ScotPHN report

Updating the Scottish Needs Assessment Programme Report on Type 2 Diabetes: Screening and Prevention

Part B: Research review for Scottish Public Health Network – Screening for and prevention of type 2 diabetes

Produced by Department of Public Health, University of Aberdeen

Authors:

Norman Waugh, Professor of Public Health

Andrew Millard, Researcher, ScotPHN

Lynn Robertson, Research Assistant

Pamela Royle, Research Fellow

CONTENTS	PAGE
SUMMARY AND RECOMMENDATIONS	**4**
CHAPTER 1 BACKGROUND AND AIMS	**6**
CHAPTER 2 INTRODUCTION	**8**
DEFINITIONS	8
PREVALENCE	9
CHAPTER 3 SCREENING	**14**
DECISION POINT	18
SCREENING STRATEGIES	18
RECOMMENDATION	28
CHAPTER 4 PREVENTION OF TYPE 2 DIABETES IN PEOPLE WITH IGT	**29**
COST-EFFECTIVENESS	30
RECOMMENDATION	31
CHAPTER 5 CURRENT SERVICES SURVEY: COMPARATIVE DATA FROM HEALTH BOARDS	**32**
1.0 AIM	32
2.0 METHODS	32
3.0 RESULT	33
CHAPTER 6 TREATMENT FOR PEOPLE WITH TYPE 2 DIABETES	**43**
CURRENT TREATMENT	43
RECOMMENDATIONS	44
CHAPTER 7 DISCUSSION AND RESEARCH NEEDS	**46**
REFERENCES	**47**
Appendix 1 Does screening for type 2 diabetes and IGT meet the criteria of the National Screening Committee?	**54**
Appendix 2 The IMAGE Report	**59**

List of Tables and Figures

Tables	Page
Table 1 Success scores and hazard ratios for diabetes in the Diabetes Prevention Study	**9**
Table 2 Obesity amongst Scottish adults: % with BMI over 30, ages 16 to 64	**13**
Table 3 Overweight and obesity in children: age range 2-15 based on BMI centiles 2003	**13**
Table 4 Endpoints in the overweight UKPDS group – controls only (N=411)	**15**
Table 5 Relative risks of mortality in IFG and IGT compared to people with normal levels	**16**
Table 6 EPIC study – relative risks by bands of HbA_{1c}	**17**
Table 7 NHANES – relative risks of PVD by bands of glycated haemoglobin	**18**
Table 8 Organised Screening for Diabetes	**36**
Table 9 Any screening for IGT	**38**
Table 10 Methods for prevention of diabetes	**39**
Table 11 Methods for secondary prevention of diabetes in those with IGT/IFG	**42**
Figures	
Figure 1 Prevalence of type 2 diabetes (GRO population)	**11**
Figure 2 Estimate of future prevalence of diabetes in Highland region	**11**
Figure 3 Increases in the consultation rate for diabetes in general practice from Continuous Morbidity Recording data – Highland region	**12**
Figure 4 Age-adjusted incidence rates of diabetes as a function of baseline BMI in 30-55 year olds (both sexes)	**13**

Summary and implication of the research review

- The prevalence of type 2 diabetes has been increasing in Scotland, due to increases in overweight and obesity, and decreasing levels of physical activity, as well as the changing demographic structure of the population.
- People can have type 2 diabetes, and be coming to harm because of it, without it being diagnosed. This may apply to perhaps 20% of cases – over 30,000 people - in Scotland. They may have diabetic complications such as eye disease by the time they are diagnosed, or may suffer a heart attack, without any warning.
- Population screening for type 2 diabetes could detect many of these people.
- In addition to diabetes, the condition of impaired glucose tolerance (IGT), where blood glucose levels are higher than normal but not yet at diabetic level, is of public health importance. This is because the risk of cardiovascular disease is almost doubled in people with IGT compared to people with normal glucose tolerance (NGT), and because many people with IGT will go on to develop diabetes. IGT causes no symptoms.
- In terms of absolute numbers of heart attacks, IGT is a greater problem than diabetes, because although the risk of heart disease is somewhat higher in diabetes, there are far more people with IGT than with undiagnosed diabetes.
- Depending on which screening strategy was used, and what cut-off levels were used, population screening for type 2 diabetes would find more, or far more, people with IGT than with diabetes.
- Screening of the whole population is not justified. Hence the first stage in screening would be identification of people at high risk by data held on general practice computer systems. Those at high risk would then have a blood glucose test. Risk would be based on age, BMI, and the presence of other metabolic conditions, such as hypertension.
- Second stage. There is no perfect screening test for diabetes, but there is increasing data to support the use of $HbA_{1c,}$ which is logistically easier to use than fasting blood glucose or oral glucose tolerance tests.
- An HbA_{1c} of 6.5% or over indicates diabetes, but needs to be confirmed by a second test, such as a second HbA_{1c} or a fasting PG
- HbA_{1c} of 6.0% or over, but under 6.5%, is associated with a high risk of progression to diabetes, and such people should be followed up with annual testing.

- The use of HbA_{1c} alone remains somewhat controversial, and so it should be recommended that the third stage should meantime involve both HbA_{1c} and FPG. The added value of FPG can be reviewed in the light of experience.
- Hence we recommend screening in three stages: first by risk factors; then by testing with HbA_{1c}; and then for those with levels over 6.0%, repeat HbA_{1c} and FPG.
- Those found to have undiagnosed diabetes would be advised to lose weight and increase physical activity. They might also be treated for higher than desirable blood cholesterol and blood pressure. Some patients might need glucose lowering drug treatment soon after diagnosis. Metformin is the drug of first choice on grounds of safety, efficacy and cost.
- Those found to have IGT would receive similar advice, aimed at reduction of cardiovascular risk, but also at reducing progression to diabetes. This should include a period of intensive lifestyle education on diet and physical activity. Weight loss is the main key to success.
- The main problem is that we know what people should do to prevent diabetes, but not how to persuade them to do it.
- A recent cost effectiveness analysis reported that a policy of rapidly (by one year) moving those with impaired glucose tolerance who do not adhere to lifestyle intervention on to metformin therapy is cost effective in preventing diabetes.
- Those with IGT should be monitored, probably annually, for progression to diabetes.
- For the prevention of diabetes, a combined approach of the medical model (screening, detection and treatment of individual people with lifestyle intervention) and the public health model (changing the behaviour and risks of the population by public health measures, such as promoting health eating and physical activity, and hence weight control) is required.
- At present within Scotland there is little systematic screening for diabetes. Most screening activity for diabetes appears to be ad hoc or as part of programmes, such as the Keep Well programme, that targets specific but small sections of the population.

Chapter 1 Background and aims

At the present time in Scotland there is no systematic screening programme for diabetes. The UK National Screening Committee (NSC) has reviewed its policy on screening for type 2 diabetes at intervals. The last review was in July 2006.[1] That review considered a Health Technology Assessment Report that included a comprehensive literature review and economic modelling pertaining to screening.[2] The HTA report found that the case for screening for undiagnosed diabetes and for impaired glucose tolerance, while still not meeting all the criteria of the UK National Screening Committee, is becoming stronger because of greater options for the reduction of cardiovascular disease and because of the rising prevalence of obesity, and hence of type 2 diabetes.

In 2008, the NSC recommended the introduction of a Vascular Risk Management Programme in which *"the whole population would be offered a risk assessment that could include, among other risk factors, measurement of blood pressure, cholesterol and glucose."* The NSC concluded that: *"targeted screening for T2DM was feasible but should be undertaken as part of an integrated programme to detect and manage vascular risk factors in certain subgroups of the population who are at high risk of T2DM."* [3]. This policy acknowledges that the relationship between glycaemia and cardiovascular disease (CVD) is a continuous one, and therefore the detection of IFG and IGT, in addition to the detection of diabetes, is an important component of CVD prevention.

The Scottish Diabetes Group therefore asked the Scottish PHN to address current public health issues in type 2 diabetes, including screening for undiagnosed diabetes. This is the subject of Chapter 3.

If we screen for diabetes, we will, depending on the screening strategy used and cut-offs chosen, identify more people with lesser degrees of hyperglycaemia, such IGT, than with type 2 diabetes. Before a screening programme is started, we should therefore consider how best to manage such people. Chapter 4 considers how to prevent or reduce progression to diabetes amongst people with IGT.

Consideration of the treatment of diagnosed type 2 diabetes is outwith the remit of this report but is covered by SIGN 116.[4] In Chapter 6, we provide a brief summary of current issues, and refer readers to other sources of information.

This report does not address prevention of obesity, which is the subject of another ScotPHN review. We have not reviewed the evidence from scratch, but have relied mainly on two HTA reports, produced for the Department of Health (England) and the National Screening Committee by the Aberdeen Health Technology Assessment Group. The first of these was on screening for type 2 diabetes [2] and the second was on prevention of diabetes in people with IGT (HTA monograph, in preparation). The Aberdeen HTA group has reviewed studies published since these reports were done, to update the evidence base. Any new evidence is highlighted in this report.

Chapter 2 Introduction

Definitions

The only constant feature of diabetes is a raised blood glucose level. There may or may not be any of the classical symptoms, such as the passing of larger volumes of urine, and thirst. Many people with type 2 have no symptoms when diagnosed. The key feature of the classification is that the diagnosis of diabetes was based on the level at which the risk of retinopathy started. At the risk of a little over-simplification, people with glucose levels below the threshold did not get retinopathy; those with levels above the threshold were at risk of retinopathy, with the risk increasing as glucose levels rose further. This was based on three studies, described in the report of the ADA's expert committee.[5]

Most people with diabetes die from heart disease. However, the risk of that increases at lower levels of hyperglycaemia than diabetes. So for public health purposes, we should perhaps supplement the definition of diabetes by also defining cardiovascular risk.

There are two main types of diabetes:

1) Type 1 diabetes, formerly known as insulin-dependent diabetes, is not addressed in this report. It has been being considered by the Short Life Working Group on Type 1 Diabetes, set up by the Scottish Diabetes Group.

2) Type 2 diabetes has been mainly a disease of older people, usually associated with overweight or obesity. About 90% of people who develop type 2 diabetes are overweight or obese. Physical inactivity also plays a part. There is often a strong family history.[6]

A recent study examined the incidence of type 2 diabetes and concluded that about 90% could be avoided by adherence to five lifestyle factors:

- physical activity
- a healthy diet
- body mass index (BMI) under 25kg/m2
- not smoking
- moderate alcohol consumption

That study [7] was in people over 65 years of age, but similar findings have been seen in all age groups. Similar findings were reported from the Finnish Diabetes Prevention Study.[8] Participants were divided into six groups according to how many lifestyle goals were achieved, so that group 5 achieved all and group 0 none.

Table 1 shows the incidence of diabetes for each group, expressed as a ratio to group 0.

Table 1 Success scores and hazard ratios for diabetes in the Diabetes Prevention Study

Success score	Hazard ratios
0	1.00
1	0.85 (0.57-1.28)
2	0.66 (0.40-1.09)
3	0.69 (0.38-1.26)
4-5	0.23 (0.10-0.52)
test for trend p=0·0004	

There are two conditions in which blood glucose is above normal but below the diabetes range:

- those with fasting glucose above the upper limit of normal (6.1 mmol/l) but below 7.0 mmol/l; this group is said to have impaired fasting glucose (IFG). This is the European definition. In the USA the cut-off for IFG is 5.5 mmol/l. The European definition omits a group with FPG above normal (up to 5.4 mmol/l) but below 6.0.
- those with the post-load level above 7.8 mmol/l but under 11.1; this group is described as having impaired glucose tolerance (IGT).

These conditions are often referred to as “pre-diabetes” but this term is somewhat misleading because under half go on to get diabetes. However those with IGT are at considerably increased risk of vascular disease compared to people with normal glucose tolerance.

Prevalence

The increase in reported prevalence of type 2 diabetes depends on a number of factors, including:

- an increase in the incidence of type 2 diabetes, related to rising levels of overweight and obesity: Data from the Framingham study show that almost all the US increase in diabetes prevalence is in the obese category[6]

- demographic change – half of all people with diabetes are over 65 years of age, so an increase in the number of people over that age will increase the prevalence of diabetes
- a fall in the age of onset of type 2 diabetes – people getting it earlier in life, probably because of earlier weight gain and reduced physical activity compared to previous generations[9]
- changes in the definition of diabetes, with the diagnosis made at a lower level of fasting plasma glucose
- better survival with diabetes because of improved control of blood glucose, blood pressure and cholesterol level
- more complete recording of diabetes on GP computer systems
- better detection of undiagnosed diabetes by opportunistic case-finding or practice-based screening, linked with greater public awareness of diabetes. (But not in Scotland, by organised population screening – see Chapter 5).

A particular concern is that the age of onset of type 2 diabetes may be falling. This could increase the prevalence of the long-term complications of diabetes, such as renal disease. It takes about 20 years duration of diabetes before renal disease starts to cause significant incidence of renal failure, and in the past when onset was later in life, people with type 2 diabetes died of other causes before they could develop end-stage renal failure.

Figure 1 shows the prevalence of type 2 diabetes as identified on the Scottish Care Information – Diabetes Collaboration population based register in May 2008, by age band and sex.

