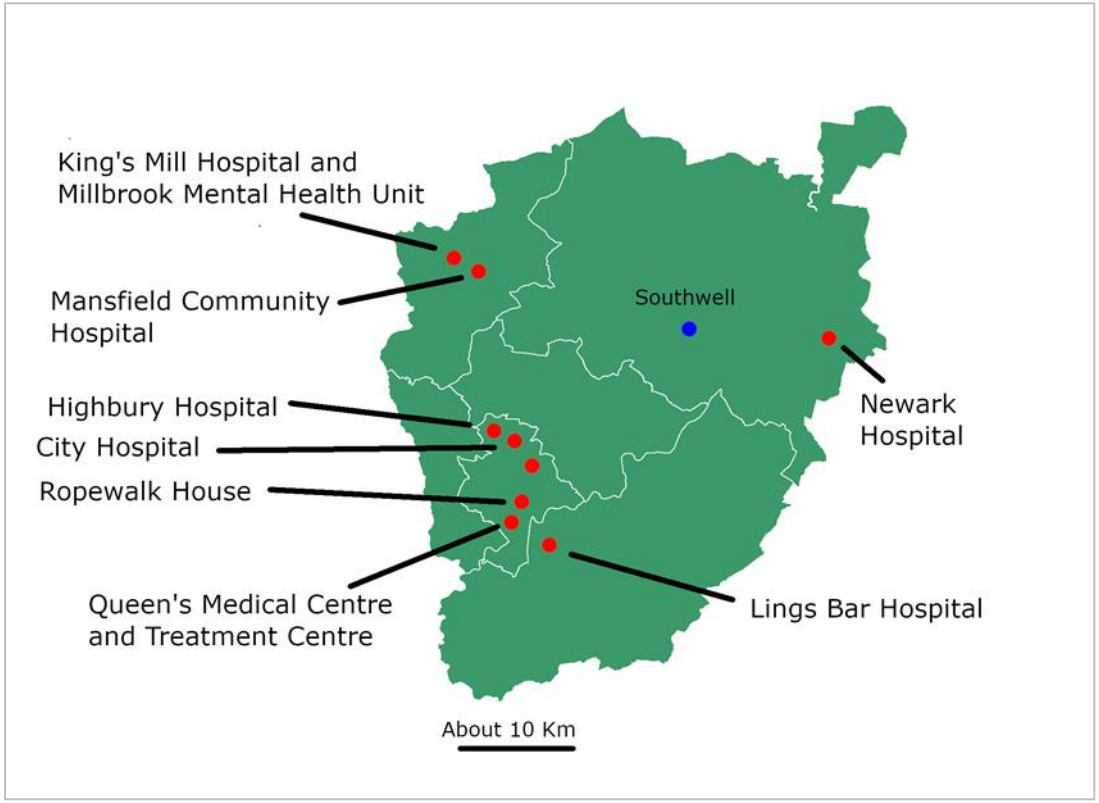
It has also been identified that poor adherence to medication[1] and recorded non-attendance at screening or clinics[2] is a marker for poor outcomes.

Targeting those with a **history of poor adherence to medication or non-attendance** at a clinic in addition to other markers of risk **for web-based structured education** with **intermittent reminders**[3] may improve overall outcomes and reduce health inequalities but may not offer the maximum return on investment.

Non-attendance can be driven by competing demands on time, so **provision of service out of hours or at weekends** may improve attendance rates[4].

1) Khunti K., Seidu S., Kunutsor S., Davies M., 2017. Association between adherence to pharmacotherapy and outcomes in type 2 diabetes: A meta-analysis. Diabetes Care 40, 1588–1596. https://doi.org/10.2337/dc16-1925/-/DC1
2) Kashim, R.M., Newton, P., Ojo, O., 2018. Diabetic Retinopathy Screening: A Systematic Review on Patients' Non-Attendance. Int J Environ Res Public Health 15. https://doi.org/10.3390/ijerph15010157
3) Zhang, X., Norris, S.L., Saadine, J., Chowdhury, F.M., Horsley, T., Kanjilal, S., Mangione, C.M., Buhrmann, R., 2007. Effectiveness of interventions to promote screening for diabetic retinopathy. Am J Prev Med 33, 318–335. https://doi.org/10.1016/j.amepre.2007.05.002
4) Finnigan, Y., Clarkson, Mandy, 2019. "What is the best model of community-based care to meet the need across City and County populations and to optimize clinical outcomes, cost-effectiveness and to reduce non-elective health care usage? Knowledge Services Evidence Summary. Greater Nottingham Clinical Commissioning Group

Slide 26. Distances



Distance may affect the ability of users to access healthcare services[1,2], health outcomes[3] and the experience of care[4].

This map has the major treatment centres in the Nottinghamshire ICS plotted in red.

Someone from Southwell (plotted in blue) is over 10km from Newark Hospital and 19km from King's Mill.

Strategies that bring services closer to people with diabetes may improve uptake and therefore outcomes.

1) Maheswaran, R., Pearson, T., Jordan, H., Black, D., 2006. Socioeconomic deprivation, travel distance, location of service, and uptake of breast cancer screening in North Derbyshire, UK. J Epidemiol Community Health 60, 208–212. https://doi.org/10.1136/jech.200X.038398
2) Ellis, D.A., McQueenie, R., McConnachie, A., Wilson, P., Williamson, A.E., 2017. Demographic and practice factors predicting repeated non-attendance in primary care: a national retrospective cohort analysis. The Lancet Public Health 2, e551–e559. https://doi.org/10.1016/S2468-2667(17)30217-7
3) Kelly, C., Hulme, C., Farragher, T., Clarke, G., 2016. Are differences in travel time or distance to healthcare for adults in global north countries associated with an impact on health outcomes? A systematic review. BMJ Open 6, e013059. https://doi.org/10.1136/bmjopen-2016-013059
4) Payne, S., Jarrett, N., Jeffs, D., 2000. The impact of travel on cancer patients' experiences of treatment: a literature review. Eur J Cancer Care (Engl) 9, 197–203. https://doi.org/10.1046/j.1365-2354.2000.00225.x

Slide 27. Overweight and obese people with diabetes

Obesity is a risk factor for the development of diabetes and patient outcomes. The table below shows the percentage of overweight and obese patients with pre-diabetes or type 2 diabetes across the three Integrated Care Partnership (ICP) areas, along with the range of values across the Primary Care Network (PCN) neighbourhoods within the ICP area.

Integrated Care Provider	% Overweight and Obese Pre-Diabetic (Range)*	% Overweight and Obese Type 2 Diabetic (Range)*
Mid Nottingham	76 (75 – 79)	86 (85 – 88)
Nottingham City	79 (69 – 82)	84 (82 – 86)
South Nottingham	78 (73 – 81)	84 (83 – 87)

*Shows percentage of overweight and obese people with diabetes in each ICP and the range in the constituent Primary Care Network (PCN) Neighbourhoods.
Mid Nottingham ICP - 6 PCN Neighbourhoods;
Nottingham City - 8 PCN Neighbourhoods;
South Nottingham - 10 PCN Neighbourhoods.

Source: Nottinghamshire PCN Diabetes Profiles, GPRCC.

Slide 28. Diabetic smokers

Smoking is a risk factor for outcomes in patients with diabetes. In Nottinghamshire, people with type 1 diabetes have the highest smoking rates. Pre- and type 2 diabetic smoking rates are similar within each ICP, but vary across ICPs.

Integrated Care Provider	% Type 1 Smokers (Range)*	% Pre-Diabetic Smokers (Range)*	% Type 2 Smokers (Range)*
Mid Nottingham	18 (15 – 22)	16 (14 – 18)	15 (13 – 16)
Nottingham City	22 (4 – 26)	18 (8 – 22)	17 (10 – 19)
South Nottingham	15 (9 – 22)	11 (8 – 15)	11 (9 – 12)

*Shows percentage of people with diabetes who currently smoke in each ICP and range of the PCN Neighbourhoods.
Mid Nottingham ICP - 6 PCN Neighbourhoods;
Nottingham City - 8 PCN Neighbourhoods;
South Nottingham - 10 PCN Neighbourhoods.

Source: Nottinghamshire PCN Diabetes Profiles, GPRCC.

Slide 29. Clinical considerations

Three major clinical complications of diabetes were identified by Nottinghamshire ICS as being of particular interest:

- **Amputations**
- **Vision loss**
- **Chronic kidney disease**

Slide 30. Clinical considerations

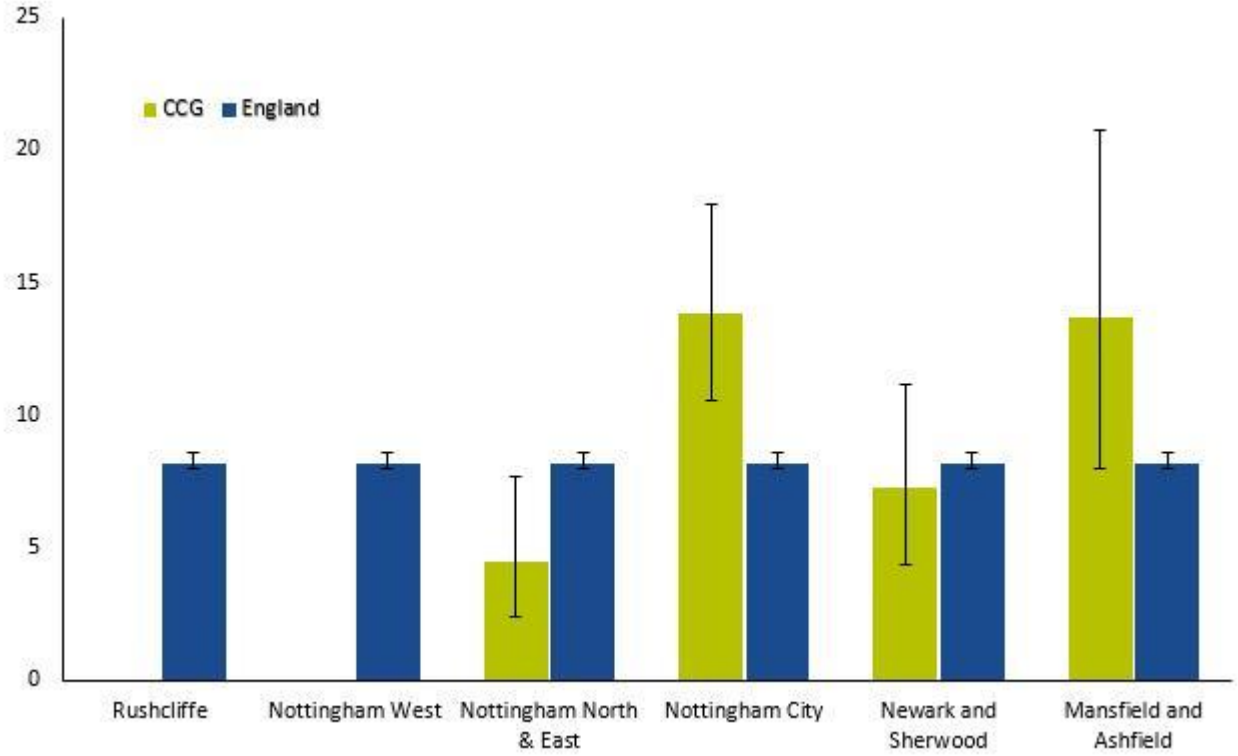
Three major clinical complications of diabetes were identified by Nottinghamshire ICS as being of particular interest – **amputations, visual loss and chronic kidney disease.**

The risk of diabetic complications are driven by the degree of control of diabetes, as measured by the **glycosylated haemoglobin (HbA1c**) and other modifiable risk factors including **smoking status**, measures of **cholesterol** (LDL and HDL) and **systolic blood pressure**.

The table below indicates the key modifiable risk factors that affect diabetic outcomes.

	Diabetic ulcers	**Amputations**	Ischaemic heart disease	Myocardial infarction	Congestive heart failure	Stroke	**Vision loss**	**Renal failure**
HbA1c	X	**X**		X		X	**X**	
Systolic blood pressure		**X**	X	X		X	**X**	**X**
Smoking				X		X		
Low-density lipoprotein (LDL			X	X	X	X		**X**
High-density lipoprotein (HDL)		**X (protective)**	X (protective)	X (protective)				

Slide 31. Major amputations



A systematic review in 2016 found that **major amputation rates** are **falling**, but that **minor amputation rates** are **rising** in England.[1]

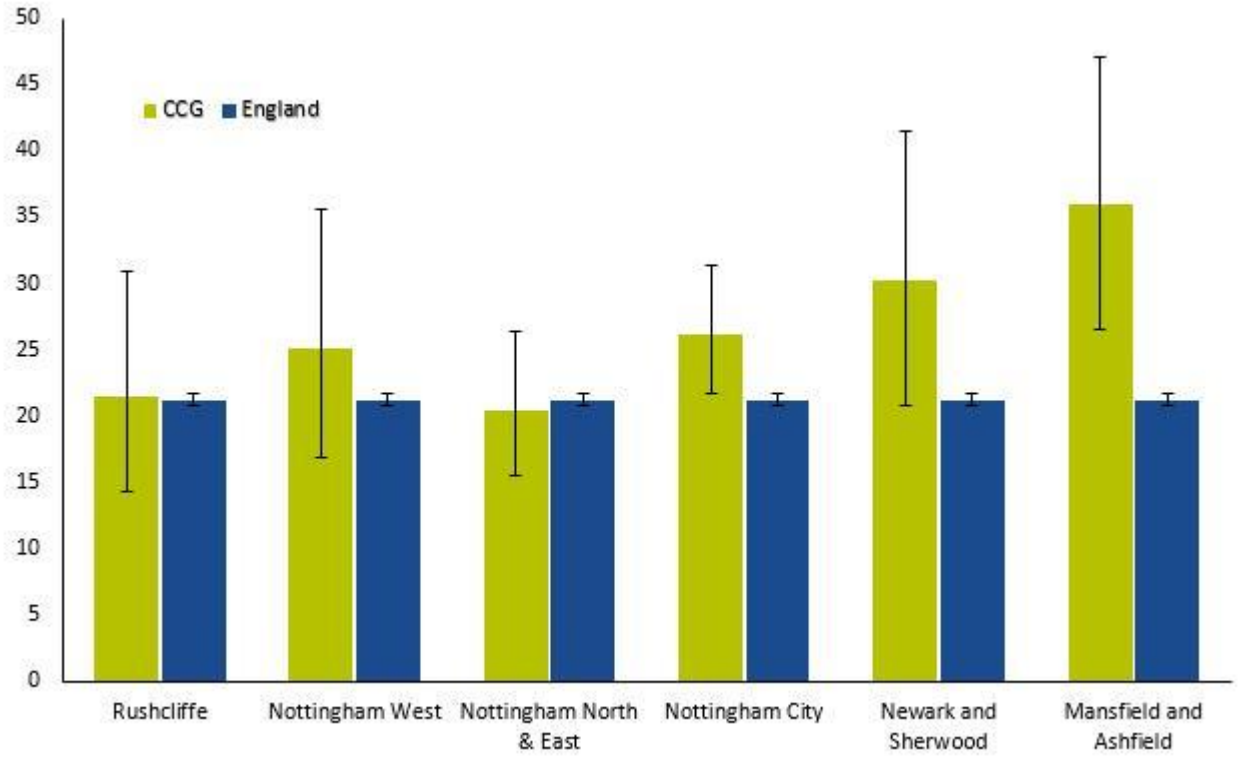
This chart shows the rate of major amputations for Nottinghamshire CCGs, alongside the rate for England as a whole. Data for Rushcliffe and Nottingham West is not show as there was no data available from the Hospital Episode Statistics.

*Amounts of major amputations dependent on source and standardisation of data.

1) Ahmad, N., Thomas, G.N., Gill, P., Torella, F., 2016. The prevalence of major lower limb amputation in the diabetic and non-diabetic population of England 2003–2013. Diabetes and Vascular Disease Research 13, 348–353. https://doi.org/10.1177/1479164116651390Public Health England – Diabetes Foot Care Profiles.

Slide 32. Minor amputations

The same systematic review found that **minor amputation rates** were **rising** in England.[1] It may be that earlier aggressive treatment including minor amputations reduces the subsequent risk of major amputation. The chart below shows the rate of minor amputations for Nottinghamshire CCGs, alongside the rate for England as a whole.



1) Ahmad, N., Thomas, G.N., Gill, P., Torella, F., 2016. The prevalence of major lower limb amputation in the diabetic and non-diabetic population of England 2003–2013. Diabetes and Vascular Disease Research 13, 348–353. https://doi.org/10.1177/1479164116651390Public Health England – Diabetes Foot Care Profiles.

2) Public Health England – Diabetes Foot Care Profiles

Slide 33. Vision loss

In 2018, the estimated percentage of people with diabetes living with **retinopathy** and **severe retinopathy** was **lower in Nottinghamshire** compared to England.[1]

- Percentage of people with diabetes with **retinopathy** was **29.8%** in Nottinghamshire versus **31.6%** in England
- Percentage of people with diabetes with **severe retinopathy** was **2.74%** in Nottinghamshire versus **2.91%** in England

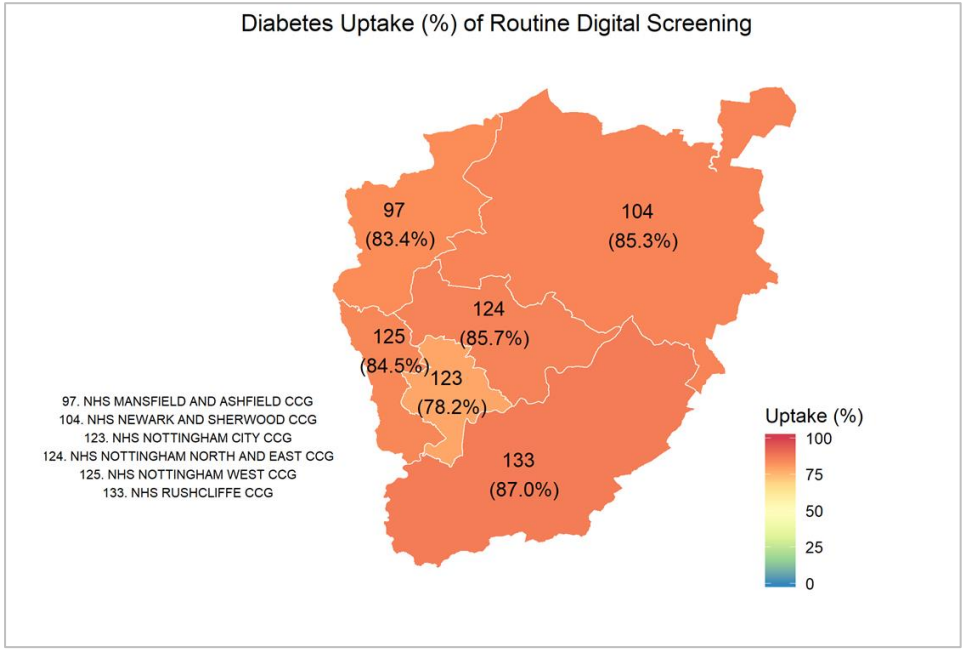
All 7 local authorities in Nottinghamshire fell **below the national average** for all forms of retinopathy.

A slightly higher percentage of patients living with retinopathy in Nottinghamshire were estimated to have severe retinopathy compared to England, **9.21%** versus **9.19%,** respectively.

- Of the 7 local authorities, 3 were above average (Gedling, Mansfield, Newark and Sherwood).

1) RNIB Sight Loss Data Tool V4.

Slide 34. Low uptake of screening in Nottingham City CCG



Here is shown a heat map of retinopathy screening uptake in Nottinhamshire CCGs. In each map area the CCG number and uptake percentage value are displayed. It can be seen that Nottingham city has the lowest uptake (78.2%) while Rushcliffe has the highest (87.0%).

The population of Nottingham City is much **younger** compared to the rest of the ICS.

Nottingham City is the CCG with the **highest levels of deprivation** in the ICS.[1]

28% of the **Nottingham City** CCG population are from **black or ethnic minority groups (BME)**, compared to between **2%** and **7%** in the rest of the ICS.[1]

Youth, deprivation and **ethnicity** are associated with **reduced attendance**.[2]

1. Nottinghamshire PCN Diabetes Profiles, GOV.CO.UK
2. Kashim, R.M., Newton, P., Ojo, O., 2018. Diabetic Retinopathy Screening: A Systematic Review on Patients' Non-Attendance. Int J Environ Res Public Health 15. https://doi.org/10.3390/ijerph15010157

Slide 35. Factors affecting attendance at retinal screening

In addition to deprivation and ethnicity, age and distance are also associated with retinal screening attendance. Below is shown a table of these four factors and reasons for their effects on attendance.

Age	Deprivation	Distance	Ethnicity
Younger age groups have **lower attendance** rates. [1]	**Deprivation** is associated with **lower attendance** rates. [1]	**Non-attendance** appears to increase with increasing **distance** from places of service delivery. [1]	Coming from a **black or ethnic minority group**, or being **born outside of the UK** increases non-attendance**.** [1]
Younger people may have **less knowledge** about diabetes and the affect of not attending retinal screening on the **risk of blindness**.	People in deprived areas have **less power and control over their daily lives** and may find it difficult to take **time off work** to attend.	The **costs of attendance** to an individual in terms of time or the cost of travel rise with the distance.	There may be **language barriers** that interfere with case finding, engagement and understanding of the need and purpose of screening.
People of working age may have **competing priorities** that make it difficult to attend screening in working hours.[1]	People in deprived area **have fewer resources** and may find the out-of-pocket **costs of attendance** such as travel harder to meet.	Non-attendance rises **0.4%** per minute of travel time[2]*, or **3%** if over **2km** away.[3]	There may be concerns about possible **cultural barriers** to participation.

*Failed to reach statistical significance when controlled for other variables

1) Kashim, R.M., Newton, P., Ojo, O., 2018. Diabetic Retinopathy Screening: A Systematic Review on Patients' Non-Attendance. Int J Environ Res Public Health 15. https://doi.org/10.3390/ijerph15010157
2) Leese, G.P., Boyle, P., Feng, Z., Emslie-Smith, A., Ellis, J.D., 2008. Screening Uptake in a Well-Established Diabetic Retinopathy Screening Program: The role of geographical access and deprivation. Diabetes Care 31, 2131–2135. https://doi.org/10.2337/dc08-1098
3) Ellis, D.A., McQueenie, R., McConnachie, A., Wilson, P., Williamson, A.E., 2017. Demographic and practice factors predicting repeated non-attendance in primary care: a national retrospective cohort analysis. The Lancet Public Health 2, e551–e559. https://doi.org/10.1016/S2468-2667(17)30217-7

Slide 36. Increasing uptake of retinopathy screening

Multiple methods have been shown to improve retinopathy screening attendance rates through addressing factors identified on the previous slide. These methods are outlined in the table below.

Education	**Reminders**	**Service side adaptation**	**Mobile screening units**	**Out of hours appointments**
Educating people with diabetes to **increase awareness** of and the potential **consequences** of diabetic retinopathy.[1,2]	Reminders before appointments or at intervals after a failure to attend.[2]	**Cultural adaptations** of the service to increase accessibility to people with diabetes from a BME background. Training of staff on systematic approaches to increasing screening uptake.[2]	Community based screening via **mobile units** can increase uptake, particularly if located at **GP surgeries**.[2] This will target **working age adults**, the **economically disadvantaged** and those living at **greater distances** from screening centres.	A recent NHS England report by Sir Mike Richards recommends increasing **out of hours provision** of screening to increase uptake.[3] This will target **working age adults**, the **economically disadvantaged**.

1) Hipwell, A.E., Sturt, J., Lindenmeyer, A., Stratton, I., Gadsby, R., O'Hare, P., Scanlon, P.H., 2014. Attitudes, access and anguish: a qualitative interview study of staff and patients' experiences of diabetic retinopathy screening. BMJ Open 4, e005498. https://doi.org/10.1136/bmjopen-2014-005498
2) Zhang, X., Norris, S.L., Saadine, J., Chowdhury, F.M., Horsley, T., Kanjilal, S., Mangione, C.M., Buhrmann, R., 2007. Effectiveness of interventions to promote screening for diabetic retinopathy. Am J Prev Med 33, 318–335. https://doi.org/10.1016/j.amepre.2007.05.002
3) Richards, M., 2019. Report of THE INDEPENDENT REVIEW OF ADULT SCREENING PROGRAMMES in England (No. 01089). NHS England, Leeds.

Slide 37. Evidence for Chronic Kidney Disease (CKD)

Prevalence amongst people with diabetes in Nottinghamshire was **4.56%** versus **4.11%** for England in 2017/18.[1]

Only 1 Clinical Commissioning Group, **NHS Nottingham City**, fell **below the England average**. This could be related to the **relative youth** of the city population.

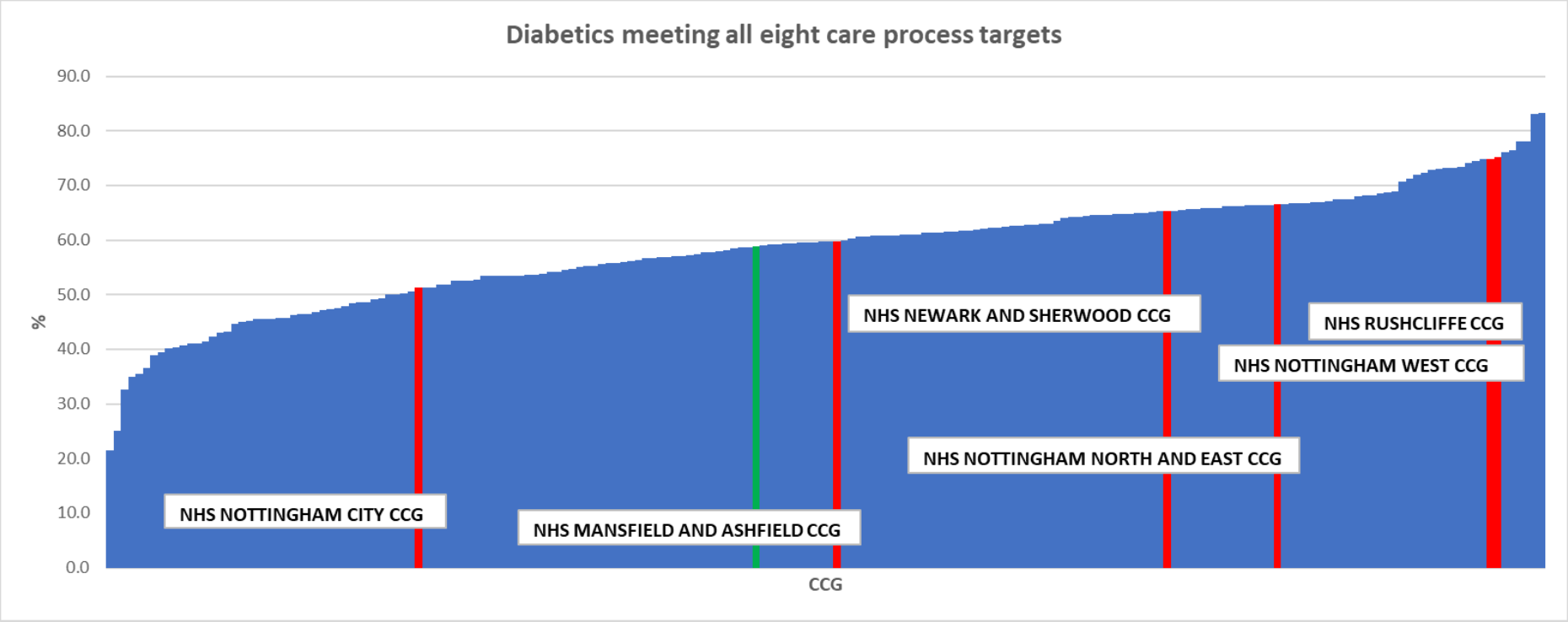
Clinical Commissioning Group	CKD Prevalence 2017/18
NHS Mansfield and Ashfield	4.96%
NHS Newark and Sherwood	5.74%
NHS Nottingham City	**2.93%**
NHS Nottingham North and East	5.77%
NHS Nottingham West	5.32%
NHS Rushcliffe	5.52%

1) Quality and Outcomes Framework, Achievement, prevalence and exceptions data – 2017/18 (qof-1718-prev-all-lev).

Slide 38. Diabetes care process targets 2017-2018

The National Diabetes Audit 2017-18 identified eight treatment targets for diabetic patients. In the chart below, England CCGs are ranked according to what percentage of its diabetic patient population met all eight targets. CCGs with the lowest percentage are shown on the left, and those with the highest are shown on the right. The eight targets were: HbA1c, blood pressure, cholesterol, serum creatinine, urinary albuminuria, foot surveillance, BMI and smoking.

Five out of the six Nottinghamshire ICS CCGs (shown as red bars) are **above the average** achievement for England (shown as a green bar).



Source: National Diabetes Audit (NDA) 2017-18 Interactive report for England, Clinical Commissioning Groups and GP practices, 2019. . NHS Digital, Health and Social Care Information Centre.

Slide 39. Return on Investment / cost effectiveness summary

Return on Investment

Return on investment (ROI) is a measure of the **financial gain** arising from an intervention. It is usually expressed as the number of pounds gained in reduced direct costs at a particular time for each pound invested. Only direct costs that the provider of the intervention incurs are included, and so does not include indirect costs such as time off work. An intervention with an **ROI of less than one costs money** to apply up to that time. An intervention with an **ROI of greater than one** will lead **cost savings** at that time. The **ROI** is important when considering the **cash-flows** when introducing an intervention.

Cost-effectiveness

Cost-effectiveness (CE) is a measure of the cost of some **clinical benefit**. It is usually expressed as a **cost per quality adjusted life-year (QALY) gained**. NICE will usually recommend interventions that cost no more than £20,000 per QALY gained. The **CE** is important when considering the **gain in population health**. Cost effectiveness can be estimated at different time-horizons, different point of time in the future. Usually, by default, an **incremental cost-effectiveness ratio** (**ICER – the cost per quality adjusted life-year (QALY) gained**) will be calculated over a lifetime. However, sometimes they are calculated at a particular time point because there may be insufficient data to project forwards, or because the cost effectiveness within a certain time-frame may be more important. Unless otherwise stated ICERs will be based on a lifelong time-horizon.

ICERs tend to decrease with time until the subjects are elderly, when it may start to rise if there is an increased survival in the treated group. Older people have more adverse events and cost more to treat. Consequently, it is possible to have an intervention that is cost-saving at a particular point in time, but with a positive ICER when calculated over a lifetime as more people live to be very elderly.

An intervention can have a high return on investment and yet not be cost-effective if it saves money, but without significantly improving the quality of life of the population.

Slide 40 Prioritising interventions

The choice of interventions to invest in will be based on a variety of factors including:

- The **initial cost** of providing the intervention;
- The population **health gain** that may be achieved (**cost-effectiveness**);
- Downstream **savings** that may be realised (**ROI**);
- The **financial resources** available;
- Other resources required such as the supply of **equipment and staff**;
- The **existing service provision,** its **effectiveness** and **plasticity***;
- Other factors like **geography**, **socio-demographics**, **ethnicity** and **cultural acceptability**.

We address the first three of these factors – **initial cost**, **effectiveness** and **potential savings**.

*The **plasticity** of an organisation is the **ease with which it can be remodelled**. Work-flows can be changed quickly and easily, redeployment of staff or changing contractual arrangements may take time, and changing infrastructure such as buildings and equipment may be difficult, slow and expensive.

Slide 41. Interventions

1. Structured education
    a) Diabetes Prevention Programme (DPP)
    b) Traditional programmes (DESMOND, DAFNE, X-PERT)
    c) Web-based structured education (DDM; My Diabetes, My Way; Changing Health; POWeR, HeLP-Diabetes) Multidisciplinary foot care services
2. Other lifestyle interventions
3. Multidisciplinary footcare services
4. Retinopathy screening
5. Bariatric surgery

Slide 42. Interventions: summary

Diabetes Prevention Programme	Structured Education	Web-based structured education
NHS Diabetes Prevention Programme (NHS DPP) identifies those at high risk and refers them onto a behaviour change programme. The NHS DPP is a joint commitment from NHS England, Public Health England and Diabetes UK. A commitment to develop digital access is part of the NHS Long- Term Plan.	Structured education programmes teach newly diagnosed people with diabetes about the disease, its treatment, and healthy lifestyles. Examples include DESMOND for people with type 2 diabetes, and DAFNE for people with type 1 diabetes. They are delivered face-to-face, classroom style and typically have low uptake rates.	These are a new generation of structured education programmes that are web based using the internet and smart-phone apps, along with face to face engagement. They have higher uptake rates and report significant remission rates but, as yet, they are less robustly evaluated as they are relatively new.

Multidisciplinary foot care services	Retinopathy screening	Bariatric surgery
Organisational reconfigurations to streamline case finding and patient pathways. These will make better use of the skills of diabetologists, specialist nurses, surgeons, podiatrists and others to improve the outcomes for people with diabetes with foot problems.	Digital retinopathy screening began in England in 2003 and was nationally implemented by 2008. About 80% of people with diabetes are screened nationally every year. The screening programme appears to have reduced the rate of sight impairment due to diabetes by about 20%.	Bariatric surgery is used to limit a person's food intake and / or its absorption. They are costly procedures but are very effective at reducing weight and have a significant associated remission rate. Types of bariatric surgery include gastric bypass procedures like 'Roux-en-Y', sleeve gastrectomy, adjustable gastric bands or small bowel bypasses.

Slide 44. 1) Structured Education

a) **Diabetes Prevention Programme (DPP)**

b) **Traditional programmes (DESMOND, DAFNE, X-PERT)**

c) **Web-based structured education (DDM; My Diabetes, My Way; Changing Health; POWeR, HeLP-Diabetes)**

Slide 45. Structured education

Educational, **lifestyle** and **social interventions** are increasingly delivered in combination as structured education programmes, and we have considered examples endorsed by the NHS including the **Diabetes Prevention Programme (DPP)** for people with **pre-diabetes**, and **DAFNE**, **DESMOND** and **X-PERT** for people with type 1 and type 2 diabetes.

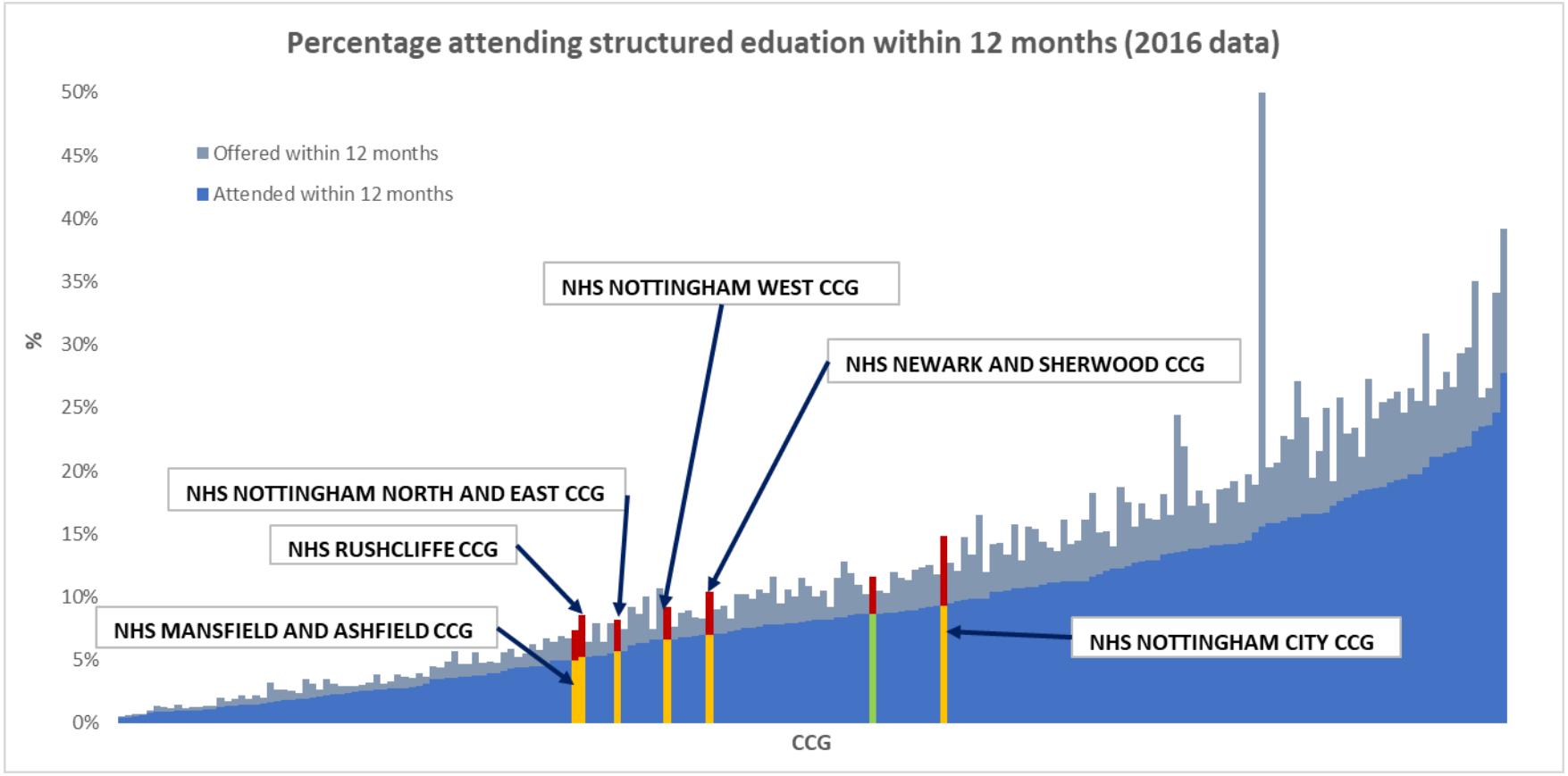
Digital platforms for the delivery of structured education are considered separately as 'web-based structured education'. Whilst the underlying content may be similar, the nature of these platforms have the potential to greatly improve access and the personalization of these services.

We have structured our report around three kinds of structured education:

- The **Diabetes Prevention Programme** representing services targeting those at risk of, but not with, diabetes.
- **Structured education programmes** for people with diabetes with **DESMOND**, **DAFNE** and **X-PERT** as examples.
- **Web-based structured education programmes** such as **DDM**, **Changing Health** and **'My Diabetes – My Way'**.