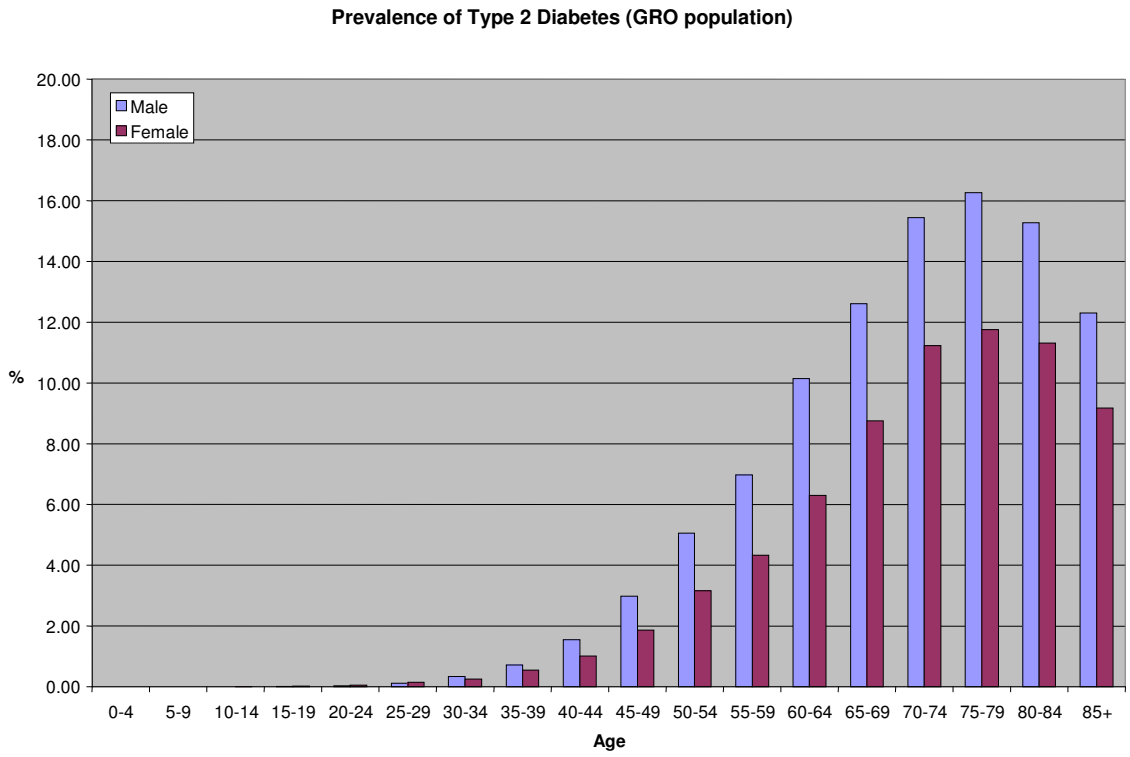


Figure 1 Prevalence of type 2 diabetes (GRO population)
(Source: Scottish Diabetes Research Network epidemiology group)

A project to estimate the future number of people with diabetes in the Highland Region (G Cramp, Public Health, NHS Highland, unpublished) considered the effect on future prevalence if the prevalence of obesity continued to rise. As shown in Table 2 below, if that is the case, the rise in the prevalence of diabetes will accelerate.

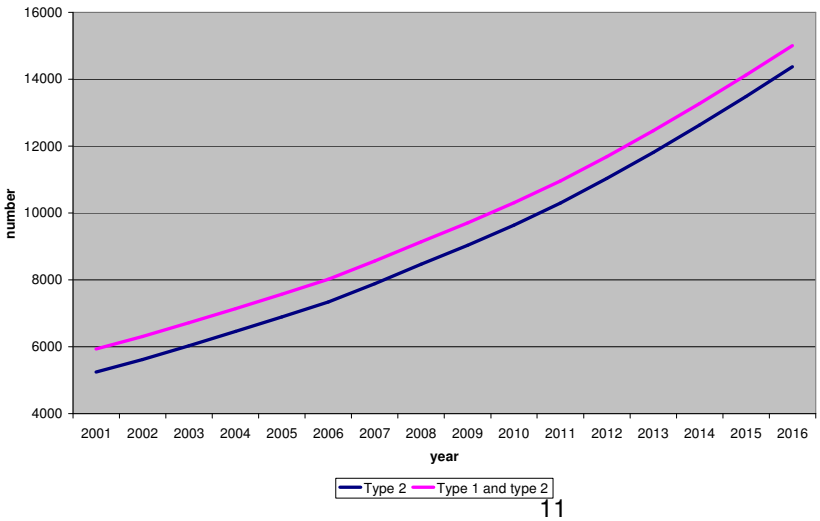


Figure 2 Estimate of future prevalence of diabetes in Highland region

Hence it is quite probable that the prevalence of type 2 diabetes will rise by 50% over the next 10 years. This would mean about another 100,000 diabetic people in Scotland.

Figure 3, also from the Highland study, shows increases in the consultation rate for diabetes in general practice from Continuous Morbidity Recording data. The number of consultations per 1000 practice population has increased from 24 to 39 over five years, an increase of over 62%. This is likely to be an underestimate of activity in primary care, as people with diabetes will often see the practice nurse rather than the general practitioner. The rise is greater than expected from the rise in prevalence alone, but probably reflects other factors, such as measures to improve glycaemic control, earlier introduction of insulin treatment and intensified treatment of hypertension and dyslipidaemia.

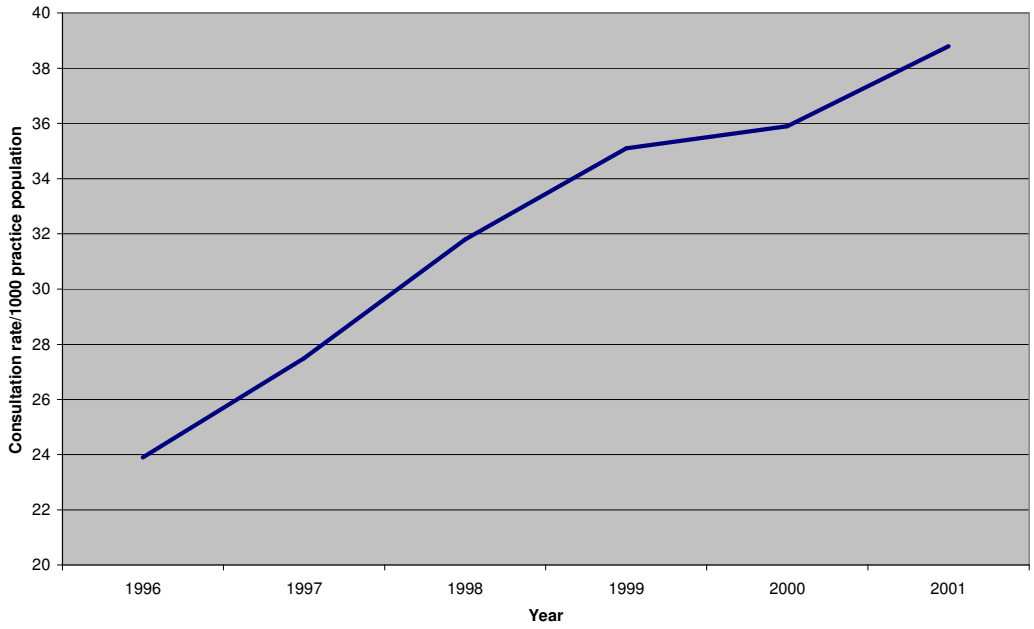


Figure 3 Increases in the consultation rate for diabetes in general practice from Continuous Morbidity Recording data – Highland region

Similar findings were reported by ISD, based on the Practice Team Information data, with a rise of about a third in the numbers of people consulting a GP or practice nurse, from an estimate of 150,673 in 2003/4 to 199,747 in 2007/8.

The prevalence of type 2 diabetes is closely linked with that of overweight. The proportion of the population which is overweight or obese (BMI 30 or over) has been increasing in recent years.

Table 2 shows that the prevalence of obesity has been rising in Scotland.

Table 2 Obesity amongst Scottish adults: % with BMI over 30, ages 16 to 64

	1995	1998	2003
Men	16%	19%	22%
Women	17%	21%	24%

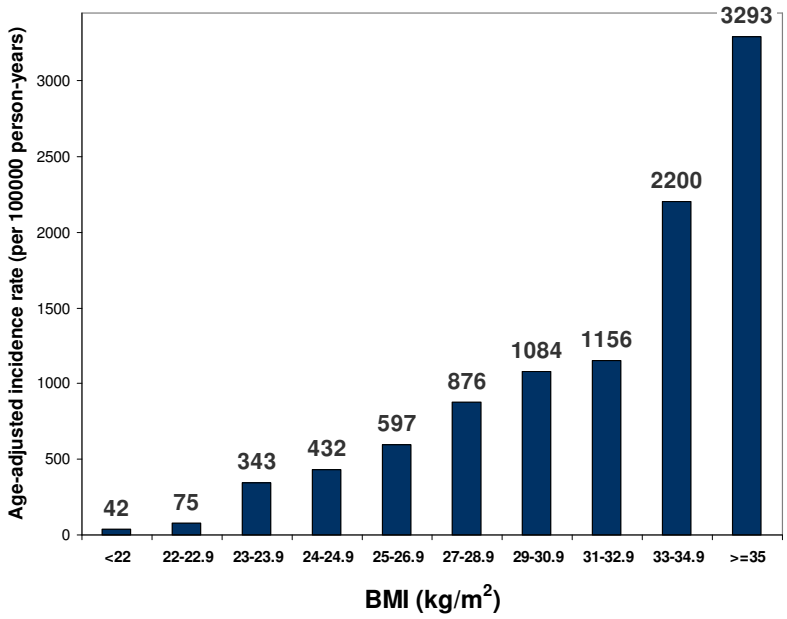
Similar trends are seen in children.

Table 3 Overweight and obesity in children: age range 2-15 based on BMI centiles 2003

	Boys	Girls
Overweight	16.7	16.1
Obese	18.0	13.8
Both	34.7	29.9

The importance of body mass index in the incidence of type 2 diabetes is shown in the following graph. There is a close relationship between BMI and the incidence of type 2 diabetes, and it is worth noting that it starts well below the obesity range.

Figure 4 Age-adjusted incidence rates of diabetes as a function of baseline BMI in 30-55 year olds (both sexes) – (based on data from Ford 1997[10])



Chapter 3 Screening

This chapter is based mainly on a Health Technology Assessment Report.[2]

It is known that a proportion of people with type 2 diabetes are undiagnosed. In the age group 52-79, the English Longitudinal Study of Ageing (ELSA)[11] in 2004/5 found that almost 20% of those with diabetes were undiagnosed, with a higher percentage in men (22%) than women (12%). The overall prevalence was 9.1%, with 1.7% undiagnosed. Predictors of undiagnosed diabetes included BMI, waist circumference, systolic blood pressure and triglycerides. Diagnosis was based on a single FPG≥7.0 mmol/l and would therefore miss those whose diabetes is manifested mainly by post-prandial hyperglycaemia.

The authors of the ELSA study note that the proportion undiagnosed has fallen, and attribute this to increased opportunistic screening in general practice.

The results from the pilot screening programme in England support this, with an overall prevalence of 4.08%, including 0.54% undiagnosed though uptake of screening was only 61%.[12]

Blood glucose levels can rise to diabetic levels with few or no symptoms. Sometimes, by the time people are diagnosed with diabetes, they have developed complications such as retinopathy, due to an effect of diabetes on small blood vessels (microvascular disease). However the main risk to health in undiagnosed type 2 diabetes is an increased risk of cardiovascular disease, in particular ischaemic heart disease (IHD), because of damage to the arteries (macrovascular disease). Early detection of diabetes would lead to measures to reduce the risk of heart disease, such as the use of statins to lower cholesterol, and treatment to reduce blood pressure, as well as reduction of blood glucose levels, initially by diet and exercise, and supplemented with hypoglycaemic drugs if necessary.

In the ADDITION-Cambridge study, high proportions of people with screen-detected diabetes had risk factors for cardiovascular disease.[13] Almost all were overweight or obese (mean BMI was 32.5); 86% had hypertension, 75% had dyslipidaemia, and many of those with hypertension and dyslipidaemia were not well controlled. Hence, those detected by screening form a group in which CVD risk can be reduced by combined treatment.

Microvascular disease, such as retinopathy, is specific to diabetes. However, the macrovascular disease seen in diabetes is broadly the same disease as seen in people

without diabetes. The difference in diabetes is an increased risk, and a more diffuse distribution of arterial disease. The distribution means that diabetic people with heart disease are more likely to need coronary artery bypass grafting than angioplasty, compared with those without diabetes, who require coronary revascularisation. They are also more likely to die after a heart attack than people without diabetes.

An important issue when considering whether there should be screening for diabetes is that unlike with retinopathy, the increase in cardiovascular risk starts below the level of blood glucose used to define diabetes. So, if reduction of heart disease is one of the aims of screening, then we should consider screening not just for diabetes, but for IGT as well. The risk of cardiovascular disease in IGT is slightly less than with type 2 diabetes, but the number of people with IGT is much higher than those with undiagnosed diabetes, and so the cardiovascular population impact of IGT is much greater than of undiagnosed diabetes.

The importance of large vessel disease can be seen in the endpoints reported in the UK Prospective Diabetes Study (UKPDS).[14] The majority of adverse events were due to large vessel disease.

If we are considering screening based on risk factors (see below), then those in the UKPDS who were overweight (defined as more than 120% ideal body weight for height) may be more similar to those who would be found by screening. Table 4 shows the numbers of end-points in the control group.[15] They are dominated by large vessel disease.

Table 4 Endpoints in the overweight UKPDS group – controls only (N=411)

Endpoint	Number
Macrovascular	
All IHD (MI, heart failure, angina)	121
Stroke	25
PVD	11
Microvascular	
renal failure	3
blind in one eye	13
vitreous haemorrhage	3
Photocoagulation	36
all macrovascular	157
all microvascular	52

The risks of cardiovascular disease in those with IFG and IGT have been reported to be higher than in people with normal glucose levels. Table 5 shows results from the DECODE meta-analysis.

Table 5 Relative risks of mortality in IFG and IGT compared to people with normal levels

Fasting and 2-hour glucose levels both normal	1.0
IFG - raised FPG but 2-h normal	1.18 (0.99 to 1.42)
IGT alone – raised 2-h but normal fasting	1.56 (1.33 to 1.83)

(Source: Balkau 2004[16])

Hence IFG alone, without IGT, is associated with a slight increase in mortality (though confidence intervals overlap with no increase), but IGT carries more risk, possibly as a consequence of stronger associations with hypertension and dyslipidaemia than for IFG.
Similar findings were reported from a meta-analysis by Coutinho and colleagues of 20 studies examining cardiovascular mortality (19 studies) or morbidity (4 studies).[17] A fasting glucose level of 6.1 mmol/l carried 1.3 times the risk of the reference one of 4.2 mmol/l; a 2-hour glucose of 7.8 mmol/l carried a relative risk of 1.6 compared to a 2-hour level of 4.2 mmol/l.