Slide 46. Context for Nottinghamshire

In 2016, **five out of six** of the Nottinghamshire ICS CCGs had **lower than average** achievement for the **uptake of structured education**.[1]



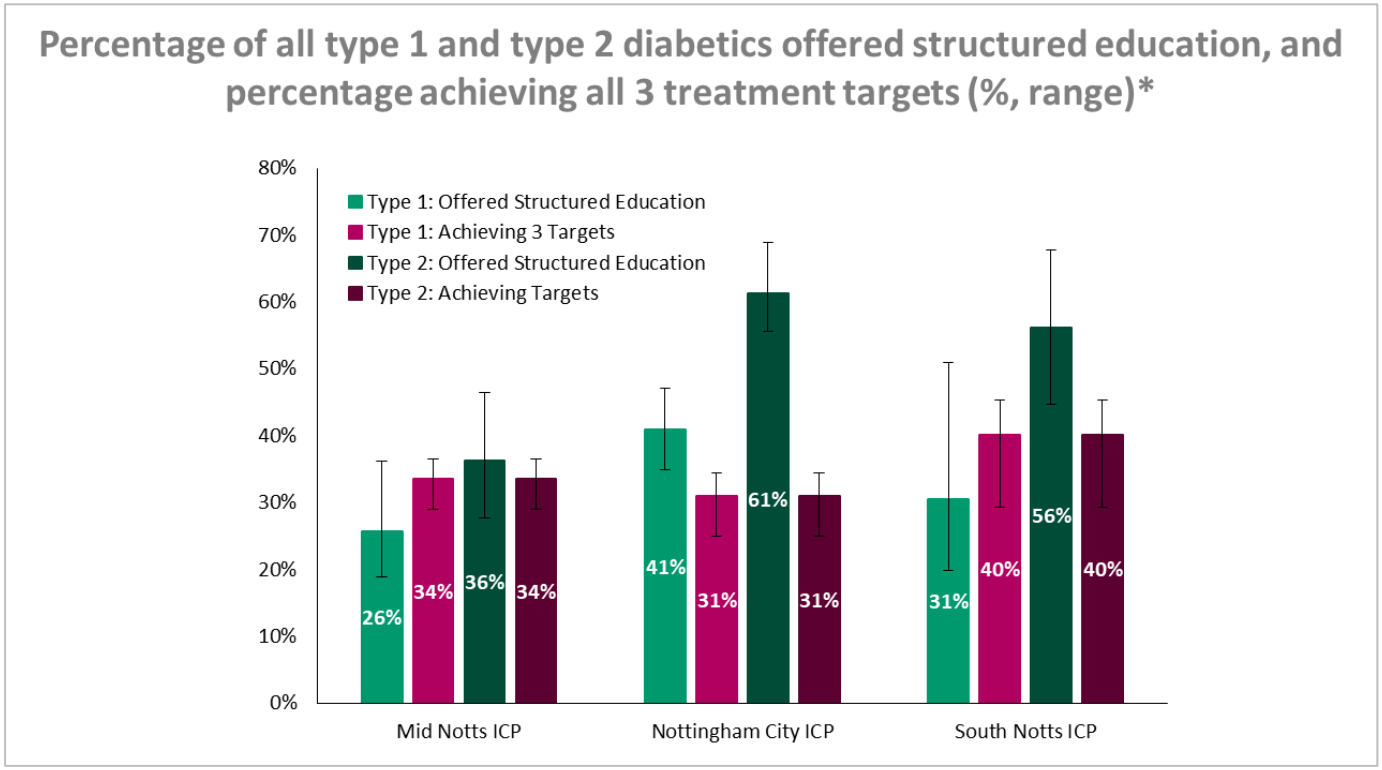
This chart shows CCGs ranked from lowest percentage achievement on the left to the most on the right.
The positions of the Nottingham CCGs shown in red, with the average for England in green.

1) National Diabetes Audit (NDA) 2017-2018 Interactive report for England, Clinical Commissioning Groups and GP practices. 13th June 2019.

Slide 47. Structured education: treatment targets

People with **type 1 and type 2** diabetes are offered the **Structured Education** to manage their diabetes.

This chart shows the proportion of patients offered structure education across the Nottinghamshire ICPs, as of 2019.



*This is the % of all people with type 1 and 2 diabetes offered structured education, and the % of all people with type 1 and 2 diabetes who are achieving all 3 treatment targets.

There is no clear relationship between the proportion of people with diabetes offered structured education and process outcomes.

Source: Nottinghamshire PCN Diabetes Profiles, GPRCC.

Slide 48. 1a) The NHS Diabetes Prevention Programme (NHS DPP)

For people who are pre-diabetic

Slide 49. The NHS Diabetes Prevention Programme (DPP)

The **NHS Diabetes Prevention Programme (DPP)** is a prevention programme for type 2 diabetes developed by the NHS, Public Health England and Diabetes UK, which is aimed at people who are non-diabetic hyperglycaemic and therefore **at risk of developing the condition**.

The programme lasts a minimum of **nine months** and consists of at least **13 sessions** totaling **16 hours or more**. The aim is for people to set and achieve goals, which help them make **heathier lifestyle choices** and **lower their diabetes risk**.

It revolves around the following core goals:

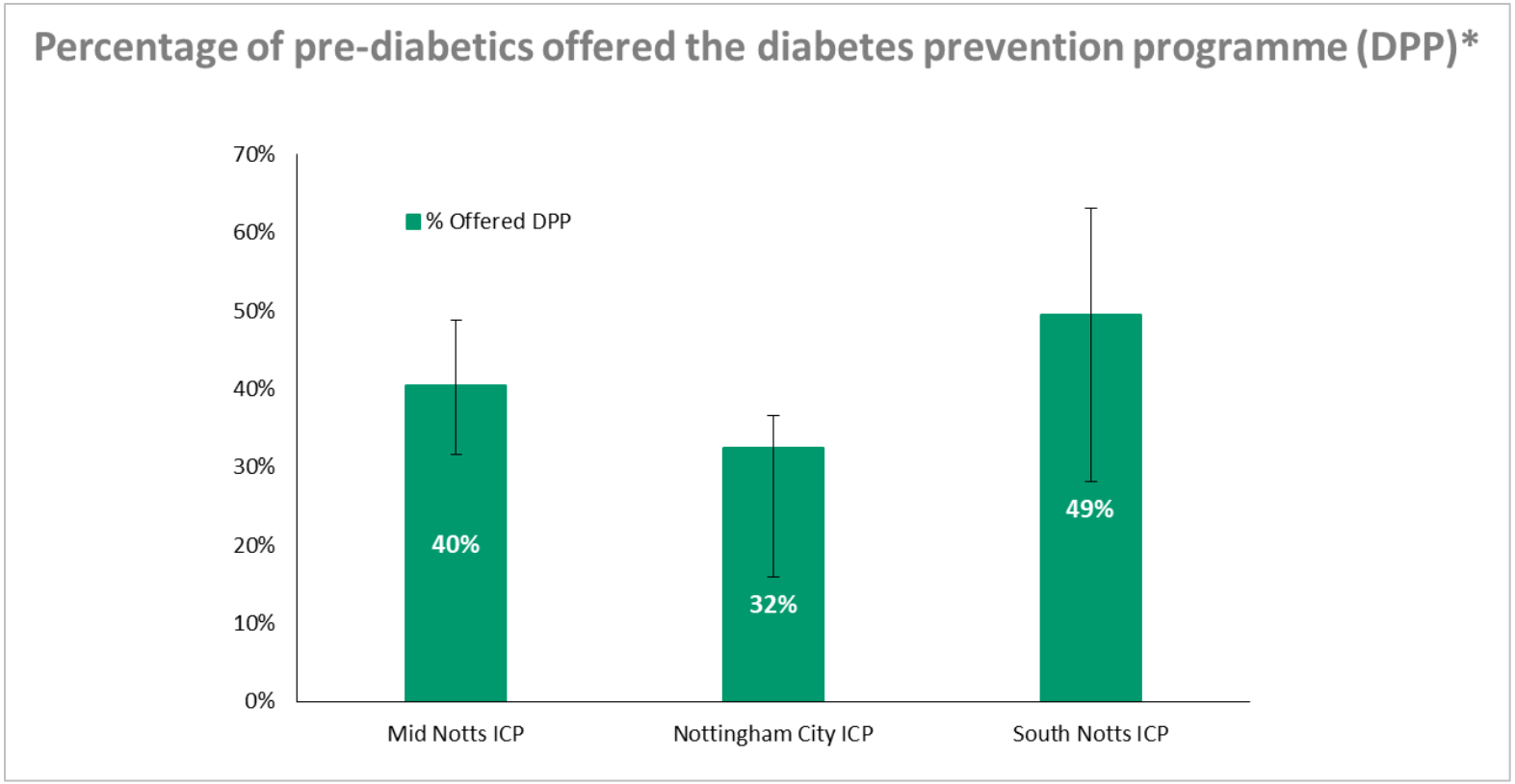
1. To achieve and maintain a **healthier weight.**
2. To achieve the Chief Medical Officer's **physical activity recommendations.**
3. To achieve **dietary recommendations**[1].

In 2017-18 DPP was offered and not declined by **103,300 people**.[2]

1) NHS England- https://www.england.nhs.uk/wp-content/uploads/2016/08/dpp-faq.pdf
2) NHS Digital (2019)- https://files.digital.nhs.uk/1B/D8C0E4/NDA_DPP_MainReport_1718_1.1.pdf

Slide 50. Prevention programmes and treatment targets in Nottinghamshire ICS

Patients with pre-diabetes are offered the DDP. This chart shows the percentages of people who are pre-diabetic offered the program as of 2019.



*This is the % of all diagnosed people who are pre-diabetic offered the diabetes prevention programme.

Source: Nottinghamshire PCN Diabetes Profiles , GPRCC.

Slide 51. NHS DPP: effects

The table below shows reported effects of the DPP program on overall diabetes prevention, as well as three diabetes-related biomarkers.

Outcome	Effect	Evidence
Overall Prevention	For every **100,000 interventions** the NHS DPP is expected to prevent/delay **4147 cases** of diabetes	Thomas et al 2017
HbA1c	**0.20%** absolute reduction in the **% HbA1c**	PHE review 2015
BMI/Obesity	**1.47 Kg/m²** reduction in **BMI**	PHE review 2015
Blood Pressure	Systolic blood pressure: **6.57mmHg reduction**	PHE review 2015

1) Thomas, C., Sadler, S., Breeze, P., Squires, H., Gillett, M., Brennan, A., 2017. Assessing the potential return on investment of the proposed UK NHS diabetes prevention programme in different population subgroups: an economic evaluation. BMJ Open 7, e014953. https://doi.org/10.1136/bmjopen-2016-014953
2) Public Health England, 2015. A systematic review and metaanalysis assessing the effectiveness of pragmatic lifestyle interventions for the prevention of type 2 diabetes mellitus in routine practice (No. 2015280). Public Health England, London.

Slide 52. NHS DPP: costs

The table below shows reported costs and cost-effectiveness of the DPP programme for preventing diabetes.

The cost of the DPP is £270 per user.

Outcome	Effect	Evidence
Return on Investment	**£1.28 saving** for every **£1 invested** (over 20 years)	Thomas et al 2017[2]
QALYs[1]	For every **100,000 interventions** given **3552 QALYs gained** (at £20,000 per QALY)	Thomas et al 2017
Population Cost-Effectiveness	Most cost effective in **obese patients**, a HbA1c between **6.2%** and **6.4%** and those aged **40 to 74**	Thomas et al 2017
Cost-Effectiveness	**97%** probability that it will be cost effective in 20 years. ICER **£21,860 per QALY** gained at 5-years, and **£1,162 in 10-years**.*	Thomas et al 2017

*Incremental cost-effectiveness ratio (ICER). The cost for each quality adjusted life-year. Thresholds for maximum willingness to pay is typically £20,000 per QALY but can be as high as £30,000.

1) Quality Adjusted Life-Years (QALYs) are a standardised measure of the impact of an intervention n a life that is commonly employed in health-economic modelling. One QALY is equivalent to one year of life in perfect health.
2) Thomas, C., Sadler, S., Breeze, P., Squires, H., Gillett, M., Brennan, A., 2017. Assessing the potential return on investment of the proposed UK NHS diabetes prevention programme in different population subgroups: an economic evaluation. BMJ Open 7, e014953. https://doi.org/10.1136/bmjopen-2016-014953

Slide 53. NHS DPP: NICE guidance

NICE recommendations for **type 2** diabetes prevention intensive lifestyle change programmes[1]:

- **Specifically designed** and **quality assured** programmes.
- Programmes must be delivered by someone with **relevant knowledge**.
- The programme must be **person centred** and **empathy building**.
- Must have at least **16 hours of contact time** over a period of **9-18 months** meeting a **minimum of 8 times**.
- The programme must be linked to **weight management** or alternative initiatives in order to help people change their **diet** or be more **physically active**.

1) NICE (2019) Type 2 diabetes: prevention in people at high risk- https://www.nice.org.uk/guidance/ph38

Slide 54. NHS DPP: gaps in the evidence

The NHS DPP has **only recently been implemented**, and therefore the **evaluation data is sparse**.

There is **active piloting** of **web-based** and **mobile versions** of the DPP, but this has yet to be reported on. However, it is reasonable to assume **greater uptake** and participation, and **lower costs** as is seen with the structured education in people with type 1 or type 2 diabetes.

Slide 55. NHS DPP: return on investment

Public Health England provide a web-based return on investment tool for the **Diabetes Prevention Plan** to calculate the **potential return on investment** by CCG. These are the results for the Nottingham ICS. For every **1,000 patients** referred to the programme assuming an **uptake of 32%**:

Time to recovery of initial cost = **11 years**.

Cumulative 5-year saving (excluding intervention cost) = **~£40,000**

Reduction in number of diabetes diagnoses = **13.4 at 5-years**

Across England, the DPP would be expected to reach **cost-effectiveness** at a threshold of **£20,000 per QALY within 6 years.**[1]

Improvements in uptake would have a proportional effect on the benefits gained and savings made.

The cost effectiveness data generated for Nottingham City are given below in Table 1.

Table 1. Cumulative incremental QALY effect, net cost (interventions cost minus NHS savings), cost-effectiveness (at £20K per QALY) to the NHS and cost-effectiveness including some social care savings of implementing one year of the DPP in the target population.

	2016/17	2017/18	2018/19	2019/20	2020/21	2025/26	2030/31	2035/36
QALYs	0.2	0.7	1.4	2.5	3.7	10.8	15.9	18.7
Total cost to NHS (net)	£113,696	£102,057	£90,829	£80,345	£68,857	£9,137	-£20,987	-£35,150
Incremental cost-effectiveness ratio (NHS costs only)								-£1,876
Total cost (Net) including social care*	£113,283	£101,112	£89,228	£77,995	£65,643	£2,675	-£28,978	-$43,763
ICER including social care*								-£2,336
*** social care savings relate to osteoarthritis and stroke only**								

At 20-years there are net savings, so the ICER is negative.

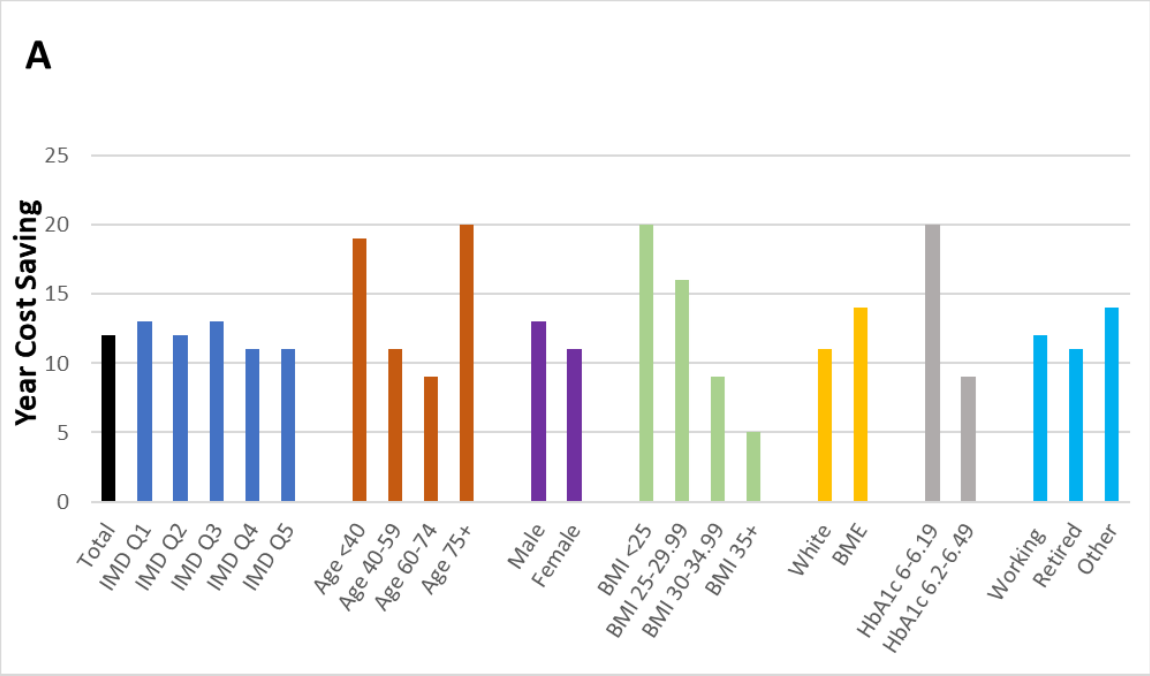
1) Thomas, C., Sadler, S., Breeze, P., Squires, H., Gillett, M., Brennan, A., 2017. Assessing the potential return on investment of the proposed UK NHS diabetes prevention programme in different population subgroups: an economic evaluation. BMJ Open 7, e014953. https://doi.org/10.1136/bmjopen-2016-014953

Slide 56. NHS DPP: return on investment

*The following three slides present predicted **cost savings**, **cost effectiveness**, and **20-year return of investment** for different **population segments**.*

The sub-groups of patients that achieve cost savings the soonest are:

1) aged **over 40 and less than 75**,
2) with **BMIs over 35 Kg.m^2** and
3) with the **highest HbA1cs** in the non-diabetic range.



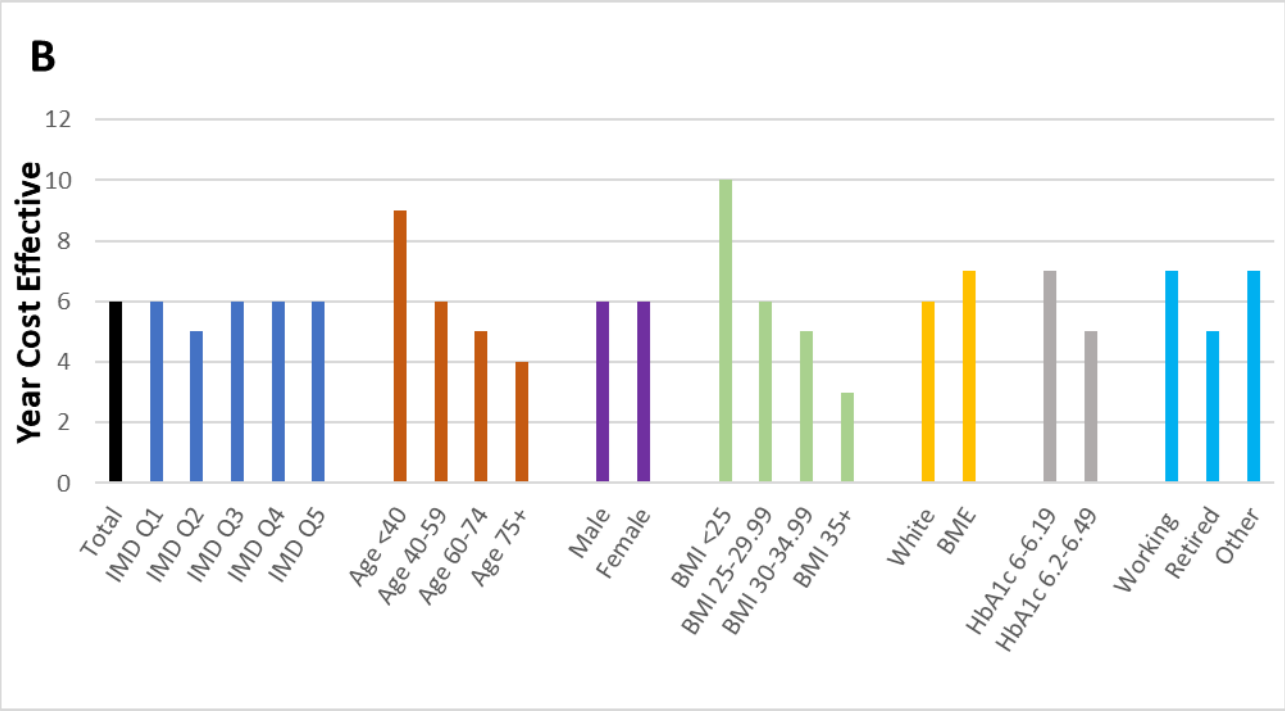
Bar charts showing the year that the National Health Service Diabetes Prevention Programme (NHS DPP) becomes cost-saving (recoups intervention costs). Vertical arrows indicate that the DPP is not cost-saving within the 20-year period modelled. BME, black minority ethnic; BMI, body mass index; IMD, index of multiple deprivation.[1]

1) Thomas, C., Sadler, S., Breeze, P., Squires, H., Gillett, M., Brennan, A., 2017. Assessing the potential return on investment of the proposed UK NHS diabetes prevention programme in different population subgroups: an economic evaluation. BMJ Open 7, e014953. https://doi.org/10.1136/bmjopen-2016-014953

Slide 57. NHS DPP: return on investment

The sub-groups of patients that achieve cost-effectiveness the soonest are:

1) **Over 75**,
2) with **BMIs over 35** Kg.m^2 and
3) with the **highest HbA1cs** in the non-diabetic range,
4) And are **retired.**



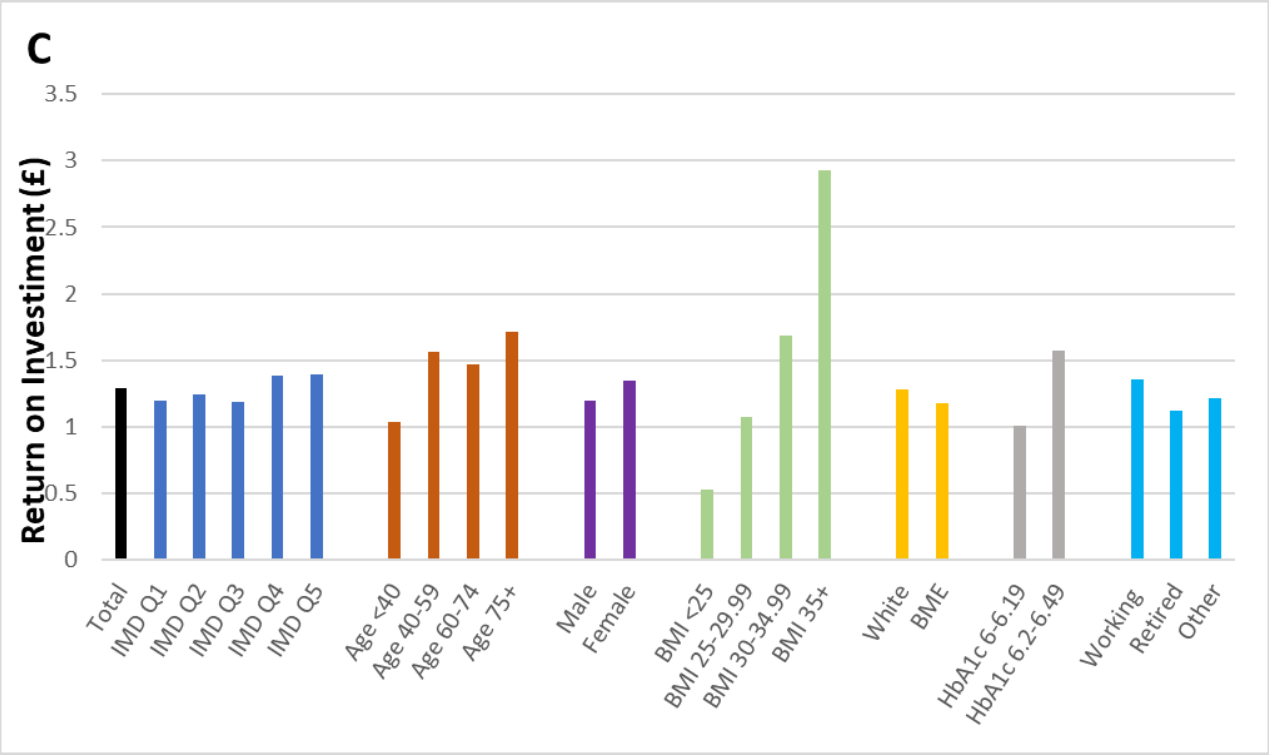
Bar charts showing the year that the NHS DPP becomes cost-effective. BME, black minority ethnic; BMI, body mass index; IMD, index of multiple deprivation.

1) Thomas, C., Sadler, S., Breeze, P., Squires, H., Gillett, M., Brennan, A., 2017. Assessing the potential return on investment of the proposed UK NHS diabetes prevention programme in different population subgroups: an economic evaluation. BMJ Open 7, e014953. https://doi.org/10.1136/bmjopen-2016-014953

Slide 58. NHS DPP: return on investment

The sub-groups of patients that achieve the greatest return on investment within 20-years are:

2) **Aged over 40-years**,
3) with **BMIs** over 35 Kg/m^2,
4) with the **highest HbA1cs** in the non-diabetic range.



Bar charts showing the total NHS return on investment within 20 years per £1 spent on the NHS DPP for each of the population subgroups. BME, black minority ethnic; BMI, body mass index; IMD, index of multiple deprivation.

1) Thomas, C., Sadler, S., Breeze, P., Squires, H., Gillett, M., Brennan, A., 2017. Assessing the potential return on investment of the proposed UK NHS diabetes prevention programme in different population subgroups: an economic evaluation. BMJ Open 7, e014953. https://doi.org/10.1136/bmjopen-2016-014953

Slide 59. DPP Summary

The Diabetes Prevention Programme DPP **encompasses the NICE recommendations** surrounding the prevention of diabetes.

For every **1,000 people** referred, there will be **13 fewer people with diabetes 5-years later.**

Online access is being piloted and appears to **increase uptake** from about **50%** to **68%**.

It is typically **cost-effective after 6 years***, but in as little as **3 years** in the **severely obese.**

It is typically **cost-saving** from **11 years**, but in as little as **3 years** in the **severely obese**.

The **return on investment** at 20-years is about **£1:25** per pound spent but is as high as **£3** in **the severely obese**.

* At a threshold of £20,000 per QALY.

Slide 60. 1b) Traditional structured education

For people with type 1 and type 2 diabetes.

Slide 61. Structured education: DESMOND

DESMOND is a family of group self management modules, toolkits and care pathways.

- Six-hour course for people with, or at risk of, Type 2 diabetes.
- Focuses on lifestyle modification, food choices, physical activities, and cardiovascular risk factors. [1-3]
- Offers training and quality assurance to allow delivery of the modules and toolkits.
- Training for Healthcare Professionals and Lay Educators.

Self-management education modules
1. DESMOND Newly Diagnosed
2. DESMOND Foundation
3. DESMOND BME Culturally Adaptation
4. DESMOND Walking Away from Diabetes
5. Going Forward with Diabetes
6. Let's Prevent Diabetes

Toolkits
1. A Safer Ramadan
2. Injectable Therapies

1) Khunti, K., Gray, L.J., Skinner, T., Carey, M.E., Realf, K., Dallosso, H., Fisher, H., Campbell, M., Heller, S., Davies, M.J., 2012. Effectiveness of a diabetes education and self management programme (DESMOND) for people with newly diagnosed type 2 diabetes mellitus: three year follow-up of a cluster randomised controlled trial in primary care. BMJ 344, e2333. https://doi.org/10.1136/bmj.e2333
2) Davies, M.J., Heller, S., Skinner, T.C., Campbell, M.J., Carey, M.E., Cradock, S., Dallosso, H.M., Daly, H., Doherty, Y., Eaton, S., Fox, C., Oliver, L., Rantell, K., Rayman, G., Khunti, K., Diabetes Education and Self Management for Ongoing and Newly Diagnosed Collaborative, 2008. Effectiveness of the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cluster randomised controlled trial. BMJ 336, 491–495. https://doi.org/10.1136/bmj.39474.922025.BE
3) https://www.desmond-project.org.uk/about/

Slide 62. Structured education: DAFNE

DAFNE is a self management structured education program for adults with Type 1 diabetes[1] that enables patients to self-manage their disease by stabilizing blood glucose.

DAFNE "trains the trainers" providing CPD, audit of outcomes, and quality assurance.

The DAFNE Portfolio
1. Original 1 Week course (Mon-Fri)
2. A 5-week course (1 day a week)
3. The DAFNE pump curriculum for insulin pump users who have never completed structured education

Evidence for DAFNE[2,3]
Improves blood glucose
Improves Quality of Life
Reduces risk of sever hypoglycaemia
Reduces complications and costs

1) http://www.dafne.uk.com/DAFNE_home-I387.html
2) DAFNE Study Group, 2002. Training in flexible, intensive insulin management to enable dietary freedom in people with type 1 diabetes: dose adjustment for normal eating (DAFNE) randomised controlled trial. BMJ 325, 746–746. https://doi.org/10.1136/bmj.325.7367.746
3) Hopkins, D., Lawrence, I., Mansell, P., Thompson, G., Amiel, S., Campbell, M., Heller, S., 2012. Improved Biomedical and Psychological Outcomes 1 Year After Structured Education in Flexible Insulin Therapy for People With Type 1 Diabetes: The U.K. DAFNE experience. Diabetes Care 35, 1638–1642. https://doi.org/10.2337/dc11-1579

Slide 63. Structured education: X-PERT

X-PERT offers a fun way of learning about and understanding diabetes.

- Uses visual aids and discovery learning, and enables individuals to make their own informed decisions.
- Based on person-centred needs and wishes, developed to prevent information overload.

X-PERT Self Management Programmes *15 hours delivered weekly in 2.5 hour sessions over 6 weeks*
1. X-PERT Prevention of Diabetes
2. X-PERT Diabetes
3. X-PERT Insulin

X-PERT outcomes
Lower blood glucose
Lower blood pressure
Lower blood cholesterol
Reduced risk of long term conditions
Fewer hypos

X-PERT aims[1]
Nutrition for health
Fat and carbohydrate awareness
Self-monitoring of glucose
Exploring Insulin

1) https://www.xperthealth.org.uk/Home/About-X-PERT-Health

Slide 64. Evidence: DESMOND

There is real-World evidence that there are significant reductions in HbA1c[3], but in the main RCT of the DESMOND programme did not find significant reductions in HbA1c, blood pressure, lipids or BMI compared to controls[1,2] as both groups had significant reductions.

Outcome	Evidence	Timing
HbA1c	Absolute reduction 0.28% greater at 1-year[1] and 0.51% at 3-years[2] *	12 and 36 months
BMI/Obesity	Absolute reduction in BMI 0.31 Kg/m^2 at 3-years[2]*	36 months
Blood pressure	Systolic 1.3 mmHg lower at 1-year[1] and 0.12 mmHg lower at 3-years[2]*	12 and 36 months
	Diastolic 0.74 mmHg lower at 12 months[1] and 1.58 mmHg lower at 36 months[2]*	12 and 36 months
Cholesterol	LDL 0.15 mmol/l higher art 12 months[1] and 0.08 mmol/l lower at 36 months[2]*	12 and 36 months
	HDL 0.06 mmol/l lower at 12 months[1] and 0.02 mmol/l higher at 36 months[2]*	12 and 36 months
Knowledge	Percentage of patients benefiting from the knowledge was 99%[3]	On completion of the course.
	Median score for illness coherence 1 point higher[1] (p = 0.01)	36 months
	Median score for seriousness 1 point higher[1] (p = 0.01)	36 months
	Median score for timeline 2 points higher[1] (p=0.01)	36 months

* Not statistically significant.

1. Davies, M.J., Heller, S., Skinner, T.C., Campbell, M.J., Carey, M.E., Cradock, S., Dallosso, H.M., Daly, H., Doherty, Y., Eaton, S., Fox, C., Oliver, L., Rantell, K., Rayman, G., Khunti, K., Diabetes Education and Self Management for Ongoing and Newly Diagnosed Collaborative, 2008. Effectiveness of the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cluster randomised controlled trial. BMJ 336, 491–495. https://doi.org/10.1136/bmj.39474.922025.BE
2. Khunti, K., Gray, L.J., Skinner, T., Carey, M.E., Realf, K., Dallosso, H., Fisher, H., Campbell, M., Heller, S., Davies, M.J., 2012. Effectiveness of a diabetes education and self management programme (DESMOND) for people with newly diagnosed type 2 diabetes mellitus: three year follow-up of a cluster randomised controlled trial in primary care. BMJ 344, e2333. https://doi.org/10.1136/bmj.e2333
3. Chatterjee, S., Davies, M.J., Stribling, B., Farooqi, A., Khunti, K., 2018. Real-world evaluation of the DESMOND type 2 diabetes education and self-management programme: Real-world evaluation of the DESMOND type 2 diabetes education and self-management programme. Practical Diabetes 35, 19–22a. https://doi.org/10.1002/pdi.2154

Slide 65. Evidence: DAFNE

Outcome	Evidence	Timing
HbA1c	Absolute **fall** of **1%***[1] (p<0.0001)	6 months
	Absolute **fall of 0.5%***[2] (statistical significance not stated)	12 months
BMI/Obesity	The weight **fell 1.2%**†[3] (p=0.012)	12 months
Patient satisfaction	Hospital **anxiety and depression** scores **fall significantly**.[3] (p=0.0003)	12 months

*In the DCCT percentage units.

† An absolute fall of 0.9Kg with an average initial weight of 75.1Kg.

1. DAFNE Study Group, 2002. Training in flexible, intensive insulin management to enable dietary freedom in people with type 1 diabetes: dose adjustment for normal eating (DAFNE) randomised controlled trial. BMJ 325, 746–746. https://doi.org/10.1136/bmj.325.7367.746
2. Mansell, P., 2012. The Dose Adjustment for Normal Eating (DAFNE) education programme. Journal of Diabetes Nursing 16, 364–369.
3. McIntyre, H.D., Knight, B.A., Harvey, D.M., Noud, M.N., Hagger, V.L., Gilshenan, K.S., 2010. Dose adjustment for normal eating (DAFNE) - an audit of outcomes in Australia. Med. J. Aust. 192, 637–640.

Slide 66. Evidence: X-PERT

Outcome	Evidence	Timing
HbA1c	Absolute **fall of 0.7%**[1] *	14 months
BMI/Obesity	**Fall of 0.4 Kg to 0.9 Kg** at 12 months*[1,2]	12 to 14 months
Blood pressure	**Systolic**: Fall of **between 2 mmHg and 3.8 mmHg***[1,2]	12 to 14 months
	Diastolic: Fall of **between 1.7 mmHg and 2.1 mmHg***[1,2]	12 to 14 months
Cholesterol	**LDL**: Fell **0.3mmol**/l*[2]	12 months
	HDL: **No change** between groups or from baseline*[2]	12 months
Patient satisfaction	Significant **improvement** in patient **satisfaction***[1]	14 months
	Patient **satisfaction** 95%[1]	6 Weeks
Knowledge	**Improvement in knowledge**.*[1]	14 Months

* Statistically significant

1. Deakin, T.A., Cade, J.E., Williams, R., Greenwood, D.C., 2006. Structured patient education: the Diabetes X-PERT Programme makes a difference. Diabetic Medicine 23, 944–954. https://doi.org/10.1111/j.1464-5491.2006.01906.x
2. Deakin, T., 2018. X-PERT National Audit Results 2018. X-PERT Health.

Slide 67. Structured education: cost-effectiveness

DESMOND[1]	
Costs	Trial: **£203 per person** for 12 months. Real world cost: £76 per person
Cost-effectiveness	Between £2,920 and £5,387 per QALY gained based on trial and real-World data respectively. (Lifetime)
Savings	Chance of being cost-saving in the long-term is between 28% and 40%.
DAFNE[2]	
Cost	**£359 per person**
Cost-effectiveness	£14,400 per QALY gained
Savings	Per patient: £2,237 at 10 years.
X-PERT[3]	
Costs	**£180 per person.**
Cost-effectiveness	~£6,800 per QALY
Savings	It is not cost-saving over a lifetime as a result of increased survival.[3]

Incremental cost-effectiveness ratio (ICER). The cost of gaining one quality adjusted life-year (QALY).

1. Gillett, M., Dallosso, H.M., Dixon, S., Brennan, A., Carey, M.E., Campbell, M.J., Heller, S., Khunti, K., Skinner, T.C., Davies, M.J., 2010. Delivering the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cost effectiveness analysis. BMJ 341, c4093–c4093. https://doi.org/10.1136/bmj.c4093
2. Kruger J., Brennan A., Thokala P., Basarir H., Jacques R., Elliott J., Heller S., Speight J., 2013. The cost-effectiveness of the Dose Adjustment for Normal Eating (DAFNE) structured education programme: An update using the Sheffield Type 1 Diabetes Policy Model. Diabet. Med. 30, 1236–1244. https://doi.org/10.1111/dme.12270
3. Jacobs-van der Bruggen, M.A.M., van Baal, P.H., Hoogenveen, R.T., Feenstra, T.L., Briggs, A.H., Lawson, K., Feskens, E.J.M., Baan, C.A., 2009. Cost-effectiveness of lifestyle modification in diabetic patients. Diabetes Care 32, 1453–1458. https://doi.org/10.2337/dc09-0363

Slide 68. Modelling outcomes structured education

Only changes statistically significant to p=0.01 are shown.

ROI at 5-years ~ £0.18 **ROI at 10-years** ~ £0.60

Years to break even ~ 15 **Increase in life expectancy** ~ 0.2 years

Outcome	NNT 5-year	RRR 5-year	NNT 10-year	RRR 10-year
Blindness	-	-	442	0.91
Foot ulcer	-	-	-	-
First amputation	-	-	-	-
Subsequent amputation	-	-	-	-
Myocardial infarction	-	-	-	-
Other ischaemic heart disease	-	-	-	-
Congestive heart failure	-	-	-	-
Stroke	-	-	-	-
Renal failure	-	-	-	-
Death	-	-	-	-

All values statistically significant to **p=0.01**. **ROI** – return on investment £ saved for each £ invested. **RRR** – relative risk reduction.

Slide 69. Traditional structured education summary

The **impact** of structured education (SE) (**DESMOND**) on measures of control in people with **type 2 diabetes** is **small and uncertain**, but there is a **significant increase in knowledge about diabetes**. It is cost-effective* but modelling suggests SE is **takes more than 10 years to become cost-saving**.

The **impact** of SE on measures of control in people with type 1 diabetes (**DAFNE**) is **significant**, **cost-effective*** and **cost-saving at 4-years**.[1]

The **X-Pert** SE package for type 1, type 2 and people who are pre-diabetic has a **significant impact on control,** is **cost-effective,** but is **not cost-saving**.*

- At a willingness to pay threshold of £20,000 per QALY.

1. Diabetes UK, 2014. THE COST OF DIABETES REPORT. Diabetes UK, London.

Slide 70. 1c) Web-based diabetes prevention and management tools

DDM; My Diabetes, My Way; Changing Health; POWeR, HeLP-Diabetes

Slide 71. Web-based diabetes prevention and management tools

Web sites and apps are becoming an important tool, both for diabetes management and prevention. For example, the online self-management platform My Diabetes My Way (MDMW) has been running in NHS Scotland since 2008, and had around 30,000 users as of 2017. It provides interactive information, management advice, social media linkage, and personal health records.