A very large (698,782 people) study also found that IFG had little effect on cardiovascular risk, with relative risks of 1.11 for the 5.6 to <6.0 mmol/l range and 1.17 for the 6.0 to 6.9 mmol/l range.[18]

More recent work has suggested that the excess risk from IGT is lower than previously thought. A meta-analysis by Sarwar and colleagues reported a relative risk of 1.05 for every 1 mmol/l increase in post-load glucose.[19] They found a stronger link between HbA_{1c} and coronary heart disease, with a relative risk (RR) of 1.2 for every 1% rise in HbA_{1c}.

The meta-analysis included early data from the AusDiab study, but at a time when there were only 31 CHD cases. A later paper from AusDiab reported a linear relationship between HbA_{1c} and CHD mortality, with the risk at HbA_{1c} 6% being double that at 4.5%.[20] Not included in the meta-analysis was the Edinburgh artery study, where isolated post-load hyperglycaemia conferred little increase in cardiovascular risk.[21]

The Hoorn study from the Netherlands found the reverse – post-load hyperglycaemia in the IGT range was associated with an RR of 1.48, but the number of events was small and the 95% CI was 0.7 to 3.2.[22] FPG in the IFG range was associated with a RR of 1.4, but after adjustment for hypertension and lipids etc, the RR was reduced to 1.07 (the same adjustment reduced the IGT RR from 1.9 to 1.48).

In the Rancho Bernardo study, the risk of cardiovascular mortality was increased in women with isolated post-challenge hyperglycaemia (age adjusted hazard ratio (HR) 2.6 and 95% confidence intervals 1.5-4.8), but not in men (HR 0.7, 95% CI 0.3-1.6).[23] The point estimates for Edinburgh Artery Study participants were similar with odds ratios for cardiovascular mortality of 2.7 (0.6-11.6) for women and 0.8 (0.09-6.7) for men.[21] However a Paris study found that the heart disease mortality rate in men with normal fasting glucose but IGT was three times that of those with normal glucose tolerance.[24] IGT is common – it affects 17% of Britons aged 40-65 years.[25]

Unlike with retinopathy, there is no sudden inflexion in the risk curve for cardiovascular disease according to blood glucose levels, but rather a continuum of risk. Indeed, even within what is regarded as being the normal range, higher blood glucose levels have higher IHD rates. In the EPIC study in Norfolk, the relationship between HbA_{1c} and cardiovascular risk started well within the non-diabetic range.[26,27]

Table 6 EPIC study – relative risks by bands of HbA_{1c}

HbA_{1c}	relative risk of cardiovascular disease	
<5%	men 1.0	women 1.0
5-5.4%	1.23	0.89
5.5-5.9%	1.56	0.98
6.0-6.4%	1.79	1.63
6.5-6.9 %	3.03	2.37
> 7% (newly diagnosed diabetes)	5.01	7.96
prior diabetes	3.32	3.36

The same applies to peripheral vascular disease. Muntner and colleagues[28] report data from the 1999-2002 NHANES survey. The figures below are after multivariate adjustment. Peripheral vascular disease was defined as an ankle/brachial blood pressure ratio under 0.9.

Table 7 NHANES – relative risks of PVD by bands of glycated haemoglobin

Glycated Hb	Relative risk of peripheral arterial disease
< 5.3%	1.0
5.3- 5.4	1.41
5.5-5.6	1.39
5.7- 6.0	1.57

However, confidence intervals were wide and only the last figure had a 95% CI which did not overlap with 1.0.

Decision point

Hence, if one aim of screening is to reduce heart disease, we should look not only for diabetes, but also for non-diabetic hyperglycaemia (NDH). Even if we did look only for diabetes, we would identify many with NDH.

The aims of treatment might be:

1. For those with definite diabetes, reduction of the risk of retinopathy and nephropathy, by reduction of plasma glucose to normal, initially trying diet and exercise, but using drug therapy when indicated.

2. For those with plasma glucose levels in the IFG and IGT ranges, prevention of progression to diabetes, by diet and exercise, or by drug therapy if indicated.

3. For all of the above, measures to reduce cardiovascular risk, by measures other than the glucose control ones already mentioned, such as qualitative improvements in diet, aspirin, cholesterol-lowering measures (such as statins), blood pressure control, and anti-obesity measures.

It also has large implications for workload and costs. There may be about 0.5 to 1% of the population with undiagnosed diabetes, but there may be 10% with IGT. Before any screening was started, there would need to be careful planning of workload, involved in both screening and follow-up. Screening might be introduced in a phased manner in order to avoid overload.

Screening strategies

Organised screening would be a three-stage process (see HTA report on screening for rationale), with the first stage being selection from the general population (using general

practice registers) of those likely to be more at risk than average, the second being testing of blood glucose levels, and the third being confirmation of raised blood glucose level.

Testing only people who are at higher than average risk means that a higher proportion of those who will be tested for glucose will be positive; the number needed to screen to detect each true positive will be lower, and the whole programme will be more cost-effective.

Risk factors.

1. Age is always a key factor, because the risk of type 2 diabetes increases steeply with age. The cost-effectiveness of screening will be lower at younger ages since the number needed to be screened to find each case will increase, and also because the event rate from cardiovascular disease will be lower.

However, although the prevalence of diabetes is greater in the older age groups, the excess mortality may fall. Tan and colleagues found that in men diagnosed with type 2 diabetes over the age of 65 in Tayside, there was no excess mortality compared to the general population.[29] The situation in women was different, with a relative risk of death of 1.29 (1.15-1.45). The implication of this might be that if the main aim of screening is to reduce heart disease mortality and morbidity, screening for diabetes in men should not include the over 65s. However if the aim is to detect undiagnosed diabetes, we should screen older age groups – perhaps to age 75.

The age at which screening should start has been debated. Kahn and colleagues modelled a range of screening strategies based on a US population, starting at ages 30, 45 and 60, or at diagnosis of hypertension, and found that the lowest costs per QALY were obtained by starting at age 45 or at diagnosis of hypertension, and screening at 3-or 5-yearly intervals.[30]

In practice, the age at which screening will start in Scotland will be determined by the Government's decision on vascular screening.

2. Body mass index is the second factor. It reflects overweight and obesity. The risk of type 2 diabetes is greatly increased by excess weight. But there is also a link with the distribution of body fat, with abdominal (especially visceral) fat distribution carrying a higher risk. Waist measurement could be used as a risk factor – for example more than 40 inches in men or 35 in women. However, waist data are unlikely to be held on GP computer systems.

3. Co-morbidities. The risk of diabetes is associated with other aspects of the metabolic syndrome such as hypertension and hyperlipidaemia, and with the presence of vascular disease, such as peripheral vascular disease or ischaemic heart disease. There will be data on co-morbidities on GP systems, even if just the fact of prescriptions for anti-hypertensive or lipid-lowering drugs or steroids.

4. Family history of diabetes, or of premature vascular disease or hypertension.

5. Ethnicity is also a predictor, in that some ethnic groups have a higher risk of type 2 diabetes than others, though this is less if adjustments are made for BMI and fat distribution. In the Manchester survey the prevalence of known diabetes in a poor inner city area was 8% and 3.7% in European men and women, and 14% and 18.2% in Pakistani men and women.[31] The Pakistani women had higher BMI than the Europeans – 29.6 vs 27.2 kg/m2 – and a higher waist/hip ratio – 0.88 vs 0.81. Pakistani and European men had similar BMIs (27.4 and 27.5 kg/m2) but the Pakistani waist/hip ratio was higher (0.96 vs 0.92; CIs 0.94 0.097 and 0.92-0.94). However, the most striking differences were in physical activity. The proportions taking at least 20 minutes of exercise three times a week were 38% and 29% for European men and women and 7% and 5% for Pakistani men and women. Physical activity reduces insulin resistance even if there is little or no weight loss.

There are various scoring systems for risk. The Finnish one, FINDRISC includes age, BMI, waist measurement, physical activity, diet (vegetable, fruit and berry consumption), treatment for hypertension, any previous hyperglycaemia and family history.[32] This requires people to complete a questionnaire. It would be easier if we could use a smaller set of indicators, and there would be little difference in predictive power since age and BMI provide most of that.[33]

One advantage of using a smaller set of risk indicators is that computer systems in general practices will usually have the necessary data – certainly age, drug treatment, co-morbidities and usually BMI. They are less likely to have family history, and probably will not have waist measurements. But it means that the first stage of any screening system could use existing data at little extra cost.

One scoring system which uses data which should be available on GP systems was developed by Hippisley-Cox and colleagues.[34] It comprises ethnicity, age, sex, BMI, smoking, family history of diabetes, Townsend deprivation score, treated hypertension, cardiovascular disease and current use of corticosteroids. It was developed using the

QResearch database and is known as the QDScore. The authors report ROC statistics of 0.85 for women and 0.83 for men for detection of diabetes

Other scoring systems include the Cambridge Risk Score (CRS), again based on data available in GP systems.[35] Those in the highest quintile of the CRS had 22 times the risk of diabetes as those in the lowest quintile, and 54% of incident cases were in the top quintile.[33]

BMI is probably the single most powerful factor, and other factors may add much less to the detection rate. A review of risk scores by Witte and colleagues for predicting undiagnosed diabetes found that a combination of age and BMI was as good as more complex scores.[36] However if all the data are on GP systems, then they may as well be used. The Townsend score is highly correlated with the Carstairs score, since only one of the four variables is different.

One issue has been raised by Griffin and colleagues and the Dutch Hoorn group. Griffin et al wondered about the dangers of reassurance in those who have high risk scores, but who do not have hyperglycaemia – will they feel they are able to persist with unhealthy lifestyles? [35] And in the Hoorn study, Spijkerman and colleagues found that the group with high risk scores, but who did not have diabetes on glucose testing, had a CVD risk almost as high as those who were glycaemia positive.[37] And since there were more of the risk-positive but glucose–negatives, they had more cardiac events, leading the authors to comment that;

> *"It may be of greater public health benefit to intervene in the screen positive group as a whole rather than only in the relatively small group who on subsequent biochemical testing have an increased glucose concentration."* [37]

However a recent study by Paddison, Griffin and colleagues from the Cambridge MRC group found that people with negative diabetes screening tests were not so reassured that they would have an adverse shift in health behaviours.[38]

In the EPIC-Norfolk study, adding a measure of hyperglycaemia, in this case HbA_{1c}, to the Framingham risk score, added little to the predictive value for coronary heart disease.[39] That might imply that glucose testing would not be necessary. However, their focus was on cardiovascular disease, and detection of diabetes would also lead to reduction of microvascular events, for example by screening for retinopathy.

The tests for blood glucose include:

- casual (non-fasting) blood glucose
- fasting plasma or blood glucose
- glucose tolerance tests, combining fasting and 2 hour levels (OGTT)
- the 50-g glucose challenge test, which has been used mainly for screening for gestational diabetes
- glycated haemoglobin (HbA_{1c}), which reflects blood glucose over the previous three months (assuming red blood cells of normal longevity, and in the absence of haemoglobin variants)

Casual blood glucose is usually discounted because of its variability and poor sensitivity (at levels which give acceptable specificity).[40]

The OGTT is expensive and inconvenient (and sometimes unpleasant) and has poor reproducibility.

The choice of test depends on what we are screening for. Fasting PG is reliable, in the sense of showing less day to day variability than OGTTs, and will identify people with diabetes and IFG. However it will miss those with IGT, who have a higher IHD risk than those with IFG.

HbA_{1c}

The ADA Expert Committee (2003) on the diagnosis and classification of diabetes mellitus summarised the advantages and disadvantages of HbA_{1c} for the diagnosis of diabetes.[41] The Committee listed the advantages as:

- HbA_{1c} measures average glycaemic levels over a period of 10 weeks or so, and is therefore more stable than FPG, and especially than 2-h GTT
- fasting is not required, and the test can be done at any time of day
- the precision of HbA_{1c} can be as good as that of PG
- HbA_{1c} is the test used for monitoring control of diabetes and correlates well with the microvascular complications; it may be useful to use the same test for diagnosis and monitoring
- it has been shown by meta-analysis that when using a statistical cut-point of 2 SDs above the non-diabetic mean value, HbA_{1c} is as good as FPG and 2-h PG in terms of sensitivity (66%) and specificity (98%).

The disadvantages were identified as:

- internationally, there had been a profusion of assay methods and reference ranges. However this can be overcome by standardisation to DCCT assay
- HbA_{1c} may be affected by other conditions which affect the life of the red blood cell; results may then be misleading. This could be a particular problems in ethnic groups in which haemoglobinopathy is common
- a chemical preparation for uniform calibration standards had only recently become available and was not universally available.

However, with the exception of the other conditions, these disadvantages need not apply in a national screening system which would include quality control measures. There is therefore a case for using HbA_{1c} as the screening test, particularly in view of its correlation with cardiovascular risk across a wide spectrum. As mentioned above, Khaw and colleagues noted that the rise in cardiovascular events with rising HbA_{1c} starts well below the diabetic range.[27] Indeed they point out that when both diabetes and HbA_{1c} are included in the statistical analysis, HbA_{1c} dominates; as Gerstein argues in an editorial;[42]

> "*the glycosylated hemoglobin level is an independent progressive risk factor for cardiovascular events, regardless of diabetes status".*

The glucose levels for the diagnosis of diabetes were based on the relationship between plasma glucose and retinopathy. Recently, a similar study has examined the relationship between HbA_{1c} and retinopathy.[43] Using the presence of moderate retinopathy as the indicator of diabetes, a diagnostic threshold of 6.1% could be used (the authors suggest 6.6%).