Other platforms such as Diabetes Digital Media (DDM) and Changing Health provide structured dietary advice to manage diabetes progression.

Due to the scalability and the reduction in the need for face-to-face contact, the potential cost-effectiveness of these web-based interventions is very high.

Slide 72. Web-based tools: examples

Mobile phone support

A meta-analysis of 22 studies that used mobile phones to support self-management of diabetes and reported on changes in HbA1c values. The interventions delivered a mixture of educational material and positive reinforcement of behaviour change, step-counting and support for self-management of blood glucose.

DDM Low-Carb Programme

This is a 12-week core behaviour change platform for people with type 2 diabetes delivered using web-sites, smartphone apps, webinars and a 'support community', with follow-on support beyond the initial 12 weeks.

Changing Health Programme

This is a smartphone delivered programme for education and lifestyle coaching for people with type 2 diabetes. The apps use AI to personalise advice, but there are also human 'coaches' assigned to users.

My Diabetes – My Way

This is the NHS Scotland interactive diabetes website designed to support self-management of diabetes, and includes information on lifestyle, complications, and self-monitoring of blood sugar.

POWeR

This trial of a web-based platform to provide support to obese adults in conjunction with limited email contact with a nurse (up to 5 emails).

Slide 73. Web-based tools: wider context

The 2019 NHS Long Term Plan commits to develop and expand web-based diabetes prevention and management tools:

- Offer digital access to the Diabetes Prevention Program (DPP).
- Expand pilots for digital structured education.
- Roll-out Healthy Living for People with Type 2 Diabetes (HeLP) self-management programme.

IPS, Individual Placement and Support

1) https://www.england.nhs.uk/diabetes/digital-innovations-to-support-diabetes-outcomes/
2) www.longtermplan.nhs.uk

Slide 74. Web-based tools: summary of outcomes measures

Due in part to the novelty of web-based interventions, high-quality outcomes assessments are often not yet available. However, research so far suggests that significant improvements in outcomes are possible. Below are summarised the reported outcomes for each intervention:

Diabetes Digital Media (DDM)

Low Carb Programme[1]

- **0.76%** (8.3mmol/mol) **reduction** in **HbA1c**
- **4.35kg reduction** in mass
- **40.4%** of participants **reducing medication**

Hypo programme[5]

- **88%** of people know how to **spot a hypo**
- **89%** of people know how to **treat a hypo**
- **63% fewer severe hypos** at 6-month follow up
-

Changing Health[2]

- **6.4** mmol/mol **reduction** in **HbA1c**
- **4.5** kg reduction in mass, 0.4 **reduction** in **BMI**
- **1.3 and 1.6** mmHg reduction in **systolic** and **diastolic** blood pressure

My Diabetes My Way (MDMW)[3,4]

- **6.4** mmol/mol reduction in **HbA1c** after one y
- **4.5** kg reduction in mass, 0.4 **reduction** in **BMI**
- **1.3 and 1.6** mmHg **reduction** in **systolic** and **diastolic** blood pressure.
-

Healthy Living for People with Diabetes (HeLP-Diabetes)[6]

- **0.24%** (2.6mmol/mol) **reduction** in **HbA1c** after one year

1) Saslow, L.R., Summers, C., Aikens, J.E., Unwin, D.J., 2018. Outcomes of a Digitally Delivered Low-Carbohydrate Type 2 Diabetes Self-Management Program: 1-Year Results of a Single-Arm Longitudinal Study. JMIR Diabetes 3, e12. https://doi.org/10.2196/diabetes.9333
2) Smith, W., 2018. Diabetes Digital Behaviour Change Programmes: North West London Pilot. Evaluation Report. Imperial College Health Partners.
3) Cunningham S.G.; Allardice B.; Brillante M.; Wilson L.; Wake D.J., 2018. My Diabetes My Way-an electronic personal health record: Impact on clinical outcomes. Diabetic Medicine 35.
4) Cunningham S.G.; Allardice B.; Wake D.J., 2017. My diabetes my way: User experiences of an electronic personal health record for diabetes. Diabetologia 60, Supplement 1 (S350).
5) https://www.hypoprogram.com/
6) Murray, E., Sweeting, M., Dack, C., Pal, K., Modrow, K., Hudda, M., Li, J., Ross, J., Alkhaldi, G., Barnard, M., Farmer, A., Michie, S., Yardley, L., May, C., Parrott, S., Stevenson, F., Knox, M., Patterson, D., 2017. Web-based self-management support for people with type 2 diabetes (HeLP-Diabetes): randomised controlled trial in English primary care. BMJ Open 7, e016009. https://doi.org/10.1136/bmjopen-2017-016009

Slide 75. Web-based tools: outcome measures

In the table below reported physiological outcomes for web-based tool interventions are shown:

Intervention	HbA1c	Blood pressure	BMI/weight	Remission
Mobile phone support	**0.5%** (6 mmol/mol)[1,2] **reduction**			
DDM Low Carb Programme	**0.76**% (9 mmol/mol)[3] **reduction**		**5.35 kg fall**[3]	**40.4**% of patients **reduced medication**[3]
Changing Health Programme	**6.4** mmol/mol **reduction**[4]	**Systolic** **1.3** mmHg **fall** **Diastolic** **1.6** mmHg **fall**[4]	**4.5** kg **fall** **0.4** Kg/m^2 **fall**[4]	
My Diabetes My Way (MDMW)	**6.4** mmol/l at **1-year** **3.1** mmol/mol **at 3-years**[5]			
POWeR			**1.27** kg[6]	

1) Liang, X., Wang, Q., Yang, X., Cao, J., Chen, J., Mo, X., Huang, J., Wang, L., Gu, D., 2011. Effect of mobile phone intervention for diabetes on glycaemic control: a meta-analysis. Diabet. Med. 28, 455–463. https://doi.org/10.1111/j.1464-5491.2010.03180.x
2) Farrell, K., Holmes-Walker, D.J., 2011. Mobile phone support is associated with reduced ketoacidosis in young adults. Diabet. Med. 28, 1001–1004. https://doi.org/10.1111/j.1464-5491.2011.03302.x
3) Saslow, L.R., Summers, C., Aikens, J.E., Unwin, D.J., 2018. Outcomes of a Digitally Delivered Low-Carbohydrate Type 2 Diabetes Self-Management Program: 1-Year Results of a Single-Arm Longitudinal Study. JMIR Diabetes 3, e12. https://doi.org/10.2196/diabetes.9333
4) https://imperialcollegehealthpartners.com/wp-content/uploads/2018/03/Diabetes-Health-Apps-Report-26th-March-2018.pdf
5) Cunningham S.G.; Allardice B.; Brillante M.; Wilson L.; Wake D.J., 2018. My Diabetes My Way-an electronic personal health record: Impact on clinical outcomes. Diabetic Medicine 35.
6) Little, P., Stuart, B., Hobbs, F.R., Kelly, J., Smith, E.R., Bradbury, K.J., Hughes, S., Smith, P.W.F., Moore, M.V., Lean, M.E.J., Margetts, B.M., Byrne, C.D., Griffin, S., Davoudianfar, M., Hooper, J., Yao, G., Zhu, S., Raftery, J., Yardley, L., 2016. An internet-based intervention with brief nurse support to manage obesity in primary care (POWeR+): a pragmatic, parallel-group, randomised controlled trial. The Lancet Diabetes & Endocrinology 4, 821–828. https://doi.org/10.1016/S2213-8587(16)30099-7

Slide 76. Web-based tools: outcome measures

In the table below reported patient satisfaction, knowledge, and unscheduled admission rate outcomes for web-based tool interventions are shown:

Intervention	Satisfaction	Knowledge	Unscheduled admission rates
Mobile phone support			**Half** as many admissions for diabetic **ketoacidosis**.[1]
DDM – Hypo programme		**88%** of people know how to **spot** a **hypo**, **89%** of people know how to **treat** a **hypo**.[2]	**63% fewer severe hypos** at 6-month follow up. [2]
Changing Health	**92**% user **satisfaction**.[3]		
My Diabetes My Way (MDMW)	**high user satisfaction** (e.g. 88.2% agreed that it helped manage diabetes better).[4]	**90.3%** self-rated improvement in patient knowledge. [4]	

1) Farrell, K., Holmes-Walker, D.J., 2011. Mobile phone support is associated with reduced ketoacidosis in young adults. Diabet. Med. 28, 1001–1004. https://doi.org/10.1111/j.1464-5491.2011.03302.x
2) https://www.hypoprogram.com/
3) Smith, W., 2018. Diabetes Digital Behaviour Change Programmes: North West London Pilot. Evaluation Report. Imperial College Health Partners.
4) Cunningham S.G.; Allardice B.; Wake D.J., 2017. My diabetes my way: User experiences of an electronic personal health record for diabetes. Diabetologia 60, Supplement 1 (S350).

Slide 77. Modelling outcomes: web-based SE

Only changes statistically significant to p=0.01 are shown.

ROI at 5-years ~ £2.35 **ROI at 10-years** ~ £5.17

Years to break even ~ 3 **Increase in life expectancy** ~ 0.2 years

Outcome	NNT 5-year	RRR 5-year	NNT 10-year	RRR 10-year
Blindness	289	0.50	157	0.50
Foot ulcer	503	0.43	321	0.50
First amputation	-	-	787	0.54
Subsequent amputation	-	-	-	-
Myocardial infarction	332	0.91	160	0.90
Other ischaemic heart disease	-	-	-	-
Congestive heart failure	185	0.77	119	0.83
Stroke	-	-	410	0.91
Renal failure	1923	0.62	1315	0.68
Death	-	-	-	-

For a 60 year-old, male diabetic with a BMI of 30.

All values statistically significant to **p=0.01**. **ROI** – return on investment £ saved for each £ invested. **RRR** – relative risk reduction.

Slide 78. Web-based tools: cost-effectiveness

Due to the scalability and the reduction in the need for face-to-face contact, the potential cost-effectiveness of these web-based interventions is very high.

Web-based interventions appear to be cost-effective. Evidence of UK cost-effectiveness is sparse but is expected to accumulate. There has been a cost-effectiveness analysis of the HeLP programme which estimated the **cost per QALY gained** was **£5,550** which is **highly cost-effective** compared to the conventional threshold of £20,000 per QALY of willingness-to-pay used by NICE.[1]

1. Li, J., Parrott, S., Sweeting, M., Farmer, A., Ross, J., Dack, C., Pal, K., Yardley, L., Barnard, M., Hudda, M., Alkhaldi, G., Murray, E., 2018. Cost-Effectiveness of Facilitated Access to a Self-Management Website, Compared to Usual Care, for Patients With Type 2 Diabetes (HeLP-Diabetes): Randomized Controlled Trial. J. Med. Internet Res. 20, e201. https://doi.org/10.2196/jmir.9256

Slide 79. Web-based tools summary

Web-based structured education interventions give a very high return on investment.

The cost is relatively low and uptake relatively high.

These applications are still fairly new, so the body of evidence is still small, but very promising.

Web apps can be used at any time, and so may be particularly useful for people of working age who may have difficulty attending face-to-face sessions in working hours.

Returns on investment at **5-years is £2.35** and at **10-years is £5.17.**

Cost-effectiveness data is limited, but the HeLP intervention was highly cost effective at 1-year with a cost of £5,500 per QALY gained.

Slide 80. 2a) Further lifestyle interventions

Slide 81. Further lifestyle interventions

Lifestyle changes can be used to prevent and manage diabetes or even cause remission.

A key randomized controlled trial which demonstrates the effect of lifestyle changes (weight loss and physical activity) on the potential for diabetes remission is the DiRECT trial[1]. The NHS plans to implement a programme in the future, which incorporates a similar intervention that is used in the trial. The intervention consists of:

- A **total diet replacement** of about 850 calories a day (Counterweight-Plus))
- Followed by a stepped food reintroduction and step goal of **15,000 steps per day**
- **Long-term support** for weight loss maintenance

Other lifestyle interventions such as smoking cessation and social interventions, have been demonstrated to help the prevention of diabetes.

1) Lean, M.E., Leslie, W.S., Barnes, A.C., Brosnahan, N., Thom, G., McCombie, L., Peters, C., Zhyzhneuskaya, S., Al-Mrabeh, A., Hollingsworth, K.G., Rodrigues, A.M., Rehackova, L., Adamson, A.J., Sniehotta, F.F., Mathers, J.C., Ross, H.M., McIlvenna, Y., Stefanetti, R., Trenell, M., Welsh, P., Kean, S., Ford, I., McConnachie, A., Sattar, N., Taylor, R., 2018. Primary care-led weight management for remission of type 2 diabetes (DiRECT): an open-label, cluster-randomised trial. Lancet 391, 541–551. https://doi.org/10.1016/S0140-6736(17)33102-1

Slide 82. Lifestyle interventions: clinical outcomes

Wight loss and exercise programmes reduce HbA1c, blood pressure, BMI and may increase patient satisfaction.

Social interventions such as including mentors appears to reduce HbA1c levels, BMI and blood pressure in some trials, but not all.

More information is needed about what type of social interventions work and which do not and the context in which they are applied.

	HbA1c	BMI	Blood pressure	Patient Satisfaction, QoL
Exercise	**Exercise reduces HbA1c between 0.32% and 0.67%.** [1,2,3,4]	**Exercise reduces BMI between 0.54 and 1.05 Kg/m^2.** [2]	**Exercise reduces systolic blood pressure by between 2.42 mmHg and 6 mmHg.** [5, 3] **Exercise reduces diastolic blood pressure by about 2.23 mmHg.** [5]	**Dutch people with type 2 diabetes on diet and exercise only treatment (A) have higher quality of life scores than those on oral (B) or insulin (C) therapy.** [6]
Weight Loss	There is a linear relationship between weight loss and HbA1c. For every **1kg in weight loss, HbA1c reduces by 0.1%.** [7]	Weight loss programmes can be effective. **37.8%** lose over **10% of their initial weight**. **Waist circumference falls** about 6.2cm. [8]	Intensive lifestyle intervention **reduces systolic** by 0.4 mmHg **and diastolic** blood pressure by 0.2 mmHg. [8]	Patients who lose over 10lbs have the **highest satisfaction** compared to those who don't lose weight. [9]
Social Intervention	Including peer support **reduces HbA1c** by about 0.57%. [10]	4 out of 7 studies found no significant difference for peer support. [11]	3 out of 5 randomised control trials (RCTs) found no significant difference for peer support. [11]	-

Slide 83. References for further lifestyle interventions

1) Avery, L., Flynn, D., van Wersch, A., Sniehotta, F.F., Trenell, M.I., 2012. Changing Physical Activity Behavior in Type 2 Diabetes: A systematic review and meta-analysis of behavioral interventions. Diabetes Care 35, 2681–2689. https://doi.org/10.2337/dc11-2452
2) Boulé, N.G., Haddad, E., Kenny, G.P., Wells, G.A., Sigal, R.J., 2001. Effects of Exercise on Glycemic Control and Body Mass in Type 2 Diabetes Mellitus: A Meta-analysis of Controlled Clinical Trials. JAMA 286, 1218. https://doi.org/10.1001/jama.286.10.1218
3) Chudyk, A., Petrella, R.J., 2011. Effects of Exercise on Cardiovascular Risk Factors in Type 2 Diabetes: A meta-analysis. Diabetes Care 34, 1228–1237. https://doi.org/10.2337/dc10-1881
4) Thomas, D.E., Elliott, E.J., Naughton, G.A., 2006. Exercise for type 2 diabetes mellitus. Cochrane.Database.Syst.Rev. 3, CD002968.
5) Hayashino, Y., Jackson, J.L., Fukumori, N., Nakamura, F., Fukuhara, S., 2012. Effects of supervised exercise on lipid profiles and blood pressure control in people with type 2 diabetes mellitus: A meta-analysis of randomized controlled trials. Diabetes Research and Clinical Practice 98, 349–360. https://doi.org/10.1016/j.diabres.2012.10.004
6) Redekop, W.K., Koopmanschap, M.A., Stolk, R.P., Rutten, G.E.H.M., Wolffenbuttel, B.H.R., Niessen, L.W., 2002. Health-related quality of life and treatment satisfaction in Dutch patients with type 2 diabetes. Diabetes Care 25, 458–463. https://doi.org/10.2337/diacare.25.3.458
7) Gummesson, A., Nyman, E., Knutsson, M., Karpefors, M., 2017. Effect of weight reduction on glycated haemoglobin in weight loss trials in patients with type 2 diabetes. Diabetes Obes Metab 19, 1295–1305. https://doi.org/10.1111/dom.12971
8) Gregg, E.W., Chen, H., Wagenknecht, L.E., Clark, J.M., Delahanty, L.M., Bantle, J., Pownall, H.J., Johnson, K.C., Safford, M.M., Kitabchi, A.E., Pi-Sunyer, F.X., Wing, R.R., Bertoni, A.G., Look AHEAD Research Group, 2012. Association of an intensive lifestyle intervention with remission of type 2 diabetes. JAMA 308, 2489–2496. https://doi.org/10.1001/jama.2012.67929
9) Gerlanc, N.M., Cai, J., Tkacz, J., Bolge, S.C., Brady, B.L., 2017. The association of weight loss with patient experience and outcomes in a population of patients with type 2 diabetes mellitus prescribed canagliflozin. Diabetes Metab Syndr Obes 10, 89–99. https://doi.org/10.2147/DMSO.S129824
10) Qi, L., Liu, Q., Qi, X., Wu, N., Tang, W., Xiong, H., 2015. Effectiveness of peer support for improving glycaemic control in patients with type 2 diabetes: a meta-analysis of randomized controlled trials. BMC Public Health 15, 471. https://doi.org/10.1186/s12889-015-1798-y
11) Dale, J.R., Williams, S.M., Bowyer, V., 2012. What is the effect of peer support on diabetes outcomes in adults? A systematic review: A systematic review of peer support on diabetes outcomes in adults. Diabetic Medicine 29, 1361–1377. https://doi.org/10.1111/j.1464-5491.2012.03749.

Slide 84. Lifestyle interventions: prevention and remission effects

	Prevention	Remission
Weight Loss	**Losing 5-10% of total body weight** within one year can reduce the risk of type 2 diabetes.[1]	-
Exercise	**Physical exercise** alone reduc**es the incidence rate of diabetes** by **about 6%. Diet and Physical** exercise **reduce** the incidence rate of diabetes by **about 31%.** [4]	-
Diet and exercise		A programme with a step counter goal of 15,000 steps a day achieved **remission in about 46%** of patients.[2] **64%** of those who **lost more than 10 kilos** achieve **remission** within 2 years.[2] A programme include **175 minutes of exercise a week** achieved a **remission rate of 11.5%** at a year. 7.3% were still in remission at 4-years.[3]
Social Intervention	Social support **reduces fasting blood sugar** about 0.25 mmol/l.[4]	

1) NICE, 2017. Type 2 diabetes: prevention in people at high risk (NICE Guideline No. ph38).
2) Lean, M.E., Leslie, W.S., Barnes, A.C., Brosnahan, N., Thom, G., McCombie, L., Peters, C., Zhyzhneuskaya, S., Al-Mrabeh, A., Hollingsworth, K.G., Rodrigues, A.M., Rehackova, L., Adamson, A.J., Sniehotta, F.F., Mathers, J.C., Ross, H.M., McIlvenna, Y., Stefanetti, R., Trenell, M., Welsh, P., Kean, S., Ford, I., McConnachie, A., Sattar, N., Taylor, R., 2018. Primary care-led weight management for remission of type 2 diabetes (DiRECT): an open-label, cluster-randomised trial. Lancet 391, 541–551.
3) Gregg, E.W., Chen, H., Wagenknecht, L.E., Clark, J.M., Delahanty, L.M., Bantle, J., Pownall, H.J., Johnson, K.C., Safford, M.M., Kitabchi, A.E., Pi-Sunyer, F.X., Wing, R.R., Bertoni, A.G., Look AHEAD Research Group, 2012. Association of an intensive lifestyle intervention with remission of type 2 diabetes. JAMA 308, 2489–2496.
4) Public Health England, 2015. A systematic review and metaanalysis assessing the effectiveness of pragmatic lifestyle interventions for the prevention of type 2 diabetes mellitus in routine practice (No. 2015280). Public Health England, London.

*Incidence rate ratio **Relative risk

Slide 85. Lifestyle interventions: gaps in evidence

Social Interventions

Data found for the impact of Social Interventions on BMI and Blood Pressure was only found in qualitative form, limited quantitative data was given. Additionally, there was limited data found for the impact of social interventions on remission and patient satisfaction.

Exercise

Data found for patient satisfaction and exercise was only available from a singular primary study.

Slide 86. Modelling outcomes weight and exercise

Only changes statistically significant to p=0.01 are shown.

ROI at 5-years ~ £0.35 **ROI at 10-years ~ £1.15**

Years to break even ~ 10 **Increase in life expectancy ~ 0.6 years**

Outcome	NNT 5-year	RRR 5-year	NNT 10-year	RRR 10-year
Blindness	75	0.53	49	0.53
Foot ulcer	169	0.44	111	0.45
First amputation	1612	0.47	521	0.45
Subsequent amputation	-	-	-	-
Myocardial infarction	69	0.88	48	0.89
Other ischaemic heart disease	-	-	-	-
Congestive heart failure	27	0.74	16	0.76
Stroke	159	0.92	110	0.94
Renal failure	-	-	-	-
Death	63	0.94	38	0.95

For a 60 year-old, male diabetic with a BMI of 30.

All values statistically significant to **p=0.01**. **ROI** – return on investment £ saved for each £ invested. **RRR** – relative risk reduction.

Slide 87. Lifestyle interventions: costs and return on investment

Advice given on physical activity and weight loss in primary care settings can be highly cost-effective.

After **2 years** there is a positive return on investment of **$1.52 for every $1 invested** in the United Kingdom. However, most of the benefits are gained outside of the health and social care sector. [1]

The DiRECT study suggests the cost burden of diabetes per year per person is £3455 inflated to 2019 costs, and the cost of one year of remission is £2661 inflated to 2019 costs. This would be a net gain of **£794 per year, per remission**. [2]

1) McDaid, D., 2018. Using economic evidence to help make the case for investing in health promotion and disease prevention (Policy Brief). World Health Organisation, HEALTH SYSTEMS FOR PROSPERITY AND SOLIDARITY.
2) Xin, Y., Davies, A., McCombie, L., Briggs, A., Messow, C.-M., Grieve, E., Leslie, W.S., Taylor, R., Lean, M.E.J., 2019. Within-trial cost and 1-year cost-effectiveness of the DiRECT/Counterweight-Plus weight-management programme to achieve remission of type 2 diabetes. Lancet Diabetes Endocrinol 7, 169–172. https://doi.org/10.1016/S2213-8587(18)30346-2

Slide 88. Lifestyle intervention summary

Lifestyle intervention are partly incorporated into the structured education programmes.

Here we have included data on the 'DiRECT' trial which used the Countereight-Plus food replacement products.

The DiRECT trial had a **high impact on outcomes**, but due to the **high cost of the Counterweight-Plus food replacement**, the **return on investment is less than £1** per £1 spent **until 10 years**, when the ROI was £1.15.

Slide 90. 4) Multidisciplinary foot care service (foot clinics)

Slide 90. Multidisciplinary foot care service (foot clinics)

According to the National Diabetes Foot Care Audit 2015-2018:

- The number of ulcers increased by 57% between 2016 and 2017-18.
- Of the patients with severe ulcers, 2.7% underwent major amputation within 6 months and 14% died within one year.
- Being alive and ulcer free is associated with a Foot Protection Service (FPS) pathway, referral for assessment pathway, step-down care between the Multi-Disciplinary Foot Care Team and the FPS.

NICE guidelines state that a foot protection service and information provided by clear explanations should be available for people with diabetes and/or their family members or carers to help reduce the rates of foot ulceration.

Foot clinics involve wound care and education for patients with diabetic foot problems.

National Diabetes Foot Care Audit, 2014-2018.

NICE NG19 Diabetic foot problems – prevention and management; updated May 2016

Slide 91. Foot clinics: outcomes

Amputations	Prevention	Admissions
Major amputation rates reduce by 4.9-43% after implementing foot care.[1]	Patient foot care education can reduce the occurrence of diabetic foot ulcers and amputation incidence. However, in a 7 year follow up of one study, there was no difference in amputation rate in the intervention group and control group.[2]	Inpatient days due to diabetic foot ulcers fell by 23% after implementing foot care.[1]

1) Diabetes UK (2017) – Improving footcare for people with diabetes and saving money: an economic study in England.
2) Dorresteijn (2014).

Slide 92. Modelling outcomes: foot care services

Only changes statistically significant to p=0.01 are shown.

ROI at 5-years ~ £1.28 **ROI at 10-years** ~ £3.24

Years to break even ~ 6 **Increase in life expectancy** ~ 0.1years

Outcome	NNT 5-year	RRR 5-year	NNT 10-year	RRR 10-year
Blindness	-	-	-	-
Foot ulcer	-	-	-	-
First amputation	49	0.59	28	0.58
Subsequent amputation	581	0.50	151	0.46
Myocardial infarction	-	-	-	-
Other ischaemic heart disease	-	-	-	-
Congestive heart failure	-	-	-	-
Stroke	-	-	-	-
Renal failure	-	-	-	-
Death	-	-	-	-

For a 60 year-old, male diabetic with a BMI of 30.

All values statistically significant to **p=0.01**. **ROI** – return on investment £ saved for each £ invested. **RRR** – relative risk reduction.

Foot clinics: cost-effectiveness

Examples of foot clinics in different parts of the country and their costs:

Outcome measures	Gain	Ratio
Somerset county-wide diabetes foot pathway[1]	£926,000	6 times the cost of service improvement
Ipswich hospital NHS trust inpatient improvement programme[1]	£214,000	More than 20 times the cost of the programme
Brent specialist foot care team[1]	£474,000	5 times the cost of service
Southampton University Hospitals[2]	£888,979	NA
James Cook Hospital (Middlesbrough) [2]	£249,459	NA

Diabetes UK estimates that multidisciplinary footcare teams are cost-effective and cost-saving within a year of implementation.[2] We were unable to identify a cost-effectiveness analysis in the UK giving a cost per QALY.

1) Kerr, M., 2017. DIABETIC FOOT CARE IN ENGLAND: AN ECONOMIC STUDY. Insight Health Economics, Diabetes UK.
2) Diabetes UK, 2014. THE COST OF DIABETES REPORT. Diabetes UK, London.

Slide 94. Multidisciplinary foot care services summary

MDFCS are very effective at reducing amputation rates and are targeted at a restricted population with diabetic foot problems in particular.

In people with diabetes with an ulcer, only 49 have to be treated to prevent a first amputation at 5-years.

There is no cost effectiveness analysis applying to England, but our modelling suggests the return on investment is greater than £1 for every £1 invested by 5-years.

Slide 95. 5) Retinopathy screening

Slide 96. Retinopathy screening

Diabetic retinopathy occurs when blood vessels in the eye are damaged which can lead to vision impairment.

The NHS Diabetic Eye Screening Programme was implemented to reduce the rick of sight loss among diabetes patients by detecting and treating early.

Patients with type 1 or type 2 diabetes who are 12 years or older are invited to a screening at least once a year (NHS 2019: Diabetic eye screening).

Screening is carried out by taking pictures of the retina.

NICE guidelines state that on diagnosis, patients with type 1 diabetes should immediately be referred to the local eye screening service and that screening should be performed no later than 3 months from referral.

https://www.nhs.uk/conditions/diabetic-eye-screening/

NICE: Type 1 diabetes in adults, section 16.1/page 466

Slide 97. Retinopathy screening: visual loss

Thomas (2017) showed that after **introducing retinopathy screening** for diabetic patients, the incidence of serious sight impairment **reduced by 10.6%.**

Serious sight impaired was classified as being blind (versus sight impaired which were patients who were partially sighted).

No other information for other outcomes were found on retinopathy screening.

Slide 98. Modelling outcomes: retinopathy screening

Only changes statistically significant to p=0.01 are shown.

ROI at 5-years ~ £0.10 **ROI at 10-years** ~ £0.20

Years to break even ~ Never **Increase in life expectancy** ~ 0.0 years

Outcome	NNT 5-year	RRR 5-year	NNT 10-year	RRR 10-year
Blindness	251	0.85	193	0.88
Foot ulcer	-	-	-	-
First amputation	-	-	-	-
Subsequent amputation	-	-	-	-
Myocardial infarction	-	-	-	-
Other ischaemic heart disease	-	-	-	-
Congestive heart failure	-	-	-	-
Stroke	-	-	-	-
Renal failure	-	-	-	-
Death	-	-	-	-

For a 60 year-old, male diabetic with a BMI of 30.

All values statistically significant to **p=0.01**. **ROI** – return on investment £ saved for each £ invested. **RRR** – relative risk reduction.

Slide 99. Retinopathy screening: cost-effectiveness

A study of cost-effectiveness of different screening intervals in England suggests that an annual screen of 1,000 people with diabetes costs £20,672 and results in a gain of 8.37 QALYs.[1]

This suggests that the **cost per QALY** gained is about **£2,469**. This is **highly cost-effective** compared to the standard willingness to pay of £20,000 per QALY.

The study found that a 3-year screening interval was the interval most likely have the maximum cost-effectiveness. This would suggest that efforts to boost uptake uptake should focus on never attenders and those who have missed more than one year.

1. Scanlon, P.H., Aldington, S.J., Leal, J., Luengo-Fernandez, R., Oke, J., Sivaprasad, S., Gazis, A., Stratton, I.M., 2015. Development of a cost-effectiveness model for optimisation of the screening interval in diabetic retinopathy screening. Health Technology Assessment 19, 1–116. https://doi.org/10.3310/hta19740

Slide 100. Retinopathy screening summary

Retinopathy screening **is cost-effective** but **does not give a significant return on investment** as it is **repeated annually**.

It has already been implemented, but the **uptake in Nottingham City is relatively low**, so there is scope to improve attendance.

A modelling study suggested that a **3-year screening interval** was the one **most likely to be cost-effective**.

Measures to target those most at risk, particularly **people who have missed two annual screens**, may improve outcomes.

Slide 101. 5. Bariatric surgery

Slide 102. Bariatric surgery

Types of bariatric surgery include Roux-en-Y, sleeve gastrectomy, jejunal resection and stapling.

NICE guidelines recommend surgery for weight loss for people who meet the criteria of having a BMI of 35 or over with recent onset type 2 diabetes, and who have completed at least 6 months of a tier 3 service (multidisciplinary weight management). [1]

In 2014-15, 6,032 type two diabetes patients underwent some form of bariatric surgery in the UK. This is about 0.002% of the eligible population compared to an uptake of 0.54% in Canada and 1.24% in the USA.[2]

1) NICE, 2019. Surgery for obese adults. (NICE Pathways). National Institute for Health and Care Excellence.
2) Desogus, D., Menon, V., Singhal, R., Oyebode, O., 2019. An Examination of Who Is Eligible and Who Is Receiving Bariatric Surgery in England: Secondary Analysis of the Health Survey for England Dataset. Obes Surg 29, 3246–3251. https://doi.org/10.1007/s11695-019-03977-3

Slide 103. Bariatric surgery: outcomes

HbA1c	BMI / obesity	Remission	Prevention	Patient satisfaction
Surgery can reduce HbA1c by 2.2 (from 8.5 preoperative to 6.3 postoperative).[1]	BMI can be reduced by 5.18-11.4.[2,3]	37-80% of patients are in remission 3-5 years after surgery. Complete or partial remission is seen more in gastric bypass (45%) compared with sleeve gastrectomy (37%). There is some evidence that patients who achieve remission one-year post surgery, relapse 5 years post surgery. [4,5]	Surgery in obese patients can reduce the development of diabetes by 15.4%.[6]	97.9% of diabetic patients who undergo surgery rate it as excellent, very good or good.[7]

Data for how bariatric surgery effects blood pressure were not found.

Significant psychological illness is a predictor of a poor response.[8]

1) Ahmed, A.E. et al., 2018. The influences of bariatric surgery on hemoglobin A1c in a sample of obese patients in Saudi Arabia. Diabetes Metab Syndr Obes 11, 271–276. https://doi.org/10.2147/DMSO.S161540
2) Li, Q. et al, 2012. Metabolic effects of bariatric surgery in type 2 diabetic patients with body mass index < 35 kg/m2. Diabetes, Obesity and Metabolism 14, 262–270. https://doi.org/10.1111/j.1463-1326.2011.01524.x3. Rizvi (2016).
3) Salminen et al, 2018. Effect of Laparoscopic Sleeve Gastrectomy vs Laparoscopic Roux-en-Y Gastric Bypass on Weight Loss at 5 Years Among Patients With Morbid Obesity: The SLEEVEPASS Randomized Clinical Trial. JAMA 319, 241–254. https://doi.org/10.1001/jama.2017.20313
4) Mingrone, G. et al, 2015. Bariatric-metabolic surgery versus conventional medical treatment in obese patients with type 2 diabetes: 5 year follow-up of an open-label, single-centre, randomised controlled trial. Lancet 386, 964–973. https://doi.org/10.1016/S0140-6736(15)00075-6.
5) Carlsson, L.M.S. et al, 2012. Bariatric surgery and prevention of type 2 diabetes in Swedish obese subjects. N. Engl. J. Med. 367, 695–704. https://doi.org/10.1056/NEJMoa1112082
6) Lee, W.-J. et al., 2016. Bariatric versus diabetes surgery after five years of follow up. Asian J Surg 39, 96–102. https://doi.org/10.1016/j.asjsur.2015.04.001.
7) Testa, G., et al., 2019. Psychological predictors of poor weight loss following LSG: relevance of general psychopathology and impulsivity. Eat Weight Disord. https://doi.org/10.1007/s40519-019-00800-x

Slide 104. Modelling outcomes: bariatric surgery

Only outcomes significantly different to p=0.01 shown.

ROI at 5-years ~ £0.13 **ROI at 10-years** ~ £0.38

Years to break even ~ 19 **Increase in life expectancy** ~ 0.8 years

Outcome	NNT 5-year	RRR 5-year	NNT 10-year	RRR 10-year
Blindness	146	0.51	76	0.50
Foot ulcer	230	0.27	133	0.28
First amputation	1639	0.40	492	0.42
Subsequent amputation	-	-	3030	0.13
Myocardial infarction	175	0.91	72	0.88
Other ischaemic heart disease	-454*	1.08	-	-
Congestive heart failure	32	0.46	15	0.47
Stroke	-	-	192	0.93
Renal failure	-	-	-	-
Death	159	0.92	58	0.91

For a 60 year-old, male diabetic with a BMI of 30.

All values statistically significant to **p=0.01**. **ROI** – return on investment £ saved for each £ invested. **RRR** – relative risk reduction.

* Increase in MI.

Slide 105. Bariatric surgery: savings

Potential savings from needing less medication for type 2 diabetes because more people achieve remission.

Time horizon	%	Year 1	Year 2	Year 3	Year 4	Year 5
Estimated number of people who have surgery each year		5,545	5,545	5,545	5,545	5,545
Remission of type 2 diabetes						
No. people 1 year after surgery	60	0	3,327	3,327	3,327	3,327
No. people 2 years after surgery	60	0	0	3,604	3,604	3,604
No. people 3 years after surgery	60	0	0	0	4,436	4,436
Total per year		0	3,327	6,931	11,367	11,367
Potential saving (£000)		0	£1,825	£3,804	£6,238	£6,238

NICE, 2014. Costing report: Obesity Implementing the NICE guideline on obesity (CG189). National Institute for Health and Care Excellence, London.

Slide 106. Bariatric surgery summary

Bariatric surgery is **very cost-effective at £7,129 per QALY gained**, but is very **expensive** meaning that it takes **many years to provide a return on investment** (19 years).

Slide 107. Recommendations

Slide 108. Recommendations

All of the interventions described here are cost-effective and are therefore **worth doing**.

To maximise **return on investment** and **health improvement**, **prioritize** the following:

- **Web-based structured education**. This offers the highest return on investment and are very cost-effective.
- **Multidisciplinary foot-care services**. They have a rapid return on investment, and whilst a comprehensive UK cost-effectiveness analysis is lacking, it is very likely to be very cost-effective given the observed savings when implemented at pilot sites.
- **Take steps to improve uptake rates** for **structured education** everywhere, and **retinopathy screening** in Nottingham City in particular by:
    - Addressing **competing time pressures**. (Out-of-hours and weekend services, web-based structured education);
    - Address **transport difficulties**. (locating services closer to users, mobile screening units);
    - **Culturally adapt provision**. (Review translation service provision, web-apps in locally used languages, consult with the local community).
- For **retinopathy screening**, identify and target those people with diabetes who have **missed two consecutive years of screening** for more **intensive reminders and engagement**.

Slide 109. Amputations

In general, Clinical Commissioning Groups are experiencing a decrease in major amputations and an increase in minor amputations.

The recommendations relevant to amputations are:

Web-based structured education

Web-based structured education offers the highest returns on investment compared to other structured education. This is largely because of greatly increased accessibility and low cost of delivery.

Multidisciplinary foot care services

Multidisciplinary foot care services offer significant returns on investment as they are targeted at people with diabetes with foot ulcers who have a high risk of amputation. Organisational reconfigurations to streamline case finding and patient pathways will make better use of the skills of specialist staff to improve the outcomes for people with diabetes with foot problems.

Structured education

Taking steps to improve uptake of traditional structured education services can improve outcomes in those unable to use web-based structured education.

Slide 110. Vision loss

Although in 2018, the estimated percentage of people with diabetes living with retinopathy, and severe retinopathy was lower in Nottinghamshire compared to England, all seven local authorities in Nottinghamshire fell below the national average for all forms of retinopathy.

In Nottingham city in particular, there is a low uptake of screening due to age, deprivation, distance and ethnicity.

Therefore, we recommend the following for vision loss and increasing uptake of screening.

Web-based structured education

Web-based structured education offers the highest returns on investment compared to other structured education. This is largely because of greatly increased accessibility and low cost of delivery.

Retinopathy screening

Retinopathy screening is cost-effective. With screening, a modest improvement in the rate of blindness can be seen.

Structured education

Taking steps to improve uptake of traditional structured education services can improve outcomes in those unable to use web-based structured education.

Slide 111. Chronic kidney disease

The prevalence of chronic kidney disease amongst people with diabetes in Nottinghamshire in 2017/18 was higher than for the average in England. NHS Nottingham City was the only CCG in England that fell below the England average.

Web-based structured education

Web-based structured education offers the highest returns on investment compared to other structured education. This is largely because of greatly increased accessibility and low cost of delivery.

Structured education

Taking steps to improve uptake of traditional structured education services can improve outcomes in those unable to use web-based structured education.

Slide 112. Bibliography

About DAFNE. http://www.dafne.uk.com/DAFNE_home-I387.html

About X-PERT Health. https://www.xperthealth.org.uk/Home/About-X-PERT-Health

Ahmad, N., Thomas, G.N., Gill, P., Torella, F., 2016. The prevalence of major lower limb amputation in the diabetic and non-diabetic population of England 2003–2013. Diabetes and Vascular Disease Research 13, 348–353. https://doi.org/10.1177/1479164116651390Public Health England – Diabetes Foot Care Profiles.