The ADA position statement in January 2010 recommended at cut-off of 6.5% for diagnosing diabetes, based on retinopathy risk.[44] They recommended a cut-off of 5.7%, and hence a range of 5.7 to <6.5%, for identifying those at high risk of diabetes. The arguments in favour of the 5.7% cut-off were that:

- the 6.0 to <6.5% range misses a lot of patients who have IFG or IGT and who are at increased risk of diabetes. They cite studies which report that people in the 5.5 to <6.0% range have a 5-year incidence of diabetes of 12 to 25%
- that unpublished NHANES data show that an HbA_{1c} corresponds to an FPG of 6.1 mmol/l (i.e. IFG)

- that other unpublished NHANES data show that an HbA_{1c} cut-off of 5.7% has modest sensitivity (about 40%) but good specificity (81-91%) for IFG and IGT
- that other unpublished analyses indicate that an HbA_{1c} of 5.7% is associated with a similar risk of diabetes to the high-risk group in the Diabetes Prevention Program.

As always, there is a trade-off between sensitivity and specificity. If we used a low cut-off of HbA_{1c} of 5.5%, there would be more false positives. However, they are at higher risk of cardiovascular disease than the rest of the population, and would benefit from lifestyle measures. The only harm might be from the labeling as "pre-diabetic".

Skriver and colleagues from the Danish arm of the ADDITION Trial, have provided data on the specificity of HbA_{1c}.[45] A high risk group (identified by questionnaire and then by a second stage casual BG or HbA_{1c}) had OGTTs, and then the HbA_{1c} levels of those with NGT (defined by OGTT) were examined. Only 0.4% had HbA_{1c} of 6.5% or over; 6.7% had HbA_{1c} in the range 6.0 to 6.49%, and 93% had $HbA_{1c} < 6.0\%$.

Concern has been raised that screening by HbA_{1c} and FPG might pick up different groups. This was examined by Carson and colleagues using NHANES data, with cut-offs on 6.5% for HbA_{1c} and 7.0 for FPG.[46] There was some disagreement between the tests, but 96% were not diabetic by both, and 1.8% were diabetic by both. In 0.5% of people, diabetes was diagnosed by HbA_{1c} but not FPG, but 82% of this group had IFG and would be treated correctly. In the 1.8% diabetic by FPG but not by HbA_{1c}, almost half were in the HbA_{1c} range 6.0 to <6.5% and would also be treated.

However there is less agreement between HbA_{1c} and FPG when it comes to diagnosing "pre-diabetes". Mann and colleagues, also using NHANES data, compared results using HbA_{1c} cut-off of 5.7% and FPG of 6 mmol/l.[47] The prevalence of diabetes using the 5.7% level was 12.5%, of whom 9% were negative by FPG. However, almost 5% were positive by FPG but negative by HbA_{1c}. One could speculate that the last group had isolated IFG and hence were at low risk of cardiovascular disease, whereas the HbA_{1c} positive but FPG negative may have had IGT.

There is no perfect test. The gold standard test might be the OGTT, but repeated a week later, because of its imperfect reproducibility. But it is impractical, and as Hanson and colleagues once pointed out, the emphasis on the OGTT may be part of the reason why so many people in the USA are undiagnosed.[48] A slightly less good test may in practice be more useful by being applied more frequently. The FPG and the 2 hour test are equally

useful for assessing the risk of microvascular complications such as retinopathy, but the 2 hour level is better for assessing macrovascular risk, because of the difference in heart disease risk between IFG and IGT. Glycated haemoglobin has advantages in terms of convenience, and reproducibility compared to the OGTT or its modified form, the 2 hour PG. FPG is also more reproducible than the OGTT.

In July 2009 an expert committee appointed by the EASD, IDF and ADA published a report on the role of the A1C assay in the diagnosis of diabetes.[49] The key recommendations of this report were that:

- HbA_{1c} should be used as a diagnostic test for diabetes with a threshold ≥6.5% defining diabetes.
- That HbA_{1c} measurement has several advantages (both logistical and technical) over fasting glucose.
- Individuals whose A1C values are close to the 6.5% A1C threshold of diabetes (i.e., ≥6.0%) should receive demonstrably effective interventions aimed at preventing progression to diabetes.
- Testing should be by clinical laboratory instruments not point of care instruments.

A cut-off of 6.0% might pick up most people with IFG, but not all. Selvin and colleagues from the ARIC study reported that an HbA_{1c} cut-off of ≥ 6.5% would detect 49% of those with FPG of 7.0 mmol/l or over, and a cut-off of 6.0% would detect 75% of those diabetic by FPG. In the band below (HbA_{1c} 5.5 to <6.0) only 3% were diabetic by FPG.[50] In this band, the mean HbA_{1c} was 5.7% and mean FPG was 5.8 mmol/l. A cut-off of 5.5% would detect 91% of those with diabetic FPGs.

Moves towards global standardisation of HbA_{1c} measurement will help.[51] HbA_{1c} has advantages of not requiring people to be fasting, and its diagnostic accuracy now rivals that of plasma glucose. However it should be noted that any cut-off will arbitrary because for vascular disease, there is a continuum of risk, unlike the dichotomy seen with moderate retinopathy.

There are ethnic differences in HbA_{1c} and the cut-off may have to be adjusted for different groups. A study from China suggested a cut-off of 6.3%.[52]

We need to distinguish the use of HbA_{1c} for diagnosing diabetes from its value in predicting vascular risk. In the latter case, it is correct to say that HbA_{1c} is a good predictor of vascular

risk on its own, but that once other traditional markers of vascular risk such as blood pressure, smoking, lipids are added, HbA_{1c} gives limited marginal benefit.[39]

Reservations about the use of HbA1c

Various concerns about reliance on HbA_{1c} as the diagnostic test for diabetes have been raised. Some of these come from the clinical biochemists, and therefore need to be recognised.

The Association of British Clinical Diabetologists (ABCD) position statement on using HbA_{1c} for diagnosis (not screening) lists the advantages and disadvantages of using HbA_{1c}.[53]

Advantages	**Disadvantages**
No need for fasting	Abnormal haemoglobins
Low biological variability	Anaemias
Measure of glycaemia over a period of months	Ageing and ethnicity
Analytical standardisation	Residual analytical variations

Each of the first three disadvantages leads to misleading results.

The ABCD choose a range of 5.8 to 7.2% for intermediate hyperglycaemia, and recommend another test, such as FPG or an OGTT to confirm or exclude diabetes. They suggest that combined HbA_{1c} and FPG could be used for diagnosis.

Schindhelm and colleagues also warn that laboratory assays for HbA_{1c} still show significant variability, noting that coefficients of variance ranged amongst methods from 1.7 to 7.6%.[54]

There has been debate about the lower cut-off for HbA_{1c}. The SPHN working noted that some groups advocate an HbA_{1c} range of 5.7% to 6.4% for defining non-diabetic hyperglycaemia, whereas others suggest 6.0% as the lower limit. Unfortunately, most studies simply report results for the whole band, whereas what we need is a comparison of the 5.7 to 5.9% with the 6.0 to 6.4% range.

Cederberg and colleagues used the 5.7% cut-off, and compared it with IGT and IFG as revealed by OGTTs. Diabetes was preceded by raised HbA_{1c}, IGT and IFG in 33%, 41% and 22% respectively, after 10 years.[55] The converse may be more important – diabetes was not preceded by raised HbA_{1c} in 67%, though if screening were to be introduced in the UK, the interval would most likely be 5 years.

Mostafa and colleagues from Leicester used data on OGTTs and HbA1c from a cohort of 8,696 to compare proportions with abnormal results.[56] Using the OGTT, 3.3% were diabetic, and of these about a third had HbA1c <6.5%. Using HbA_{1c} of 6.5% as the threshold for diabetes increased the prevalence to 5.8%, but on OGTT over half had IGT or IFG. Of 595 people, 198 were diabetic by both OGTT and HbA_{1c}, 93 only by OGTT, and 304 only by HbA_{1c}. The paper does not give details of how many who were diabetic by OGTT, had the diagnosis made by the FPG or the 2-hour PG or both. All those who were diabetic on OGTT had the OGTT repeated – a third were not diabetic on the second OGTT. Mostafa and colleagues noted that an HbA_{1c} cut-off of 5.7% would identify 51% of their cohort as abnormal.

Borg and colleagues from Denmark also compared the characteristics of those diagnosed by OGTT and HbA_{1c}, but again give no details of the OGTT time points responsible for diagnosis.[57] Using an HbA_{1c} cut-off of 6.5% or more, 6.6% were diabetic, compared to 4.1% by OGTT. Almost 58% of those diabetic by OGTT were not so by HbA_{1c}. In terms of cardiovascular risk profile, those diabetic by HbA_{1c} but not by OGTT had as high a risk (actually higher, but not statistically significantly so). Hence, OGTT and HbA_{1c} appear to be detecting groups which only partly overlap.

Lorenzo and colleagues from the IRAS study reported that HbA_{1c} was less sensitive than IFG or IGT for detection of risk (not diabetes), but what was meant by this was that HbA_{1c} classified fewer individuals as having abnormal glucose tolerance – it was not about diabetes. No specificity was reported.[58]

The incremental risks of higher HbA_{1c}s vary amongst outcomes. Selvin and colleagues took an HbA_{1c} of 5.0 - <5.7% as the reference range (RR = 1.0). For diabetes, RRs for HbA_{1c} of 5.7 - <6.5% and 6.5% or over were for diabetes, 3.0 and 13.7 respectively, but for coronary heart disease were 1.6 and 1.9 respectively.[50,59]

The glucose challenge test

Used mainly in screening for gestational diabetes, this test has been little studied in screening for type 2 diabetes. It can be used for people who have not fasted, which makes it more convenient. An analysis by Chatteree and colleagues examined the cost-effectiveness of screening by random PG, the 1-hour 50-g GCT, and the 75-g OGTT. Their model included costs of testing and treatment (with metformin). They also examined the costs of no screening, selective screening and universal screening. They concluded that the most cost-effective approach was selective screening (by BMI and age).[60]

Abdul-Ghani and De Fronzo have reviewed the evidence on relationships of FPG and PG at all time points after the 75-g OGTT.[61] They make a convincing case for the 1 hour PG being the strongest predictor of later diabetes. This would suggest that it would be worth researching the value of the 50-g 1-hour GCT in screening for IGT and diabetes.

How often should screening be done?

There is a shortage of evidence to answer this question. Takahashi and colleagues[62] carried out annual OGTTs in Japan and found that the cumulative incidence (CI) of diabetes after 3 years by band of HbA_{1c} was:

Baseline < 5.0%	CI 0.05%
5.0 to 5.4%	CI 0.05%
5.5 to 5.9	CI 1.2%
6.0 to 6.4	CI 20%

This not only suggests that the screening interval should not be less than 3 years for those with initial HbA_{1c} under 6.0%, but also supports the case for using the cut-off of 6.0% HbA_{1c}.

Recommendations

1. The first step in screening for diabetes and IGT should be selection by risk factor score.
2. The second stage would use HbA_{1c} as the screening test with 6.0% as the cut-off.
3. In the third stage, the diagnosis of diabetes should be confirmed by a second test of blood glucose, either FPG or HbA_{1c}. Two HbA_{1c} results of 6.5% or over would confirm diagnosis.
4. Given the lack of agreement on the use of HbA_{1c} alone, we recommend that the third stage should meantime use both HbA_{1c} and FPG, with FPG of 7.0 mmol/l used as the diabetes cut-off as in the standard definitions. It is unlikely that people with HbA_{1c} in the range 6.0 to 6.49% will have FPG of 7.0 mmol/l or over, and his recommendation can be reviewed in the light of experience, and FPG dropped if it does not contribute.
5. Treatment of both newly diagnosed diabetes and IGT should be with diet, weight loss and physical activity.

These recommendations are discussed further in Part A of the full needs assessment report.

Chapter 4 Prevention of type 2 diabetes in people with IGT

This chapter is based on a technology assessment report commissioned on behalf of the Department of Health for England, which will be published in the Health Technology Assessment monograph series.

The question here is whether progression to diabetes can be prevented, or at least delayed, in people with IGT or IFG. A review of the evidence for a report for the Department of Health found nine published randomised controlled trials (RCTs) comparing lifestyle interventions (predominantly diet and physical activity advice, with regular reinforcement and frequent follow-up) with standard lifestyle advice or placebo. They included 5,875 people randomised to receive lifestyle advice, exercise programmes, or combinations thereof. The trials varied in design and quality. The primary outcome for the trials was progression to type 2 diabetes. Five recent systematic reviews were also identified.

The RCTs compared the effect of non-pharmacological lifestyle interventions with a control intervention (usually standard lifestyle advice with non-intensive follow-up) in participants with impaired glucose tolerance (IGT). In most of the trials, lifestyle interventions reduced progression to diabetes (RR range 0.33 to 0.96).

The Diabetes Prevention Program (DPP) from North America (which had higher risk recruits than most other trials) reported that the prevalence of diabetes at three years was 29% in the control group compared to 14% in the lifestyle intervention arm.[63]

The Finnish Diabetes Prevention Study (DPS) had the longest follow-up, to seven years, which included the four years of intervention and then three years of post-intervention follow-up. After four years, 4% of the lifestyle group and 7.4% of the control group had developed diabetes, roughly a halving of risk. At seven years, the difference had diminished slightly, but the intervention group retained most of the benefit, suggesting that four years of the lifestyle intervention had resulted in a sustained change in lifestyle habits. [64]

The benefits of the lifestyle intervention were greatest in those with the highest compliance and who achieved more of the targets (such as weight loss and dietary change). For example, in the Finnish study, those who achieved four or five of the five targets had a risk of developing diabetes which was only 23% of those who achieved none. However, even amongst the volunteers in the trials, many did not

succeed, and others succeeded in the short term (such as the first six months) but not in the longer term. The key to success is sustained lifestyle change, especially weight loss.