Ahmed, A.E. et al., 2018. The influences of bariatric surgery on hemoglobin A1c in a sample of obese patients in Saudi Arabia. Diabetes Metab Syndr Obes 11, 271–276. https://doi.org/10.2147/DMSO.S161540

Avery, L., Flynn, D., van Wersch, A., Sniehotta, F.F., Trenell, M.I., 2012. Changing Physical Activity Behavior in Type 2 Diabetes: A systematic review and meta-analysis of behavioral interventions. Diabetes Care 35, 2681–2689. https://doi.org/10.2337/dc11-2452

Boulé, N.G., Haddad, E., Kenny, G.P., Wells, G.A., Sigal, R.J., 2001. Effects of Exercise on Glycemic Control and Body Mass in Type 2 Diabetes Mellitus: A Meta-analysis of Controlled Clinical Trials. JAMA 286, 1218. https://doi.org/10.1001/jama.286.10.1218

Carlsson, L.M.S. et al, 2012. Bariatric surgery and prevention of type 2 diabetes in Swedish obese subjects. N. Engl. J. Med. 367, 695–704. https://doi.org/10.1056/NEJMoa1112082

Chatterjee, S., Davies, M.J., Stribling, B., Farooqi, A., Khunti, K., 2018. Real-world evaluation of the DESMOND type 2 diabetes education and self-management programme: Real-world evaluation of the DESMOND type 2 diabetes education and self-management programme. Practical Diabetes 35, 19–22a. https://doi.org/10.1002/pdi.2154

Chudyk, A., Petrella, R.J., 2011. Effects of Exercise on Cardiovascular Risk Factors in Type 2 Diabetes: A meta-analysis. Diabetes Care 34, 1228–1237. https://doi.org/10.2337/dc10-1881

Cunningham S.G.; Allardice B.; Brillante M.; Wilson L.; Wake D.J., 2018. My Diabetes My Way-an electronic personal health record: Impact on clinical outcomes. Diabetic Medicine 35.

Cunningham S.G.; Allardice B.; Wake D.J., 2017. My diabetes my way: User experiences of an electronic personal health record for diabetes. Diabetologia 60, Supplement 1 (S350).

Bibliography

Dale, J.R., Williams, S.M., Bowyer, V., 2012. What is the effect of peer support on diabetes outcomes in adults? A systematic review: A systematic review of peer support on diabetes outcomes in adults. Diabetic Medicine 29, 1361–1377. https://doi.org/10.1111/j.1464-5491.2012.03749

DAFNE Study Group, 2002. Training in flexible, intensive insulin management to enable dietary freedom in people with type 1 diabetes: dose adjustment for normal eating (DAFNE) randomised controlled trial. BMJ 325, 746–746. https://doi.org/10.1136/bmj.325.7367.746

Davies, M.J., Heller, S., Skinner, T.C., Campbell, M.J., Carey, M.E., Cradock, S., Dallosso, H.M., Daly, H., Doherty, Y., Eaton, S., Fox, C., Oliver, L., Rantell, K., Rayman, G., Khunti, K., Diabetes Education and Self Management for Ongoing and Newly Diagnosed Collaborative, 2008. Effectiveness of the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cluster randomised controlled trial. BMJ 336, 491–495. https://doi.org/10.1136/bmj.39474.922025.BE

Deakin, T., 2011. Diabetes education drives quality and fuels NHS efficiency savings: Outcome data from recent trials show the effect patient-centred training can have on increasing self-management, as Trudi Deakin describes. Primary Health Care 21, 21–24. https://doi.org/10.7748/phc2011.12.21.10.21.c8849

Deakin, T., 2018. X-PERT National Audit Results 2018. X-PERT Health.

Deakin, T.A., Cade, J.E., Williams, R., Greenwood, D.C., 2006. Structured patient education: the Diabetes X-PERT Programme makes a difference. Diabetic Medicine 23, 944–954. https://doi.org/10.1111/j.1464-5491.2006.01906.x

Desmond Project: https://www.desmond-project.org.uk/about/

Desogus, D., Menon, V., Singhal, R., Oyebode, O., 2019. An Examination of Who Is Eligible and Who Is Receiving Bariatric Surgery in England: Secondary Analysis of the Health Survey for England Dataset. Obes Surg 29, 3246–3251. https://doi.org/10.1007/s11695-019-03977-3

Bibliography

Diabetes Health Apps Report: https://imperialcollegehealthpartners.com/wp-content/uploads/2018/03/Diabetes-Health-Apps-Report-26th-March-2018.pdf

Diabetes UK, 2014. THE COST OF DIABETES REPORT. Diabetes UK, London.

Diabetes UK, 2017. Improving footcare for people with diabetes and saving money: an economic study in England.

Digital Innovations to Support Diabetes Outcomes: https://www.england.nhs.uk/diabetes/digital-innovations-to-support-diabetes-outcomes/

Dorresteijn, J.A., Kriegsman, D.M., Assendelft, W.J., Valk, G.D., 2014. Patient education for preventing diabetic foot ulceration. Cochrane Database of Systematic Reviews. https://doi.org/10.1002/14651858.CD001488.pub5

Ellis, D.A., McQueenie, R., McConnachie, A., Wilson, P., Williamson, A.E., 2017. Demographic and practice factors predicting repeated non-attendance in primary care: a national retrospective cohort analysis. The Lancet Public Health 2, e551–e559. https://doi.org/10.1016/S2468-2667(17)30217-7

Farrell, K., Holmes-Walker, D.J., 2011. Mobile phone support is associated with reduced ketoacidosis in young adults. Diabet. Med. 28, 1001–1004. https://doi.org/10.1111/j.1464-5491.2011.03302.x

Finnigan, Y., Clarkson, Mandy, 2019. “What is the best model of community-based care to meet the need across City and County populations and to optimize clinical outcomes, cost-effectiveness and to reduce non-elective health care usage? Knowledge Services Evidence Summary. Greater Nottingham Clinical Commissioning Group.

Gerlanc, N.M., Cai, J., Tkacz, J., Bolge, S.C., Brady, B.L., 2017. The association of weight loss with patient experience and outcomes in a population of patients with type 2 diabetes mellitus prescribed canagliflozin. Diabetes Metab Syndr Obes 10, 89–99. https://doi.org/10.2147/DMSO.S129824

Gillett, M., Dallosso, H.M., Dixon, S., Brennan, A., Carey, M.E., Campbell, M.J., Heller, S., Khunti, K., Skinner, T.C., Davies, M.J., 2010. Delivering the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cost effectiveness analysis. BMJ 341, c4093–c4093. https://doi.org/10.1136/bmj.c4093

Bibliography

Gregg, E.W., Chen, H., Wagenknecht, L.E., Clark, J.M., Delahanty, L.M., Bantle, J., Pownall, H.J., Johnson, K.C., Safford, M.M., Kitabchi, A.E., Pi-Sunyer, F.X., Wing, R.R., Bertoni, A.G., Look AHEAD Research Group, 2012. Association of an intensive lifestyle intervention with remission of type 2 diabetes. JAMA 308, 2489–2496. https://doi.org/10.1001/jama.2012.67929

Gulliford, M.C., Charlton, J., Prevost, T., Booth, H., Fildes, A., Ashworth, M., Littlejohns, P., Reddy, M., Khan, O., Rudisill, C., 2017. Costs and Outcomes of Increasing Access to Bariatric Surgery: Cohort Study and Cost-Effectiveness Analysis Using Electronic Health Records. Value Health 20, 85–92. https://doi.org/10.1016/j.jval.2016.08.734

Gummesson, A., Nyman, E., Knutsson, M., Karpefors, M., 2017. Effect of weight reduction on glycated haemoglobin in weight loss trials in patients with type 2 diabetes. Diabetes Obes Metab 19, 1295–1305. https://doi.org/10.1111/dom.12971

Hayashino, Y., Jackson, J.L., Fukumori, N., Nakamura, F., Fukuhara, S., 2012. Effects of supervised exercise on lipid profiles and blood pressure control in people with type 2 diabetes mellitus: A meta-analysis of randomized controlled trials. Diabetes Research and Clinical Practice 98, 349–360. https://doi.org/10.1016/j.diabres.2012.10.004

Hayes, A.J., Leal, J., Gray, A.M., Holman, R.R., Clarke, P.M., 2013. UKPDS Outcomes Model 2: a new version of a model to simulate lifetime health outcomes of patients with type 2 diabetes mellitus using data from the 30 year United Kingdom Prospective Diabetes Study: UKPDS 82. Diabetologia 56, 1925–1933. https://doi.org/10.1007/s00125-013-2940-y

Hipwell, A.E., Sturt, J., Lindenmeyer, A., Stratton, I., Gadsby, R., O'Hare, P., Scanlon, P.H., 2014. Attitudes, access and anguish: a qualitative interview study of staff and patients' experiences of diabetic retinopathy screening. BMJ Open 4, e005498. https://doi.org/10.1136/bmjopen-2014-005498

Hopkins, D., Lawrence, I., Mansell, P., Thompson, G., Amiel, S., Campbell, M., Heller, S., 2012. Improved Biomedical and Psychological Outcomes 1 Year After Structured Education in Flexible Insulin Therapy for People With Type 1 Diabetes: The U.K. DAFNE experience. Diabetes Care 35, 1638–1642. https://doi.org/10.2337/dc11-1579

Hypo Program: https://www.hypoprogram.com/

Jacobs-van der Bruggen, M.A.M., van Baal, P.H., Hoogenveen, R.T., Feenstra, T.L., Briggs, A.H., Lawson, K., Feskens, E.J.M., Baan, C.A., 2009. Cost-effectiveness of lifestyle modification in diabetic patients. Diabetes Care 32, 1453–1458. https://doi.org/10.2337/dc09-0363

Bibliography

Kashim, R.M., Newton, P., Ojo, O., 2018. Diabetic Retinopathy Screening: A Systematic Review on Patients' Non-Attendance. Int J Environ Res Public Health 15. https://doi.org/10.3390/ijerph15010157

Kelly, C., Hulme, C., Farragher, T., Clarke, G., 2016. Are differences in travel time or distance to healthcare for adults in global north countries associated with an impact on health outcomes? A systematic review. BMJ Open 6, e013059. https://doi.org/10.1136/bmjopen-2016-013059

Kerr, M., 2017. DIABETIC FOOT CARE IN ENGLAND: AN ECONOMIC STUDY. Insight Health Economics, Diabetes UK

Khunti, K., Gray, L.J., Skinner, T., Carey, M.E., Realf, K., Dallosso, H., Fisher, H., Campbell, M., Heller, S., Davies, M.J., 2012. Effectiveness of a diabetes education and self management programme (DESMOND) for people with newly diagnosed type 2 diabetes mellitus: three year follow-up of a cluster randomised controlled trial in primary care. BMJ 344, e2333. https://doi.org/10.1136/bmj.e2333

Khunti K., Seidu S., Kunutsor S., Davies M., 2017. Association between adherence to pharmacotherapy and outcomes in type 2 diabetes: A meta-analysis. Diabetes Care 40, 1588–1596. https://doi.org/10.2337/dc16-1925/-/DC1

Kruger J., Brennan A., Thokala P., Basarir H., Jacques R., Elliott J., Heller S., Speight J., 2013. The cost-effectiveness of the Dose Adjustment for Normal Eating (DAFNE) structured education programme: An update using the Sheffield Type 1 Diabetes Policy Model. Diabet. Med. 30, 1236–1244. https://doi.org/10.1111/dme.12270

Lean, M.E., Leslie, W.S., Barnes, A.C., Brosnahan, N., Thom, G., McCombie, L., Peters, C., Zhyzhneuskaya, S., Al-Mrabeh, A., Hollingsworth, K.G., Rodrigues, A.M., Rehackova, L., Adamson, A.J., Sniehotta, F.F., Mathers, J.C., Ross, H.M., McIlvenna, Y., Stefanetti, R., Trenell, M., Welsh, P., Kean, S., Ford, I., McConnachie, A., Sattar, N., Taylor, R., 2018. Primary care-led weight management for remission of type 2 diabetes (DiRECT): an open-label, cluster-randomised trial. Lancet 391, 541–551. https://doi.org/10.1016/S0140-6736(17)33102-1

Bibliography

Kelly, C., Hulme, C., Farragher, T., Clarke, G., 2016. Are differences in travel time or distance to healthcare for adults in global north countries associated with an impact on health outcomes? A systematic review. BMJ Open 6, e013059. https://doi.org/10.1136/bmjopen-2016-013059

Kerr, M., 2017. DIABETIC FOOT CARE IN ENGLAND: AN ECONOMIC STUDY. Insight Health Economics, Diabetes UK

Khunti, K., Gray, L.J., Skinner, T., Carey, M.E., Realf, K., Dallosso, H., Fisher, H., Campbell, M., Heller, S., Davies, M.J., 2012. Effectiveness of a diabetes education and self management programme (DESMOND) for people with newly diagnosed type 2 diabetes mellitus: three year follow-up of a cluster randomised controlled trial in primary care. BMJ 344, e2333. https://doi.org/10.1136/bmj.e2333

Khunti K., Seidu S., Kunutsor S., Davies M., 2017. Association between adherence to pharmacotherapy and outcomes in type 2 diabetes: A meta-analysis. Diabetes Care 40, 1588–1596. https://doi.org/10.2337/dc16-1925/-/DC1

Kruger J., Brennan A., Thokala P., Basarir H., Jacques R., Elliott J., Heller S., Speight J., 2013. The cost-effectiveness of the Dose Adjustment for Normal Eating (DAFNE) structured education programme: An update using the Sheffield Type 1 Diabetes Policy Model. Diabet. Med. 30, 1236–1244. https://doi.org/10.1111/dme.12270

Johnson, D., Deterding, S., Kuhn, K.-A., Staneva, A., Stoyanov, S., Hides, L., 2016. Gamification for health and wellbeing: A systematic review of the literature. Internet Interv 6, 89–106. https://doi.org/10.1016/j.invent.2016.10.002

Lean, M.E., Leslie, W.S., Barnes, A.C., Brosnahan, N., Thom, G., McCombie, L., Peters, C., Zhyzhneuskaya, S., Al-Mrabeh, A., Hollingsworth, K.G., Rodrigues, A.M., Rehackova, L., Adamson, A.J., Sniehotta, F.F., Mathers, J.C., Ross, H.M., McIlvenna, Y., Stefanetti, R., Trenell, M., Welsh, P., Kean, S., Ford, I., McConnachie, A., Sattar, N., Taylor, R., 2018. Primary care-led weight management for remission of type 2 diabetes (DiRECT): an open-label, cluster-randomised trial. Lancet 391, 541–551. https://doi.org/10.1016/S0140-6736(17)33102-1

Bibliography

Lee, W.-J. et al., 2016. Bariatric versus diabetes surgery after five years of follow up. Asian J Surg 39, 96–102. https://doi.org/10.1016/j.asjsur.2015.04.001.

Leese, G.P., Boyle, P., Feng, Z., Emslie-Smith, A., Ellis, J.D., 2008. Screening Uptake in a Well-Established Diabetic Retinopathy Screening Program: The role of geographical access and deprivation. Diabetes Care 31, 2131–2135. https://doi.org/10.2337/dc08-1098

Li, Q. et al, 2012. Metabolic effects of bariatric surgery in type 2 diabetic patients with body mass index < 35 kg/m2. Diabetes, Obesity and Metabolism 14, 262–270. https://doi.org/10.1111/j.1463-1326.2011.01524.x3. Rizvi (2016).

Li, J., Parrott, S., Sweeting, M., Farmer, A., Ross, J., Dack, C., Pal, K., Yardley, L., Barnard, M., Hudda, M., Alkhaldi, G., Murray, E., 2018. Cost-Effectiveness of Facilitated Access to a Self-Management Website, Compared to Usual Care, for Patients With Type 2 Diabetes (HeLP-Diabetes): Randomized Controlled Trial. J. Med. Internet Res. 20, e201. https://doi.org/10.2196/jmir.9256

Liang, X., Wang, Q., Yang, X., Cao, J., Chen, J., Mo, X., Huang, J., Wang, L., Gu, D., 2011. Effect of mobile phone intervention for diabetes on glycaemic control: a meta-analysis. Diabet. Med. 28, 455–463. https://doi.org/10.1111/j.1464-5491.2010.03180.x

Little, P., Stuart, B., Hobbs, F.R., Kelly, J., Smith, E.R., Bradbury, K.J., Hughes, S., Smith, P.W.F., Moore, M.V., Lean, M.E.J., Margetts, B.M., Byrne, C.D., Griffin, S., Davoudianfar, M., Hooper, J., Yao, G., Zhu, S., Raftery, J., Yardley, L., 2016. An internet-based intervention with brief nurse support to manage obesity in primary care (POWeR+): a pragmatic, parallel-group, randomised controlled trial. The Lancet Diabetes & Endocrinology 4, 821–828. https://doi.org/10.1016/S2213-8587(16)30099-7

Long Term Plan: www.longtermplan.nhs.uk

Maheswaran, R., Pearson, T., Jordan, H., Black, D., 2006. Socioeconomic deprivation, travel distance, location of service, and uptake of breast cancer screening in North Derbyshire, UK. J Epidemiol Community Health 60, 208–212. https://doi.org/10.1136/jech.200X.038398

Bibliography

Mansell, P., 2012. The Dose Adjustment for Normal Eating (DAFNE) education programme. Journal of Diabetes Nursing 16, 364–369.

McDaid, D., 2018. Using economic evidence to help make the case for investing in health promotion and disease prevention (Policy Brief). World Health Organisation, HEALTH SYSTEMS FOR PROSPERITY AND SOLIDARITY.

McIntyre, H.D., Knight, B.A., Harvey, D.M., Noud, M.N., Hagger, V.L., Gilshenan, K.S., 2010. Dose adjustment for normal eating (DAFNE) - an audit of outcomes in Australia. Med. J. Aust. 192, 637–640. Deakin, T.A., Cade, J.E., Williams, R., Greenwood, D.C., 2006. Structured patient education: the Diabetes X-PERT Programme makes a difference. Diabetic Medicine 23, 944–954. https://doi.org/10.1111/j.1464-5491.2006.01906.x

Mingrone, G. et al, 2015. Bariatric-metabolic surgery versus conventional medical treatment in obese patients with type 2 diabetes: 5 year follow-up of an open-label, single-centre, randomised controlled trial. Lancet 386, 964–973. https://doi.org/10.1016/S0140-6736(15)00075-6.

Murray, E., Sweeting, M., Dack, C., Pal, K., Modrow, K., Hudda, M., Li, J., Ross, J., Alkhaldi, G., Barnard, M., Farmer, A., Michie, S., Yardley, L., May, C., Parrott, S., Stevenson, F., Knox, M., Patterson, D., 2017. Web-based self-management support for people with type 2 diabetes (HeLP-Diabetes): randomised controlled trial in English primary care. BMJ Open 7, e016009. https://doi.org/10.1136/bmjopen-2017-016009

National Diabetes Audit (NDA) 2017-18 Interactive report for England, Clinical Commissioning Groups and GP practices, 2019. NHS Digital, Health and Social Care Information Centre

National Diabetes Foot Care Audit, 2015-2018.

NHS, 2019. Diabetic eye screening https://www.nhs.uk/conditions/diabetic-eye-screening/

NHS Diabetes Prevention Programme Return on Investment Tool V1.0. https://dpp-roi-tool.shef.ac.uk/

NHS Digital (2019)-Diabetes Prevention Programme, 2017-18 Diagnoses and Demographics. 11th July 2019. https://files.digital.nhs.uk/1B/D8C0E4/NDA_DPP_MainReport_1718_1.1.pdf

NHS England- NHSDPP overview and FAQ . https://www.england.nhs.uk/wp-content/uploads/2016/08/dpp-faq.pdf

NHS. The NHS Long Term Plan, 2019. . NHS England. https://www.longtermplan.nhs.uk/

Bibliography

NHS England. Digital innovations in diabetes. https://www.england.nhs.uk/diabetes/digital-innovations-to-support-diabetes-outcomes/

NICE, 2014. Costing report: Obesity Implementing the NICE guideline on obesity (CG189). National Institute for Health and Care Excellence, London.