The DPS involved quite intensive lifestyle intervention. A subsequent study from Finland used low intensity intervention (six sessions of counselling by public health nurses) over an 8-week period, and found that the effects persisted for three years.[65] However the effects were much less than in DPS – 0.8kg weight loss compared to 4.5kg in the DPS. The most successful prevention studies had more intensive interventions with more frequent contacts.[66]

Perry and colleagues[67] from Cork in Ireland identified factors from previous studies, which protected against diabetes: BMI <25; waist-hip ratio <0.85 for women and 0.90 for men; never-smoking; medium to high level physical activity; light drinking (3-5 to 7 unit a week); and a prudent diet. In their sample of middle-aged Irish men and women drawn from general practice populations, 7.5% had none of these protective factors. Insulin resistance was calculated using the HOMA (homeostasis model analysis) score (based on fasting levels of both insulin and glucose). Taking the 7.5% with no protective factors as the reference group, multivariate analysis gave odds ratios for insulin resistance of 0.59 with one protective factor, 0.48 with two, 0.14 with three, and 0.04 with four or more. About 13% had four or more protective factors.

Hence there is little doubt that lifestyle measures could prevent most cases of type 2 diabetes. Weight loss would also benefit those who already have diabetes, or hypertension, and improvements can follow even modest weight loss. Goldstein reviewed studies in which large and small amounts of weight were lost, and concluded that even modest weight reductions of 10% or less, resulted in significant benefit in a substantial subset.[68] Even loss of a few kg can provide benefit.

A more radical option, bariatric surgery for obesity, is being considered by a National Planning Forum Short Life Working Group. It greatly reduces progression from IGT to diabetes (and also reverses diabetes in many cases).

Cost-effectiveness

A number of studies of the cost-effectiveness of intervention to reduce progression to diabetes in people with IGT have been published. Most conclude that it is cost-effective, and in some scenarios, cost saving. One of the key factors in cost-

effectiveness analysis is adherence to lifestyle changes. Even amongst the volunteers in the trials, a large proportion did not adhere. It was also noticeable that in many trials, initial gains were lost after the intervention ceased.

As part of the health technology assessment report for the Department of Health (HTA monograph in preparation), the Aberdeen and Sheffield team assessed the cost-effectiveness of a system wherein people with IGT would initially be treated with a structured lifestyle intervention similar to that in the Finnish trial, but that those who did not comply would be switched to metformin after 12 months. Metformin is now a very cheap drug, and reduces the risk of progression to diabetes, though not by as much as adherence to lifestyle measures does. Applying an early switch to metformin in the non-adherers means that the adherers remaining on diet and physical activity will do better than seen in the lifestyle arms of the trials. It was assumed that the non-adherers to lifestyle modifications will have better adherence to metformin, so that they will also do better than if left on the lifestyle interventions. Using the switching assumption, intervention is highly cost-effective, and in certain scenarios, cost-saving.

In summary, there is very good evidence that diet and physical activity changes can reduce the risk of diabetes. The research most needed is how to persuade people at risk to adopt and persevere with the changes.

A review of how best to encourage people to adhere to preventive measures has been being carried out as part of the IMAGE project (Colin Greaves, personal communication, and a summary is attached as Appendix 2).

Recommendation

People with IGT should diet to achieve weight loss, and should increase their levels of physical activity.

Chapter 5 Current services survey: comparative data from health boards

Author: Andrew Millard. This is a summary of the full report published as Part C.

Aim

The aim of this chapter is to describe the current situation as regards screening for and prevention of type 2 diabetes in Scotland.

Methods

1. Telephone interviews with one key figure in each of the 14 Diabetes Managed Clinical Networks in Scotland (usually the Managed Clinical Network Manager, or the lead clinician if the manager was not available). These covered screening and prevention (and other aspects of service provision covered in a companion document to this one).
2. Postal questionnaires to all 14 Directors of Public Health (or their nominee) in the 14 Scottish health boards. These focused on screening and prevention, and are reported in separate sections within the screening and prevention sections below. The questionnaires were sent in April to May 2009.

The 14 questionnaires to Directors of Public Health resulted in the return of 12 completed questionnaires. For the data sourced from the interviews and questionnaires the source is referenced as such where confusion might otherwise arise. Other sources are stated or referenced in the text.

Other relevant documents were consulted for background information.[69-76]

The terms MCN and Health Board are used interchangeably when referring to geographical areas, but not when referring to organisations.

Results

Population screening and prevention

The Scottish Diabetes Survey for 2008 reports that there were 219,000 people recorded on local diabetes registers, which is 4.1% of the population. Prevalence ranges from 3.7% to 4.6% by NHS Board. Of these 85% have type 2 diabetes. Half of all diabetic people are aged 65 years and over.[77]

The results reported were from two sources, MCN key staff (mainly managers) and Directors of Public Health (or their nominee). There are some anomalies, which are to be expected from differing human data sources. The results from each source have been reported separately to retain the extra information afforded to the reader through the additional context given by knowledge of the source.

Population Screening

Keep Well is an anticipatory care programme introduced in 2007 in some Scottish Health Board areas and is now being extended to all of Scotland. Focusing on deprived populations, it aims to provide practice-based cardiovascular health checks to reduce health inequalities. Well North is an adaptation of Keep Well for remote and rural areas. These projects screen people aged between 45 and 64 (or 69 in the case of some aspects of Well North) for a variety of health problems including diabetes. Seven MCNs were in Keep Well pilot areas, and five were in Well North areas, although not all GPs in each area necessarily took part in either Keep Well or Well North.[78] At 31.3.2009, based on an estimated population of 1,112,935 at 30/6/2008 [79] in the seven Keep Well Health Boards aged between 45-64, 11.9% (132,021/1,112,935) were eligible for a Keep Well check. Of these, 38.5% (50,784/132,021) had actually been checked at 31.3.2009.[1] [2]

No equivalent figures are available for Well North.

[1] Figures supplied by Information Services Division, 07.07.2009

[2] Update from ISD: at the end of 2009, 67,712 patients had received checks out of a total eligible population of 139,192 people.

Keep well	Well North
Tayside* Lothian Lanarkshire* Greater Glasgow & Clyde Ayrshire & Arran* Grampian Fife	Western Isles* Shetland Highland Grampian Orkney

* = mentioned Keep Well or Well North as part of MCN interview screening question.

Population screening for Type 2 Diabetes

MCN interviews

Most MCNs said they screened opportunistically or ad hoc. None used a population-wide call and recall system. Three MCNs reported their NHS Boards taking part in Keep Well, in connection with population screening for Diabetes, and one was taking part in Well North.[80] One MCN mentioned a Local Enhanced Service (LES) for other long term conditions (CHD and Stroke) which screened its participants for diabetes systematically.

About half of MCNs (including those in Keep Well and Well North) said they had a systematic approach, but with reference to at risk patients rather than the whole population. The implementation varied by practice, but was generally opportunistic, rather than call and recall, with the exception of those participating in Keep Well or Well North. In some areas new patients were given a general health screen. Guidelines for Tayside and Dumfries and Galloway recommended annual recall and diabetes screening for patients with IFG/IGT.

Directors of Public Health Questionnaire

The Directors of Public Health (DsPH) questionnaire results for population screening for diabetes were as follows (Table 8)

Table 8 Organised Screening for Diabetes

Organised screening for type 2 diabetes	
AYRSHIRE & ARRAN	Keep Well programme only
BORDERS	None at present but planning a local Keep Well service
DUMFRIES & GALLOWAY	None, except GPs QOF activity
FIFE	Diabetes LES last year for the diabetes care pathway. Keep Well across whole area, with screening opportunity for eligible patients (age selected as for Keep Well)
FORTH VALLEY	No organised screening, but ad hoc linked to QOF related CHD clinics
GRAMPIAN	None, but there may substantial ad hoc taking place. Note a comment received suggested Grampian had not fully answered the questionnaire as established initiatives were not reflected.
GLASGOW	Yes, done as part of the primary care LES, priority for CHD/stroke. Ad hoc in Pharmacy
HIGHLANDS	None, but opportunistic checks
LANARKSHIRE	Keep Well in some areas. Opportunistic through Braveheart and Body check. (North). Up for it Lifestyle intervention programme (South) Opportunistic in schools, nurseries, and in CV clinics. Old age medicine. SALUS as part of Healthy Working Lives (NHS Lanarkshire staff)
LOTHIAN	Keep Well in 14 central Edinburgh practices, expanding to another 5 in west Lothian and to gypsy travellers, offenders and ethnic minorities
ORKNEY	No standardised approach, each GP practice does its own opportunistic screening, if family history of type 2 diabetes.
SHETLAND	No reply
TAYSIDE	Keep Well, with targeted screening in Dundee, and the Cardiology unmet needs project, but no population-wide screening programme
WESTERN ISLES	No reply

Six areas mentioned Keep Well as a form of systematic or organised population screening for diabetes (including one planning a local version of this national initiative). Thus two areas of the seven which were involved in national Keep Well did not mention Keep Well in connection with diabetes screening. With the exception of Fife, Keep Well did not generally cover entire health board areas, but focused on specific localities within them.

There were some other screening initiatives, in particular Lanarkshire mentioned chemists, screening in older peoples' services and healthy working lives for example. The overall picture was partial coverage by general health promotion rather than diabetes-focused initiatives, even in Keep Well areas.

The overall picture from both MCNs and DsPH was partial coverage by general rather than diabetes-focused initiatives, including the Keep Well or Well North areas, because these projects generally did not cover the entire board area and were targeted to a particular age range. As MCNs mentioned an LES once and DsPH twice, it appeared the LES was not generally perceived as a population screening mechanism for diabetes.

Population screening for impaired fasting glucose (IFG) and impaired glucose tolerance (IGT)

MCN Interviews

Screening for IGT and IFG was generally ad hoc and not systematic, and based on identifying and screening those with risk factors rather than everyone. In Tayside GP teams were encouraged to perform annual oral glucose tolerance (OGT) tests on patients with equivocal venous glucose. Glasgow will be doing the same, based on patients identified through Stroke and Coronary Heart Disease (CHD) Local Enhanced Services (LESs).

Directors of Public Health Questionnaire

The Directors of Public Health questionnaire results on population screening for IGT/IFG were as follows (Table 9):

Table 9 Any screening for IGT

Screening for impaired glucose tolerance (IGT)	
AYRSHIRE & ARRAN	Ad Hoc screening based on clinical presentation and risk factors
BORDERS	Keep Well random testing, otherwise symptom driven in primary care
DUMFRIES & GALLOWAY	No
FIFE	As for Diabetes itself as part of LES and Keep Well as above.
FORTH VALLEY	Targeted if a family history of diabetes or other risk factors
GRAMPIAN	No organised screening, but there may be substantial ad hoc screening. Note a comment received suggested Grampian had not fully answered the questionnaire as established initiatives were not reflected.
GLASGOW	As for diabetes screening - as part of primary care LES programme, priority for CHD/stroke patients, ad hoc in chemists
HIGHLANDS	Nothing systematic, opportunistic only.
LANARKSHIRE	There is a many years old guideline on glucose testing in pregnancy, but no evidence as to how far it is implemented
LOTHIAN	As part of Keep Well
ORKNEY	No standardised screening, but most patients with known IGT get a yearly recall for annual check by the GP
SHETLAND	No reply
TAYSIDE	Targeted and opportunistic screening for diabetes identifies significant numbers with IGT
WESTERN ISLES	No reply

Keep Well and LES were mentioned in some of the same areas as for diabetes with regard to population screening for IGT, but mentions were less frequent than for diabetes, and QOF was not mentioned here at all.

The general picture from both MCNs and DsPH was one similar to population screening for diabetes, of ad hoc or opportunistic screening based on symptoms and

clinical presentation, and targeted screening based on risk factors, although Keep Well would be more systematic for its target age range in practices implementing it.

It therefore appears that there is currently no systematic population screening or prevention activity for diabetes or pre-diabetic conditions.

Prevention

Primary prevention of type 2 diabetes

MCN Interviews

Nearly all MCN respondents said there were no specific prevention measures for type 2 diabetes, but that generic public health initiatives such as general lifestyle advice, obesity and exercise classes, secondary school healthy lifestyle education and active schools, would help to prevent diabetes as well as other health problems. One respondent mentioned an annual diabetes day and awareness raising through spot checks in supermarkets and theatre events. Family and friends without diabetes were encouraged to attend Structured Patient Education (SPE) in some MCNs.

The Q2 2008-09 monitoring report (DAPQ2) for the Diabetes Action Plan[49,81] states that seven MCNs have completed the task of making health improvement resources available to front line staff. It also states 4 MCNs had achieved the target of applying lessons learned from preventive medicine initiatives, such as prevention 2010.

Directors of Public Health Questionnaire

The Directors of Public Health questionnaire results on population prevention of diabetes were as follows (Table 10)

Table 10 Methods for prevention of diabetes

Prevention of type 2 diabetes in the general population	
AYRSHIRE & ARRAN	Local guidelines recommend higher awareness be maintained by health professionals for defined risk groups, and Public Health Education should raise awareness of symptoms, and promote earlier diagnosis. GPs, Community Pharmacists, and Health Promotion Specialists are identified as well placed to provide earlier diagnosis, advice, and to raise the profile of the issue respectively.
BORDERS	General health improvement activities around healthy lifestyles – physical activity, diet, weight, including a child obesity strategy and an adult obesity strategy under development linked to the planned local Keep Well service.
DUMFRIES & GALLOWAY	General work to reduce obesity – promoting healthy eating and increased physical activity. Weight management treatment service and Bariatric surgery.
FIFE	Fife joint health improvement plan (JHIP) is the framework for assigning desired outcomes to individuals or strategy groups for topics such as physical activity and diet to inform their action plans, which guide local service plans or CHP/health unit improvement activities and local projects and programmes.
FORTH VALLE	No formal screening – done on an individual patient basis. General population – lifestyle advice to prevent obesity – diet, exercise (referral by GPs). South Asians healthy lifestyles. Healthy weight strategy in place.
GRAMPIAN	Not aware of any work in last year. Note a comment received suggested Grampian had not fully answered the questionnaire as established initiatives were not reflected.
GLASGOW	Eat Up, Shape Up Exercise Referral, Weight management service
HIGHLANDS	Healthy weight intervention programme for children, physical activity opportunities for adults, healthy eating initiatives. No progress in higher risk BME interventions.
LANARKSHIRE	General Lifestyle measures – diabetes is not the primary reason, but it is an objective – broad range, inc promotion of breastfeeding, healthy eating in nurseries, physical activity in schools and nurseries. Healthy weight strategy for children, exercise and walking programmes. Diabetes prevention is cited as a reason for weight management and good nutrition in the joint health improvement plan.
LOTHIAN	Healthy weight strategic framework exists. Physical activity and food and health groups active in all four local authority areas.
ORKNEY	No structured approach. General healthy lifestyle promotion by Practice and Community nurses through individual contact and leaflets. Dietetic service and Health Information liaise with practices. Diabetes UK and diabetes team run annual diabetes awareness day.
SHETLAND	No reply
TAYSIDE	General Community Health promotion on weight and lifestyle management for high risk groups. Not targeted to diabetes alone.
WESTERN ISLES	No reply

The prevention methods in the general population were not restricted to those at risk of diabetes, or targeted to diabetes alone, but were general healthy lifestyle advice on diet, exercise, obesity management and (less often) referral for specific intervention measures involving for example physical activity, bariatric surgery, weight management. Professionals mentioned as delivering the advice included practice nurses, health promotion specialists and community pharmacists. Some of these were targeted at children and young people, and some were supported by a strategy or strategic framework such as a healthy weight strategy, although resource issues were mentioned as a barrier to implementation.

So again, the information from the two data sources had a good degree of coherence with general health lifestyle measures rather than diabetes targeted approaches, although the prevention of diabetes was a recognised beneficial outcome. Bariatric surgery was seen as a method of preventing diabetes by treating obesity, but could include patients already diabetic. Bariatric surgery can cure type 2 diabetes of recent onset in obese people.

Secondary prevention of type 2 diabetes in those with IGT

MCN Interviews

Generally ad hoc measures were used, based on healthy lifestyle advice. Patients with known IGT were reported to be systematically retested annually or as required dependent on age and progression rate in six boards. These were Dumfries and Galloway, Forth Valley, Tayside, Western Isles, Glasgow (Stroke and CHD LES patients only), and some GPs in Lothian. In Fife a pilot was underway in one CHP where CV and diabetes nurses were targeting people with IGT. Five of the seven MCNs named here were Keep Well or Well North areas. It is likely some practices in other Keep Well pilot areas were retesting people with IGT/IFG annually also, but that was not explicitly mentioned at interview.

Directors of Public Health Questionnaire

The Directors of Public Health questionnaire results on prevention of diabetes in people with IGT/IFG were as follows (Table 11):

Table 11 Methods for secondary prevention of diabetes in those with IGT/IFG

Prevention of type 2 diabetes in people with impaired glucose tolerance or impaired fasting glycaemia	
AYRSHIRE & ARRAN	See table 10
BORDERS	IGT is a criterion for referral to the Lifestyle Adviser Support service
DUMFRIES & GALLOWAY	See table 10
FIFE	See table 10
FORTH VALLEY	Aim is to prevent progression to diabetes. Prevention measures as for table 10 (lifestyle advice) and additional monitoring of status
GRAMPIAN	See table 10
GLASGOW	See table 10
HIGHLANDS	Nothing specific at present, but there are plans to extend provision of existing 6 week 'Your Life your choice' course offered by partnerships for wellbeing and similar condition specific courses in partnership with Diabetes UK among others. Note: a comment on this response stated it was uncertain whether the participants had IGT and the study did not progress as expected
LANARKSHIRE	See table 10
LOTHIAN	See table 10Practitioners will offer lifestyle advice as appropriate and screen for diabetes annually
ORKNEY	See table 10
SHETLAND	No reply
TAYSIDE	Guidance is available to MCNs to encourage PCTs to identify and support patients with pre-diabetic conditions in weight, lifestyle and CV risk management, and to carry out annual IFG on these groups.
WESTERN ISLES	No reply

In eight boards the methods for prevention of diabetes in these patients were said to be the same as those for prevention of diabetes in the population. Three areas mentioned that once identified as pre-diabetic, patients were recalled for annual checks, which would not happen for a member of the general population. In another area, those with IGT were referred to a lifestyle adviser who will advise on how to maintain a healthy diet and weight. Two areas thus alluded to specific protocols for the management of pre-diabetic conditions.

Thus generally, as for all the screening and prevention questions, the two data sources supported each other, but were opinion-based and reported policy and strategy rather than evidence of implementation.

Finally, the DAP(Q2) states that support measures to reduce the risk of people developing diabetes were in place in 8 MCNs.[81] There is insufficient space for full details for all MCNs, but typical interventions included:

- the development of guidelines for risk management of CV risk,
- screening for and treating risk of diabetes as a part of CV risk screening,
- working with health promotion and diabetes UK on healthy living initiatives
- links to Keep Well and Well North,
- development of an at risk register for developing diabetes as a component of the LES.
- Public Health strategies on physical activity and counterweight launched.
- health improvement service pathways for healthy eating, weight management, smoking cessation,
- developing an obesity strategy with the DPH,
- Community Pharmacists undertaking a waist measurement initiative, offering tape measures to any patient who wishes one.
- awareness campaigns to coincide with Diabetes week and World Diabetes Day.
- working more closely with Health Promotion to support more healthy living initiatives

Chapter 6 Treatment for people with type 2 diabetes

NICE issued guidelines (CG66) on the management of type 2 diabetes in May of 2008, and updated these to take account of new drug developments in May 2009.[82] Several new classes of drugs have become available, including the glucagon-like peptide agonists, the DPP4 inhibitors, and the (not so new) insulin analogues. SIGN released updated diabetes guidelines in 2010.[4]

This report will not go into details of treatment, but a few points are worth mentioning from a public health/health care planning perspective;

- recent evidence on rosiglitazone shows that it is associated with a small increase in cardiac events – a 40% increase in relative risk, but small in absolute terms. If no alternative drug was available, rosiglitazone would remain a useful drug. But given that we do have other options, its use should be phased out.
- The new long-acting basal insulins, glargine and detemir, are not cost-effective compared to once daily NPH insulin in type 2 diabetes. They are slightly better, especially in terms of hypoglycaemia, but are much more expensive. However it is probably too late to engineer a switch back to NPH. But NHS managers could point out that such a switch could release resources for other forms of diabetes care.
- In people failing to achieve adequate glycaemic control on combinations of oral agents, there is some evidence that an intensive lifestyle intervention may be as effective as commencing them on insulin in terms of glycaemic control, and better in terms of cardiac risk. The relevant trial was small, and done in Denmark. It needs to be repeated in the UK.
- About 90% of people with type 2 diabetes are obese or overweight.
- The most important person in the management of type 2 diabetes is the patient. There are variations in the provision of structured diabetes education.
- The value of self monitoring of blood glucose in type 2 diabetes not treated with insulin is doubtful, but is currently under review by a DH working party. A report should be issued in the autumn.

Current treatment

The general approach to treatment has been described in the NICE guidelines of management of type 2 diabetes – CG 66 and CG87.[82] It takes account of the fact that type 2 diabetes is usually a progressive disease, due to loss of beta cell capacity.

Treatment uses a step-wise approach, starting with lifestyle measures – diet, weight loss, physical activity. If those fail, as they usually do after a time, then metformin is added. The next step after that is to add another oral agent, usually a sulphonylurea. If glycaemic control deteriorates, a third drug is added. Until recently, this would be insulin, but several other options are now available, including pioglitazone, exenatide and the gliptins.

This report does not cover choice of drug, other than to note the need for cost-effectiveness to be taken into account. However, several studies have shown that people with type 2 diabetes are often left poorly controlled on oral agents before insulin is started. This may last for several years, or indefinitely, which increases the risk of complications.[83,84]

This occurs for several reasons, one being that starting insulin in overweight or obese people with type 2 diabetes often does not improve control.[85] So physicians may be dubious about the value of starting insulin. Patients may also be reluctant.[86,87]

The new GP contract, with its HbA_{1c} targets, may change this. Anecdotal evidence from some diabetologists is that the new contract has led to an increase in referrals for commencing insulin therapy.

Recommendations

The first aim in the treatment of type 2 diabetes should be weight loss, by a combination of calorie restriction and an increase in physical activity. This may be helped by a period of intensive lifestyle education.

When that fails, drug treatment should be with metformin, a cheap, effective and soundly evidence-based therapy.

If a second-line drug is needed, it should be a sulphonylurea, on grounds of known efficacy, safety data and low cost.

If a third drug is added, the choice should be generally as per the SIGN guideline. But there also appears to be a place, even at this stage, for an intensive lifestyle intervention which appeared effective in a small Danish trial by Aas and colleagues.[88]

Research is needed into how to motivate people with type 2 diabetes to lose weight, and the extent to which lifestyle measures can reduce progression of disease.

Chapter 7 Discussion and research needs

About 80-90% of type 2 diabetes could be prevented by lifestyle measures. The key problem is that we know what people should do to avoid type 2 diabetes, but not how to persuade them to do it.

One issue is what balance to strike between the "medical model" of screening, detection and treatment of individuals, and the "public health" model of changing behaviour in the entire population. The latter could include not only health education measures, but also other interventions such as those to make physical activity easier (e.g. good quality cycle lanes entirely separate from traffic) and weight control easier (changes to taxation of foodstuffs, legislation on fat content, taxation by unit of alcohol).

Part of the balance problem is that there is a good evidence base for the medical model, whereas the effectiveness and cost effectiveness of many health promotion measures are not proven.

Research needs include:

- How to motivate people to adopt healthier lifestyles. The IMAGE report (appendix 2) has addressed this, but has also identified some further research needs.
- Replication of the trial by Aas et al [88] of intensive lifestyle intervention as an alternative to starting insulin in people with type 2 diabetes failing on combination oral drugs.
- Data on the prevalence of undiagnosed type 2 diabetes and IGT in the Scottish population.
- Cost-effectiveness modelling of selection for screening at different risk scores.
- Modelling of different screening scenarios to determine a screening strategy which the NHS could cope with. That might involve screening only those at highest risk in the first year or two of the programme, and then gradually extending it.
- Determining the incidence of type 2 diabetes in 10-year age bands, and hence the extent of earlier onset. This will be possible using SCI-DC data.
- Follow-up of those screened, to determine numbers missed by using HbA_{1c}. In the first year, both FPG and a second HbA_{1c} should be done.

References

1. UK National Screening Committee. The UK NSC policy on Diabetes screening in adults. 2006 http://www.screening.nhs.uk/diabetes (accessed 11 October 2010)

2. Waugh N, Scotland G, McNamee P, Gillett M, Brennan A, Goyder E *et al*. Screening for type 2 diabetes: literature review and economic modelling. *Health Technol Assess* 2007;11:iii-xi, 1.

3. UK National Screening Committee. DPH Newsletter. 2008, March http://www.screening.nhs.uk/publications (accessed 7 July 2009)

4. Scottish Intercollegiate Guidelines Network. Management of diabetes: Guideline No.116. 2010, March http://www.sign.ac.uk/guidelines/fulltext/116/index.html (accessed 5 May 2010)

5. Gavin II, Alberti KGMM, Davidson MB, DeFronzo RA, Drash A, Gabbe SG *et al*. Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* 1997;20:1183-97.

6. Wilson PW, Meigs JB, Sullivan L, Fox CS, Nathan DM, D'Agostino RB, Sr. Prediction of incident diabetes mellitus in middle-aged adults: the Framingham Offspring Study. *Arch Intern Med* 2007;167:1068-74.

7. Mozaffarian D, Kamineni A, Carnethon M, Djousse L, Mukamal KJ, Siscovick D. Lifestyle risk factors and new-onset diabetes mellitus in older adults: the cardiovascular health study. *Arch Intern Med* 2009;169:798-807.

8. Tuomilehto J, Lindstrom J, Eriksson JG, Valle TT, Hamalainen H, Ilanne-Parikka P *et al*. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance.[see comment]. *New England Journal of Medicine* 2001;344:1343-50.

9. Grant I, Fischbacher C, Whyte B, Scottish Public Health Observatory (ScotPHO) collaboration. Obesity in Scotland: an epidemiology briefing. 2007 http://www.scotpho.org.uk/home/Publications/scotphoreports/pub_obesityinscotland.asp (accessed 7 July 2009)

10. Ford ES, Williamson DF, Liu S. Weight change and diabetes incidence: findings from a national cohort of US adults. *Am J Epidemiol* 1997;146:214-22.

11. Pierce MB, Zaninotto P, Steel N, Mindell J. Undiagnosed diabetes-data from the English longitudinal study of ageing. *Diabet Med* 2009;26:679-85.

12. Goyder E, Wild S, Fischbacher C, Carlisle J, Peters J. Evaluating the impact of a national pilot screening programme for type 2 diabetes in deprived areas of England. *Fam Pract* 2008;25:370-5.

13. Echouffo-Tcheugui JB, Sargeant LA, Prevost AT, Williams KM, Barling RS, Butler R *et al*. How much might cardiovascular disease risk be reduced by intensive therapy in people with screen-detected diabetes? *Diabet Med* 2008;25:1433-9.

14. Stratton IM, Adler AI, Neil HA, Matthews DR, Manley SE, Cull CA *et al*. Association of glycaemia with macrovascular and microvascular

complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ* 2000;321:405-12.

15. UKPDS Study Group. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). *Lancet* 1998;352:854-65.

16. Balkau B. Prediction of the risk of cardiovascular mortality using a score that includes glucose as a risk factor. The DECODE Study. *Diabetologia* 2004;47:2118-28.