NICE, 2017. Type 2 diabetes: prevention in people at high risk (NICE Guideline No. ph38).

NICE NG19. Diabetic foot problems – prevention and management; updated May 2016.

NICE, 2019. Surgery for obese adults. (NICE Pathways). National Institute for Health and Care Excellence.

NICE, 2019. Type 2 diabetes: prevention in people at high risk- https://www.nice.org.uk/guidance/ph38

NICE: Type 1 diabetes in adults, section 16.1/page 466

Office for National Statistics (ONS), Mid 2018 population estimates

Payne, S., Jarrett, N., Jeffs, D., 2000. The impact of travel on cancer patients' experiences of treatment: a literature review. Eur J Cancer Care (Engl) 9, 197–203. https://doi.org/10.1046/j.1365-2354.2000.00225.x

Public Health England, 2015. A systematic review and metaanalysis assessing the effectiveness of pragmatic lifestyle interventions for the prevention of type 2 diabetes mellitus in routine practice (No. 2015280). Public Health England, London

Public Health England, NHS Diabetic Eye Screening Programme 2016-17.

Public Health England. Fingertips Public Health Profiles. www.fingertips.phe.org.uk

Qi, L., Liu, Q., Qi, X., Wu, N., Tang, W., Xiong, H., 2015. Effectiveness of peer support for improving glycaemic control in patients with type 2 diabetes: a meta-analysis of randomized controlled trials. BMC Public Health 15, 471. https://doi.org/10.1186/s12889-015-1798-y

Quality and Outcomes Framework, Achievement, prevalence and exceptions data – 2017/18 (qof-1718-prev-all-lev).

Redekop, W.K., Koopmanschap, M.A., Stolk, R.P., Rutten, G.E.H.M., Wolffenbuttel, B.H.R., Niessen, L.W., 2002. Health-related quality of life and treatment satisfaction in Dutch patients with type 2 diabetes. Diabetes Care 25, 458–463. https://doi.org/10.2337/diacare.25.3.458

Bibliography

Richards, M., 2019. Report of THE INDEPENDENT REVIEW OF ADULT SCREENING PROGRAMMES in England (No. 01089). NHS England, Leeds

RNIB Sight Loss Data Tool V4. https://www.rnib.org.uk/professionals/knowledge-and-research-hub/key-information-and-statistics/sight-loss-data-tool

Salminen et al, 2018. Effect of Laparoscopic Sleeve Gastrectomy vs Laparoscopic Roux-en-Y Gastric Bypass on Weight Loss at 5 Years Among Patients With Morbid Obesity: The SLEEVEPASS Randomized Clinical Trial. JAMA 319, 241–254. https://doi.org/10.1001/jama.2017.20313

Saslow, L.R., Summers, C., Aikens, J.E., Unwin, D.J., 2018. Outcomes of a Digitally Delivered Low-Carbohydrate Type 2 Diabetes Self-Management Program: 1-Year Results of a Single-Arm Longitudinal Study. JMIR Diabetes 3, e12. https://doi.org/10.2196/diabetes.9333

Scanlon, P.H., Aldington, S.J., Leal, J., Luengo-Fernandez, R., Oke, J., Sivaprasad, S., Gazis, A., Stratton, I.M., 2015. Development of a cost-effectiveness model for optimisation of the screening interval in diabetic retinopathy screening. Health Technology Assessment 19, 1–116. https://doi.org/10.3310/hta19740

Shabestari, O., Roudsari, A., 2009. Potential Return on Investment (RoI) on web-based diabetes education in UK. Stud Health Technol Inform 143, 258–263.

Smith, W., 2018. Diabetes Digital Behaviour Change Programmes: North West London Pilot. Evaluation Report. Imperial College Health Partners.

Testa, G., et al., 2019. Psychological predictors of poor weight loss following LSG: relevance of general psychopathology and impulsivity. Eat Weight Disord. https://doi.org/10.1007/s40519-019-00800-x

Thomas, C., Sadler, S., Breeze, P., Squires, H., Gillett, M., Brennan, A., 2017. Assessing the potential return on investment of the proposed UK NHS diabetes prevention programme in different population subgroups: an economic evaluation. BMJ Open 7, e014953. https://doi.org/10.1136/bmjopen-2016-014953

Thomas, D.E., Elliott, E.J., Naughton, G.A., 2006. Exercise for type 2 diabetes mellitus. Cochrane.Database.Syst.Rev. 3, CD002968.

Bibliography

Xin, Y., Davies, A., McCombie, L., Briggs, A., Messow, C.-M., Grieve, E., Leslie, W.S., Taylor, R., Lean, M.E.J., 2019. Within-trial cost and 1-year cost-effectiveness of the DiRECT/Counterweight-Plus weight-management programme to achieve remission of type 2 diabetes. Lancet Diabetes Endocrinol 7, 169–172. https://doi.org/10.1016/S2213-8587(18)30346-2

X-PERT Health: https://www.xperthealth.org.uk/Home/About-X-PERT-Health

Zhang, X., Norris, S.L., Saadine, J., Chowdhury, F.M., Horsley, T., Kanjilal, S., Mangione, C.M., Buhrmann, R., 2007. Effectiveness of interventions to promote screening for diabetic retinopathy. Am J Prev Med 33, 318–335. https://doi.org/10.1016/j.amepre.2007.05.002

Appendix A Stochastic modelling of outcomes in people with type 2 diabetes for return on investment.

The modelling of outcomes used in this analysis is based upon the UKPDS Outcomes Models 2.[1] It consists of seventeen different regression models to calculate the probability of events occurring in a given year. The events modelled are:

1. Blindness.
2. Diabetic foot ulcer.
3. A first amputation (roughly corresponding to minor amputation) in someone without a history of foot ulcer.
4. A first amputation in someone with a history of foot ulcer.
5. A subsequent amputation (roughly corresponding to a major amputation).
6. Renal failure.
7. Congestive heart failure.
8. A first myocardial infarct in a male .
9. A first myocardial infarct in a female.
10. A subsequent myocardial infarct.
11. Other ischaemic heart disease.
12. A first stroke
13. A subsequent stroke.
14. Death in someone with no history of an event.
15. Death in the year following an event.
16. Death after the first year of an event.
17. Death with a history but no event.

[1] Hayes, A.J., Leal, J., Gray, A.M., Holman, R.R., Clarke, P.M., 2013. UKPDS Outcomes Model 2: a new version of a model to simulate lifetime health outcomes of patients with type 2 diabetes mellitus using data from the 30 year United Kingdom Prospective Diabetes Study: UKPDS 82. Diabetologia 56, 1925–1933. https://doi.org/10.1007/s00125-013-2940-y

The model is stochastic, meaning that it uses random numbers to decide if an event occurs in any given year, and records the change in state. If the event was death, the simulation ends, if not, another year is simulated with the changed state. This process is continued until the simulated subject has died. The process is repeat many times so that an average rate of events in each year and the prevalence of the states can be calculated.

Intervention modelling

The effect of intervention can be modelled in two ways. Either the impact of an intervention on risk factors used in the modelling can be estimated, and original values for relevant risk factors adjusted. Both the adjusted and unadjusted subject are them modelled and the outcomes compared.

Interventions that impact risk factors were applied with reference to an ideal value or a floor for those risk factor values. This prevents the occurrence of impossibly low risk factor values.

Also, the direct impact of an intervention on the transition probabilities for the events can be modelled. The probability of events are adjusted by the relative risk reduction for the intervention.

Medications

Medication costs can be calculated. The average medication costs for people with diabetes in Nottinghamshire were supplied. The impact of an intervention on medication consumption is used to adjust the medication costs each year.

Remission

Remission was modelled by randomly allocating subjects to a remission state according to the impacts of an intervention. Subjects in a state of remission were prevented from incurring diabetes related events, and medication costs for the subject were set to zero.

Simulations

In order to achieve stable outcome estimates it was necessary to simulate 100 thousand subjects for each intervention.

The probability of any difference between outcomes occurring by chance is calculated for each year to determine if any apparent difference is a result of the random play of chance or is a genuine effect.

Treatment definitions

The definitions of the interventions are given in the table below.

Ideal	Mean ratio	Structured education	Web based structured education	Multidisciplinary foot care teams	Bariatric surgery	Weight and exercise	Retinopathy screening
0	**FEMALE**	1	1	1	1	1	1
0	**Ethnic_Gp**	1	1	1	1	1	1
0	**AGE**	1	1	1	1	1	1
0	**AGE_DIAG**	1	1	1	1	1	1
0	**ATFIB**	1	1	1	1	1	1
6	**HbA1C**	0.955	0.85	1	0.86	0.88	1
22	**BMI**	0.984	0.925	1	0.65	0.86	1
2	**LDL**	1	1	1	1	1	1
1.9	**HDL**	1	1	1	1	1	1
115	**SBP**	1	0.99	1	1	0.99	1
120	**eGFR**	1	1	1	1	1	1
13	**HAEM**	1	1	1	1	1	1
70	**HEART_R**	1	1	1	1	1	1
0	**MALB**	1	1	1	1	1	1
0	**PVD**	1	1	1	1	1	1
0	**SMOKER**	0.932	1	1	1	1	1
3	**WBC**	1	1	1	1	1	1
0	**AMP_EVENT**	1	1	0.57	1	1	1
0	**AMP_HIST**	1	1	1	1	1	1
0	**AMP2_EVENT**	1	1	1	1	1	1
	CHF_EVENT	1	1	1	1	1	1

0	**CHF_HIST**	1	1	1	1	1	1
0	**IHD_EVENT**	1	1	1	1	1	1
0	**IHD_HIST**	1	1	1	1	1	1
0	**MI_EVENT**	1	1	1	1	1	1
0	**MI_HIST**	1	1	1	1	1	1
0	**RENAL_EVENT**	1	1	1	1	1	1
0	**RENAL_HIST**	1	1	1	1	1	1
0	**STROKE_EVENT**	1	1	1	1	1	1
0	**STROKE_HIST**	1	1	1	1	1	1
0	**BLIND_EVENT**	1	1	1	1	1	0.89
0	**BLIND_HIST**	1	1	1	1	1	1
0	**ULCER_HIST**	1	1	1	1	1	1
0	**ULCER_EVENT**	1	1	1	1	1	1
0	**REMISSION**	0	0.35	0	0.4	0.4	0
0	**MEDICATION**	1	0.65	1	0.65	1	1

Structured education

Structured education impact through the HbA1c, smoking status and BMI.

Risk factor	Source
HbA1c	DESMOND 1.49% decrease v 1.21% in controls (Davies 2007). Cluster RCT (others are observational). Uplift for 25% non-completers.[1]
BMI	Davies 2007 cluser RCT 2.98Kg loss v 1.86 Kg. 92Kg baseline. *3 for completers. Uplift for 25% non-completers[1]
Smokig status	5.1% reduction with uplift for 25% non-completers. [1]

Web-based structured education

Adjustment target	Source
HbA1c	Saslow ~15% relative reduction -1.17(1.43) Baseline 7.78% in completers.[2]
BMI	Saslow 2018 -7.45% (12.63%) change in weight in completers. [2]
Systolic BP	1.3-1.9 mmHg reduction on average. Assume average systolic 135 mmHg. ~1% reduction. [2]
Remission	From Saslow 2018[2]
Medication	Assume average taking 1.2 medicaqtions (Saslow) and 40% reduce by one medication. Assume base of metformin (100%) and linagliptin(20%). If half the linagliptin users stop, the this equates to 35% drop in medication costs. [2]

Multidisciplinary foot care teams

Adjustment target	Source
Amputation event	Diabetes UK 2017 Somerset 43% reduction (~20).[3]

Bariatric surgery

Adjustment target	Source
HbA1c	Ding et al 2015. 1.2% reduction in HbA1c from baseline ave of 8.4%. [4]
BMI	Ricci 2015 baseline 45.2, final 31.7. Ave loss 15.4 (13.5-17.1)[5]
Remission	KASHYAP 2010 - 80% intially[6], but Hallberg says only 40% by 5 years.[7]
Medication	As per web based interventions

Weight and exercise

Adjustment target	Source
HbA1c	Lean 2018 table 2 -0.9 (sd 1.4)[8]
BMI	Lean 2018 - table S3 - 86.4Kg end weight in completers (100Kg baseline). [8]
Systolic BP	Lean 2018 133 mmHg /134.3 mmHg. [8]
Remission	Lean 2018 (0.6 is a 40% reduction in diabetes. 46% reduction in DM but ~4% reduction in controls. Rounded down. [8]

Retinopathy screening

Adjustment target	Source
Blindness event	Thomas 2017 supplement.[9]

Costs

	Event	Subsequent	Source
Foot ulcers	**£ 250.75**	**£ -**	Thomas 2017 inflated to 2019.[9]
Amputation	£ 11,726.11	£ 2,201.04	Thomas 2017 inflated to 2019. [9]
Visual loss	£ 1,664.71	£ 556.06	Thomas 2017 inflated to 2019. [9]
Renal failure	£ 1,948.06	£ 1,948.06	£25046 costs of ESRD inflated to 2019 multiplied by transition probability of CKD4 to ESRD (0.067) (Sugrue 2019) - left blank for retinal screening to remove the influence of the association of blindness and nephropathy, which is an association but not causative!
MI	£ 5,587.34	£ 475.96	Thomas 2017 inflated to 2019. [9]
IHD	£ 5,425.98	£ 475.96	Thomas 2017 inflated to 2019. [9]
Stroke	£ 11,279.16	£ 3,169.22	Thomas 2017 inflated to 2019. [9]
CHF	£ 3,588.30	£ 3,588.30	Thomas 2017 inflated to 2019. [9]
Death	£ 827.71	£ -	Assume the same cost as CHD death in Thomas 2017. [9]
Medication	£ -	£ 330.00	Diabetes medication costs per head in Nottinghamshire.

Bariatric surgery	£ 6,235.00	£ -	NICE 2014 (Obesity) table 8. "Future practice" (from 2014). £24,940,000 for 4,820 procedures.[10]
Web based structured education	£ 170.00	£ 170.00	Based on DDM - £70 for the low carb app, £100 for the testing app, forum app free, Diabetes Manager app free, hypo app free (Novo-Nordisk)
Structured education	£ 313.44	£ -	£270 (Thomas 2017 supplement table 38) inflated from 2015 to 2019 at rate of 3.8% per year.[9]
Weight and exercise	£ 1,223.00	£ -	Used £1223 from Xin et al as this reflects cost of the food replacement.[10(£270 (Thomas 2017 supplement table 38) inflated from 2015 to 2019 at rate of 3.8% per year.)
Multidisciplinary foot care teams	£ 330.00	£ -	Kerr 2017 One CCG spent about £100K on the service improvement. Typically ~3,000 people with diabetes in a CCG making ~£330 per diabetic.[12]
Retinopathy screening	£ 313.00	£ 313.00	Scanlon 2015 £273 inflated from 2015 to 2019. Other estimate of £40 discarded.[13]

1. Davies, M.J., Heller, S., Skinner, T.C., Campbell, M.J., Carey, M.E., Cradock, S., Dallosso, H.M., Daly, H., Doherty, Y., Eaton, S., Fox, C., Oliver, L., Rantell, K., Rayman, G., Khunti, K., 2008. Effectiveness of the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cluster randomised controlled trial. BMJ 336, 491–495. https://doi.org/10.1136/bmj.39474.922025.BE
2. Saslow, L.R., Summers, C., Aikens, J.E., Unwin, D.J., 2018. Outcomes of a Digitally Delivered Low-Carbohydrate Type 2 Diabetes Self-Management Program: 1-Year Results of a Single-Arm Longitudinal Study. JMIR Diabetes 3, e12. https://doi.org/10.2196/diabetes.9333
3. Diabetes UK, 2017. Improving footcare for people with diabetes and saving money: an economic study in England. Diabetes UK.
4. Ding, S.-A., Simonson, D.C., Wewalka, M., Halperin, F., Foster, K., Goebel-Fabbri, A., Hamdy, O., Clancy, K., Lautz, D., Vernon, A., Goldfine, A.B., 2015. Adjustable Gastric Band Surgery or Medical Management in Patients With Type 2 Diabetes: A Randomized Clinical Trial. The Journal of Clinical Endocrinology & Metabolism 100, 2546–2556. https://doi.org/10.1210/jc.2015-1443
5. Ricci, C., Gaeta, M., Rausa, E., Asti, E., Bandera, F., Bonavina, L., 2015. Long-Term Effects of Bariatric Surgery on Type II Diabetes, Hypertension and Hyperlipidemia: A Meta-Analysis and Meta-Regression Study with 5-Year Follow-Up. Obesity Surgery 25, 397–405. https://doi.org/10.1007/s11695-014-1442-4
6. Kashyap, S.R., Gatmaitan, P., Brethauer, S., Schauer, P., 2010. Bariatric surgery for type 2 diabetes: weighing the impact for obese patients. Cleve Clin J Med 77, 468–476. https://doi.org/10.3949/ccjm.77a.09135
7. Hallberg, S.J., Gershuni, V.M., Hazbun, T.L., Athinarayanan, S.J., 2019. Reversing Type 2 Diabetes: A Narrative Review of the Evidence. Nutrients 11, 766. https://doi.org/10.3390/nu11040766
8. Lean, M.E., Leslie, W.S., Barnes, A.C., Brosnahan, N., Thom, G., McCombie, L., Peters, C., Zhyzhneuskaya, S., Al-Mrabeh, A., Hollingsworth, K.G., Rodrigues, A.M., Rehackova, L., Adamson, A.J., Sniehotta, F.F., Mathers, J.C., Ross, H.M., McIlvenna, Y., Stefanetti, R., Trenell, M., Welsh, P., Kean, S., Ford, I., McConnachie, A., Sattar, N., Taylor, R., 2018. Primary care-led weight management for remission of type 2 diabetes (DiRECT): an open-label, cluster-randomised trial. Lancet 391, 541–551. https://doi.org/10.1016/S0140-6736(17)33102-1
9. Thomas, C., Sadler, S., Breeze, P., Squires, H., Gillett, M., Brennan, A., 2017. Assessing the potential return on investment of the proposed UK NHS diabetes prevention programme in different population subgroups: an economic evaluation. BMJ Open 7, e014953. https://doi.org/10.1136/bmjopen-2016-014953
10. NICE, 2014. Costing report: Obesity Implementing the NICE guideline on obesity (CG189). National Institute for Health and Care Excellence, London.
11. Xin, Y., Davies, A., McCombie, L., Briggs, A., Messow, C.-M., Grieve, E., Leslie, W.S., Taylor, R., Lean, M.E.J., 2019. Within-trial cost and 1-year cost-effectiveness of the DiRECT/Counterweight-Plus weight-management programme to achieve remission of type 2 diabetes. Lancet Diabetes Endocrinol 7, 169–172. https://doi.org/10.1016/S2213-8587(18)30346-2
12. Kerr, M., 2017. DIABETIC FOOT CARE IN ENGLAND: AN ECONOMIC STUDY. Insight Health Economics, Diabetes UK.

13. Scanlon, P.H., Aldington, S.J., Leal, J., Luengo-Fernandez, R., Oke, J., Sivaprasad, S., Gazis, A., Stratton, I.M., 2015. Development of a cost-effectiveness model for optimisation of the screening interval in diabetic retinopathy screening. Health Technology Assessment 19, 1–116. https://doi.org/10.3310/hta19740