17. Coutinho M, Gerstein HC, Wang Y, Yusuf S. The relationship between glucose and incident cardiovascular events. A metaregression analysis of published data from 20 studies of 95,783 individuals followed for 12.4 years. *Diabetes Care* 1999;22:233-40.

18. The Emerging Risk Factors Collaboration. Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. *Lancet* 2010;375:2215-22.

19. Sarwar N, Aspelund T, Eiriksdottir G, Gobin R, Seshasai SR, Forouhi NG *et al*. Markers of dysglycaemia and risk of coronary heart disease in people without diabetes: Reykjavik prospective study and systematic review. *PLoS Med* 2010;7:e1000278.

20. Barr EL, Boyko EJ, Zimmet PZ, Wolfe R, Tonkin AM, Shaw JE. Continuous relationships between non-diabetic hyperglycaemia and both cardiovascular disease and all-cause mortality: the Australian Diabetes, Obesity, and Lifestyle (AusDiab) study. *Diabetologia* 2009;52:415-24.

21. Wild SH, Smith FB, Lee AJ, Fowkes FG. Criteria for previously undiagnosed diabetes and risk of mortality: 15-year follow-up of the Edinburgh Artery Study cohort. *Diabet Med* 2005;22:490-6.

22. de Vegt F, Dekker JM, Ruhe HG, Stehouwer CD, Nijpels G, Bouter LM *et al*. Hyperglycaemia is associated with all-cause and cardiovascular mortality in the Hoorn population: the Hoorn Study. *Diabetologia* 1999;42:926-31.

23. Barrett-Connor E, Ferrara A. Isolated postchallenge hyperglycemia and the risk of fatal cardiovascular disease in older women and men. The Rancho Bernardo Study. *Diabetes Care* 1998;21:1236-9.

24. Charles MA, Balkau B, Vauzelle-Kervroedan F, Thibult N, Eschwege E. Revision of diagnostic criteria for diabetes. *Lancet* 1996;348:1657-8.

25. Davies MJ, Gray IP. Impaired glucose tolerance. *British Medical Journal* 1996;312:264-5.

26. Khaw KT, Wareham N, Luben R, Bingham S, Oakes S, Welch A *et al*. Glycated haemoglobin, diabetes, and mortality in men in Norfolk cohort of european prospective investigation of cancer and nutrition (EPIC-Norfolk). *British Medical Journal* 2001;322:15-8.

27. Khaw KT, Wareham N, Bingham S, Luben R, Welch A, Day N. Association of hemoglobin A1c with cardiovascular disease and mortality in adults: the European prospective investigation into cancer in Norfolk. *Annals of Internal Medicine* 2004;141:413-20.

28. Muntner P, Wildman RP, Reynolds K, Desalvo KB, Chen J, Fonseca V. Relationship between HbA1c level and peripheral arterial disease. *Diabetes Care* 2005;28:1981-7.

29. Tan HH, McAlpine RR, James P, Thompson P, McMurdo MET, Morris AD *et al*. Diagnosis of type 2 diabetes at an older age: Effect on mortality in men and women. *Diabetes Care* 2004;27:2797-9.

30. Kahn R, Alperin P, Eddy D, Borch-Johnsen K, Buse J, Feigelman J *et al*. Age at initiation and frequency of screening to detect type 2 diabetes: a cost-effectiveness analysis. *Lancet* 2010;375:1365-74.

31. Riste L, Khan F, Cruickshank K. High prevalence of type 2 diabetes in all ethnic groups, including Europeans, in a British inner city: relative poverty, history, inactivity, or 21st century Europe? *Diabetes Care* 2001;24:1377-83.

32. Lindstrom J, Tuomilehto J. The diabetes risk score: a practical tool to predict type 2 diabetes risk. *Diabetes Care* 2003;26:725-31.

33. Rahman M, Simmons RK, Harding AH, Wareham NJ, Griffin SJ. A simple risk score identifies individuals at high risk of developing Type 2 diabetes: a prospective cohort study. *Fam Pract* 2008;25:191-6.

34. Hippisley-Cox J, Coupland C, Robson J, Sheikh A, Brindle P. Predicting risk of type 2 diabetes in England and Wales: prospective derivation and validation of QDScore. *British Medical Journal* 2009;338:b880.

35. Griffin SJ, Little PS, Hales CN, Kinmonth AL, Wareham NJ. Diabetes risk score: towards earlier detection of type 2 diabetes in general practice. *Diabetes Metab Res Rev* 2000;16:164-71.

36. Witte DR, Shipley MJ, Marmot MG, Brunner EJ. Performance of existing risk scores in screening for undiagnosed diabetes: an external validation study. *Diabet Med* 2010;27:46-53.

37. Spijkerman A, Griffin S, Dekker J, Nijpels G, Wareham NJ. What is the risk of mortality for people who are screen positive in a diabetes screening programme but who do not have diabetes on biochemical testing? Diabetes screening programmes from a public health perspective. *Journal of Medical Screening* 2002;9:187-90.

38. Paddison CA, Eborall HC, Sutton S, French DP, Vasconcelos J, Prevost AT *et al*. Are people with negative diabetes screening tests falsely reassured? Parallel group cohort study embedded in the ADDITION (Cambridge) randomised controlled trial. *British Medical Journal* 2009;339:b4535.

39. Simmons RK, Sharp S, Boekholdt SM, Sargeant LA, Khaw KT, Wareham NJ *et al*. Evaluation of the Framingham risk score in the European Prospective Investigation of Cancer-Norfolk cohort: does adding glycated hemoglobin improve the prediction of coronary heart disease events? *Arch Intern Med* 2008;168:1209-16.

40. Qiao Q, Keinanen-Kiukaanniemi S, Rajala U, Uusimaki A, Kivela SL. Random capillary whole blood glucose test as a screening test for diabetes mellitus in a middle-aged population. *Scandinavian Journal of Clinical & Laboratory Investigation* 1995;55:3-8.

41. American Diabetes Association. Report of the expert committee on the diagnosis and classification of diabetes mellitus. *Diabetes Care* 2003;26 Suppl 1:S5-20.

42. Gerstein HC. Glycosylated hemoglobin: finally ready for prime time as a cardiovascular risk factor. *Annals of Internal Medicine* 2004;141:475-6.

43. Sabanayagam C, Liew G, Tai ES, Shankar A, Lim SC, Subramaniam T *et al*. Relationship between glycated haemoglobin and microvascular complications: is there a natural cut-off point for the diagnosis of diabetes? *Diabetologia* 2009;52:1279-89.

44. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care* 2010;33 Suppl 1:S62-S69.

45. Skriver MV, Borch-Johnsen K, Lauritzen T, Sandbaek A. HbA1c as predictor of all-cause mortality in individuals at high risk of diabetes with normal glucose tolerance, identified by screening: a follow-up study of the Anglo-Danish-Dutch Study of Intensive Treatment in People with Screen-Detected Diabetes in Primary Care (ADDITION), Denmark. *Diabetologia* 2010;53:2328-33.

46. Carson AP, Reynolds K, Fonseca VA, Muntner P. Comparison of A1C and fasting glucose criteria to diagnose diabetes among U.S. adults. *Diabetes Care* 2010;33:95-7.

47. Mann DM, Carson AP, Shimbo D, Fonseca V, Fox CS, Muntner P. Impact of A1C screening criterion on the diagnosis of pre-diabetes among U.S. adults. *Diabetes Care* 2010;33:2190-5.

48. Hanson RL, Nelson RG, McCance DR, Beart JA, Charles MA, Pettitt DJ *et al*. Comparison of screening tests for non-insulin-dependent diabetes mellitus. *Archives of Internal Medicine* 1993;153:2133-40.

49. The International Expert Committee. International Expert Committee report on the role of the A1C assay in the diagnosis of diabetes. *Diabetes Care* 2009;32:1327-34.

50. Selvin E, Steffes MW, Zhu H, Matsushita K, Wagenknecht L, Pankow J *et al*. Glycated hemoglobin, diabetes, and cardiovascular risk in nondiabetic adults. *N Engl J Med* 2010;362:800-11.

51. John WG. Haemoglobin A_{1c} towards global standardization. *Diabetic Medicine* 2010;27:733-4.

52. Bao Y, Ma X, Li H, Zhou M, Hu C, Wu H *et al*. Glycated haemoglobin A1c for diagnosing diabetes in Chinese population: cross sectional epidemiological survey. *British Medical Journal* 2010;340:c2249.

53. Kilpatrick ES, Winocour PH. ABCD position statement on haemoglobin A1c for the diagnosis of diabetes. *Practical Diabetes International* 2010;27:306-10.

54. Schindhelm RK, Lenters-Westra E, Slingerland RJ. Glycated haemoglobin A(1c) (HbA(1c)) in the diagnosis of diabetes mellitus: don't forget the performance of the HbA(1c) assay. *Diabet Med* 2010;27:1214-5.

55. Cederberg H, Saukkonen T, Laakso M, Jokelainen J, Harkonen P, Timonen M *et al*. Postchallenge glucose, A1C, and fasting glucose as predictors of

type 2 diabetes and cardiovascular disease: a 10-year prospective cohort study. *Diabetes Care* 2010;33:2077-83.

56. Mostafa SA, Davies MJ, Webb D, Gray LJ, Srinivasan BT, Jarvis J *et al*. The potential impact of using glycated haemoglobin as the preferred diagnostic tool for detecting Type 2 diabetes mellitus. *Diabetic Medicine* 2010;27:762-9.

57. Borg R, Vistisen D, Witte DR, Borch-Johnsen K. Comparing risk profiles of individuals diagnosed with diabetes by OGTT and HbA1c The Danish Inter99 study. *Diabet Med* 2010;27:906-10.

58. Lorenzo C, Wagenknecht LE, Hanley AJG, Rewers MJ, Karter AJ, Haffner SM. A1C between 5.7 and 6.4% as a marker for identifying pre-diabetes, insulin sensitivity and secretion, and cardiovascular risk factors: the Insulin Resistance Atherosclerosis Study (IRAS). *Diabetes Care* 2010;33:2104-9.

59. Selvin E, Steffes MW, Bergenstal R, Coresh J, Brancati FL. 2010 American Diabetes Association (ADA) Cut-Points for Glycated Hemoglobin (A1c) and the Risk of Diabetes, Kidney, and Cardiovascular Disease. *American Diabetes Association 70th Scientific Sessions* 2010;Abstract Number : 44-LB.

60. Chatterjee R, Narayan K, Lipscomb J, Kolm P, Phillips L. Screening for Diabetes and Prediabetes Should Be Cost-Saving in High-Risk Patients. *American Diabetes Association 70th Scientific Sessions* 2010;Abstract Number: 65-LB.

61. Abdul-Ghani MA, DeFronzo RA. Plasma glucose concentration and prediction of future risk of type 2 diabetes. *Diabetes Care* 2009;32 Suppl 2:S194-S198.

62. Takahashi O, Farmer AJ, Shimbo T, Fukui T, Glasziou PP. A1C to detect diabetes in healthy adults: when should we recheck? *Diabetes Care* 2010;33:2016-7.

63. Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *New England Journal of Medicine* 2002;346:393-403.

64. Lindstrom J, Ilanne-Parikka P, Peltonen M, Aunola S, Eriksson JG, Hemio K *et al*. Sustained reduction in the incidence of type 2 diabetes by lifestyle intervention: follow-up of the Finnish Diabetes Prevention Study. *Lancet* 2006;368:1673-9.

65. Absetz P, Oldenburg B, Hankonen N, Valve R, Heinonen H, Nissinen A *et al*. Type 2 diabetes prevention in the real world: three-year results of the GOAL lifestyle implementation trial. *Diabetes Care* 2009;32:1418-20.

66. Norris SL, Zhang X, Avenell A, Gregg E, Schmid CH, Lau J. Long-term non-pharmacological weight loss interventions for adults with prediabetes. *Cochrane Database Syst Rev* 2005;CD005270.

67. Perry IJ, Villegas R, Salim A, Flynn A. Clustering of protective factors for glucose intolerance and insulin resistance: a cross-sectional study. *Diabetic Medicine* 2005;22:1091-7.

68. Goldstein DJ. Beneficial health effects of modest weight loss. *Int J Obes Relat Metab Disord* 1992;16:397-415.

69. Clinical Standards Board for Scotland. Clinical Standards. Diabetes. http://www.nhshealthquality.org/nhsqis/files/Diabetes%20Oct%202002.pdf 2002 (accessed 7 July 2009)

70. Scottish Executive. Diabetes in Scotland: Current challenges and future opportunities Reviewing the Scottish Diabetes Framework. http://www.scotland.gov.uk/Publications/2004/11/20236/46458 2004 (accessed 7 July 2009)

71. Cromie, D. and Teo, P. Diabetes Mellitus. Glasgow: Scottish Needs Assessment Programme. Acute Services Network. 1999.

72. Scottish Intercollegiate Guidelines Network. Management of Diabetes. SIGN Guideline 55. http://www.sign.ac.uk/guidelines/fulltext/55/index.html 2001 (accessed 7 July 2009)

73. NHS Quality Improvement Scotland. National Overview Follow-up Report: Diabetes. http://www.nhshealthquality.org/nhsqis/files/DIABETES_NOV_MAR08Final.pdf 2004 (accessed 7 July 2009)

74. NHS Quality Improvement Scotland. National Overview: Diabetes. http://www.nhshealthquality.org/nhsqis/files/diabetes%20-%20National.pdf 2009 (accessed 7 July 2009)

75. Scottish Executive. Scottish Diabetes Framework. http://www.scotland.gov.uk/Publications/2002/04/14452/1980 2002

76. The Scottish Government. Better Diabetes Care. A Consultation Document. (Draft). http://www.scotland.gov.uk/Publications/2009/05/28085904/0 . 2009. 2009 Jul 7;

77. Scottish Diabetes Survey Monitoring Group. Scottish Diabetes Survey 2007. http://www.diabetesinscotland.org.uk/Publications/Scottish%20Diabetes%20Survey%202007.PDF 2008 (accessed 7 July 2009)

78. NHS Health Scotland. Keep well. http://www.keepwellscotland.com/ 2009 (accessed 9 July 2009)

79. General Register Office for Scotland. Mid-2008 Populations Estimates Scotland. http://www.gro-scotland.gov.uk/statistics/publications-and-data/population-estimates/mid-2008-population-estimates-scotland/index.html 2009 (accessed 9 July 2009)

80. Farman P. Well North (Remote and Rural Anticipatory Care). http://www.nhshighland.scot.nhs.uk/Meetings/BoardsMeetings/Documents/Board%20Meeting%206%20May%202008/5.1%20Well%20North%20Anticipatory%20Care.doc 2008 (accessed 9 July 2009)

81. Scottish Diabetes Managed Clinical Network. Delivering the Diabetes Action Plan. Progress report - Q2 2008/2009, 1 July to 30 September 2008, Summary. 2009. Scottish Diabetes Managed Clinical Network.

82. National Institute for Health and Clinical Excellence. Type 2 diabetes: the management of type 2 diabetes (update).Clinical Guideline:CG66. 2009 http://www.nice.org.uk/Guidance/CG66 (accessed 25 September 2008)

83. Calvert MJ, McManus RJ, Freemantle N. Management of type 2 diabetes with multiple oral hypoglycaemic agents or insulin in primary care: retrospective cohort study. *Br J Gen Pract* 2007;57:455-60.

84. Rubino A, McQuay LJ, Gough SC, Kvasz M, Tennis P. Delayed initiation of subcutaneous insulin therapy after failure of oral glucose-lowering agents in patients with Type 2 diabetes: a population-based analysis in the UK. *Diabet Med* 2007;24:1412-8.

85. Hayward RA, Manning WG, Kaplan SH, Wagner EH, Greenfield S. Starting insulin therapy in patients with type 2 diabetes: effectiveness, complications, and resource utilization. *JAMA* 1997;278:1663-9.

86. Marrero DG. Overcoming patient barriers to initiating insulin therapy in type 2 diabetes mellitus. *Clin Cornerstone* 2007;8:33-40.

87. Hummel J, Kuhner C, Kopf D, Krumm B, Deuschle M, Lederbogen F. Psychosocial barriers to starting insulin therapy in type 2 diabetes mellitus. *Diabetes Res Clin Pract* 2008;82:e25-e26.

88. Aas AM, Bergstad I, Thorsby PM, Johannesen O, Solberg M, Birkeland KI. An intensified lifestyle intervention programme may be superior to insulin treatment in poorly controlled Type 2 diabetic patients on oral hypoglycaemic agents: results of a feasibility study. *Diabetic Medicine* 2005;22:316-22.

89. UK National Screening Committee. Criteria for appraising the viability, effectiveness and appropriateness of a screening programme. 2009, June http://www.screening.nhs.uk/criteria (accessed 7 July 2009)

90. Greaves CJ, Sheppard K, Abraham C, Evans P, Roden M, Schwarz P. Health psychology in action: Preventing type 2 diabetes: Recommendations on achieving lifestyle change from the IMAGE guideline development project. *Psychology & Health* 2008;23:17.

Appendix 1 Does screening for type 2 diabetes and IGT meet the criteria of the National Screening Committee?

The UK National Screening Committee (NSC) criteria for evaluating screening programmes were adapted from the WHO criteria published in 1966. The criteria are published by the NSC on their website.[89] The HTA report on screening considered the case for it against the NSC criteria. Most criteria were met, but not all.[2]

The Condition

1. The condition should be an important health problem

Met for both diabetes and IGT

2. The epidemiology and natural history of the condition, including development from latent to declared disease, should be adequately understood and there should be a detectable risk factor, disease marker, latent period or early symptomatic stage.

Diabetes – partially met, for two reasons. Firstly, the terminology is not quite right, since rather than a latent period, there can be an asymptomatic period during which undiagnosed diabetes can be causing microvascular or macrovascular damage. Secondly, the natural history of the pre-diabetic condition is not fully understood, in that there is uncertainty about the duration and speed of progression of the pre-diabetic stage, and about the duration of undiagnosed diabetes.

IGT – partially understood. We do not know why some people progress, but most do not. Nor do we know if the progression is linear, or initially slow with a rapid decline.

But despite uncertainties, enough is known to justify the criterion being met.

3. All the cost-effective primary prevention interventions should have been implemented as far as practicable

Diabetes and IGT – debatable. We know what people should do to avoid developing both conditions – lifestyle measures such as maintaining a healthy weight and diet, and physical activity. But we don't know how to persuade them to do so.

4. If the carriers of a mutation are identified as a result of screening the natural history of people with this status should be understood, including the psychological implications.

Not applicable.

The Test

5. There should be a simple, safe, precise and validated screening test

Met for both diabetes and IGT, although there are several test options..

6. The distribution of test values in the target population should be known and a suitable cut-off level defined and agreed

Met for diabetes, though as usual there are trade-offs between sensitivity and specificity. The English Vascular Risk manual suggests a cut-off for HbA_{1c} of <6% as normal, and a level of 6.5% or over as confirming diabetes if symptoms are present. The intermediate results require further investigation. However the International Expert Group[49] regard an HbA_{1c} of 6.5% as diagnostic.

For IGT, things are less certain, because most research into the use of HbA_{1c} has been for its use in screening for diabetes, and less is known about its performance in distinguishing IGT from normality. The EPIC and other results show a clear gradient of HbA_{1c} and vascular disease.

7. The test should be acceptable to the population

Given a fully informed public, one might expect screening to be acceptable, and bodies such as Diabetes UK support it. Those who did not wish to accept screening would not need to do so.

Met.

8. There should be an agreed policy on the further diagnostic investigation of individuals with a positive test result and on the choices available to those individuals.

Met for diabetes.

Those with HbA_{1c} levels of 6.0% to 6.4% would be given intensive lifestyle advice and re-screened one year later. If they had failed to improve on lifestyle alone, metformin would be added.

9 If the test is for mutations the criteria used to select the subset of mutations to be covered by screening, if all possible mutations are not being tested, should be clearly set out.

Not applicable.

The Treatment

10. There should be an effective treatment or intervention for patients identified through early detection, with evidence of early treatment leading to better outcomes than late treatment

Met. Lifestyle change is effective in both conditions, and drug treatment with metformin is cost-effective if lifestyle fails, or if people do not adhere. Note that treatment is not just to reduce glucose levels, but that the diagnosis can trigger measures to reduce cardiovascular risk, such as statin treatment.

11. There should be agreed evidence based policies covering which individuals should be offered treatment and the appropriate treatment to be offered
Met.

12. Clinical management of the condition and patient outcomes should be optimised in all health care providers prior to participation in a screening programme
Not met – many people with type 2 diabetes do not have their condition optimally controlled. The Scottish Diabetes Survey shows that about 40% of all people with diabetes have HbA_{1c} above 7.5%. (But note that targets should be tailored to the individual, and for many elderly people, seeking to achieve the NICE target of 6.5% is undesirable. And in the wake of trials such as ADVANCE, ACCORD and VADT, it may be that we should not aim to go below 7%).

The Screening programme

13. There should be evidence from high quality Randomised Controlled Trials that the screening programme is effective in reducing mortality or morbidity.
Not met. The ADDITION trial is underway but will not report for a few more years.

14. There should be evidence that the complete screening programme (test, diagnostic procedures, treatment/ intervention) is clinically, socially and ethically acceptable to health professionals and the public
Screening would be offered, and this criterion would be met by those who accepted.

15. The benefit from the screening programme should outweigh the physical and psychological harm (caused by the test, diagnostic procedures and treatment)
Uncertain. The Hoorn study suggests that those diagnosed were not unduly anxious because they felt they could deal with the condition. A bigger problem might be those, screened on the grounds of being higher risk, who are screen-negative and reassured – would they feel so reassured that they continued unhealthy lifestyles?

16. The opportunity cost of the screening programme (including testing, diagnosis and treatment, administration, training and quality assurance) should be

economically balanced in relation to expenditure on medical care as a whole (i.e. value for money).
Met – see HTA report on screening.

17. There should be a plan for managing and monitoring the screening programme and an agreed set of quality assurance standards.
Not yet applicable.

18. Adequate staffing and facilities for testing, diagnosis, treatment and programme management should be available prior to the commencement of the screening programme
Not met at present? Screening would be done in General Practice, and GPs would no doubt request additional resources. There would be some minor administrative costs for selecting the high risk people; then the HbA_{1c} test. The main costs would follow – informing patients of the results and their implications, and then providing lifestyle intervention including dietetic time.

19. All other options for managing the condition should have been considered (e.g. improving treatment, providing other services), to ensure that no more cost effective intervention could be introduced or current interventions increased within the resources available.

Uncertain. In theory, an effective health education campaign to encourage people to keep weight down and take exercise would prevent much of the cases. However health education appears to be ineffective. Should we try harder? Is there a danger of "medicalising" unhealthy lifestyles and discouraging people from taking personal responsibility for their own health?

20. Evidence-based information, explaining the consequences of testing, investigation and treatment, should be made available to potential participants to assist them in making an informed choice.
Would be met.

21. Public pressure for widening the eligibility criteria for reducing the screening interval, and for increasing the sensitivity of the testing process, should be anticipated. Decisions about these parameters should be scientifically justifiable to the public.
Uncertain.

22. If screening is for a mutation the programme should be acceptable to people identified as carriers and to other family members.

Not applicable.

Appendix 2

The IMAGE report.

The IMAGE group have produced a systematic review of the evidence for behaviour change. The review starts by summarising the stages of change;

- Establishing an intention to change
- Making plans for change
- Overcoming barriers
- Making the changes
- Maintaining the new routine, resisting temptations to slip back to old ways

The IMAGE report reviewed systematic reviews of interventions aimed at preventing diabetes in those at risk, including those who were overweight or obese, sedentary, hypertensive, had IFG or IGT, metabolic syndrome and other cardiovascular risk factors.[90]

The main conclusions are in the box below

IMAGE: Conclusions and Recommendations

There is strong evidence that individual level dietary and /or physical activity interventions can produce significant and clinically meaningful changes in weight and physical activity. There is also strong evidence that weight loss from such interventions can be sustained for 3 to 7 years (although this is not always the case), that interventions can be implemented successfully by a wide range of people in a wide range of settings, and that they can be effective for a wide range of ethnic and age groups. However, there are many examples of unsuccessful as well as successful interventions, especially when longer-term effectiveness is considered. This reflects the wide heterogeneity in intervention content reported by most review authors. Identifying the elements of intervention content which are associated with effectiveness was a major aim of this review.

Our analysis of the data from 30 high quality reviews of dietary and /or physical activity interventions reveals that more intensive interventions (defined in terms of frequency or total number of contacts) which use established behaviour change techniques, and those which address both diet and physical activity seem to be the most effective. There are some indications that interventions which include specific components designed to: a) encourage change, and b) maintain change (see evidence sections for details) are likely to be more effective.

The comprehensive research versions of the Finnish and US diabetes prevention programmes possess all of the properties outlined above. As the largest studies showing a direct and sustained effect on prevention of type 2 diabetes these can therefore be considered as gold standard interventions in this area. However, pragmatically the level of resources (money and qualified personnel) required to implement these interventions in the European Community may vary from country to country and methods for optimising interventions to deliver the best balance of effectiveness and cost are required. To this end, we will now provide recommendations, based on the review-level evidence examined, on how to optimise the design of dietary and /or physical activity interventions.

Recommendations for practice

Interventions aimed at dietary change and increases in physical activity should be offered to people at high risk of developing type 2 diabetes.

A training curriculum reflecting the recommendations below should be developed and

implemented for adults at risk of type 2 diabetes.

Individual level interventions for people at risk of type 2 diabetes should …

A Aim *to support changes in both diet and physical activity*

A *Use established, well defined behaviour change techniques (e.g. Specific goal-setting, relapse prevention, self-monitoring, motivational interviewing, prompting self-talk, prompting practice, individual tailoring, time management).*

A *Work with participants to engage social support (i.e. to engage others who are important to them such as family, friends, and colleagues) in supporting the planned behaviour change.*

B *Maximize the frequency or number of contacts, at least in the active intervention phase (the stage where motivation is established, plans made and new behaviour(s) initiated and practiced), within the resources available.*

A *Include a strong focus on maintenance. It is not clear how best to achieve behaviour maintenance but behaviour change techniques designed to address maintenance include establishing self-monitoring of progress, providing feedback (e.g. on changes achieved in blood glucose and other diabetes /cardiovascular risk factors), reviewing of goals, engaging social support, use of relapse prevention /relapse management techniques and providing follow-up prompts (e.g. by letter, telephone).*

C *Building on the coherent set of intervention techniques represented by Control Theory (Specific goal setting; Prompting self-monitoring; Providing feedback on performance; Review of behavioural goals) may provide a good starting point for intervention design. However, this is by no means the only approach available.*

A *Interventions to prevent type 2 diabetes may be delivered by a wide range of people /professions, subject to appropriate training (including the use of established behaviour change techniques). There are numerous examples of successful physical activity and /or dietary interventions delivered by doctors, nurses, dieticians /nutritionists, exercise specialists and lay people, often working within a multi-disciplinary team.*

A *Interventions to prevent type 2 diabetes may be delivered in a wide range of settings. There are numerous examples of successful physical activity and /or dietary interventions delivered, in health care settings, the workplace, the home, and in the*

community.

A *Interventions to prevent type 2 diabetes may be delivered using group, individual or mixed modes (individual and group). There are numerous examples of successful physical activity and /or dietary interventions intervention using each of these delivery modes.*

D *People planning and delivering interventions should consider whether adaptations are needed for different ethnic groups (particularly with regard to culturally-specific dietary advice), people with physical limitations and people with mental health problems.*

D *A training curriculum reflecting the recommendations above should be developed and made available to healthcare providers wishing to develop programmes for the prevention of type 2 diabetes.*