

Screening for diabetes in unconventional locations: resource implications and economics of screening in optometry practices

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Abstract

Objectives: *Unconventional locations outwith general medical practice may prove opportunities for screening. The aim was to determine the resource implications and economics of a screening service using random capillary blood glucose (rCBG) tests to detect raised blood glucose levels in the “at risk” population attending high street optometry practices.*

Method: *A screening service was implemented in optometry practices in North East England: the cost of the service and the implication of different screening strategies was estimated.*

Results: *The cost of a screening test was £5.53-£11.20, depending on the screening strategy employed and who carried out the testing. Refining the screening strategy to target those ≥ 40 years with BMI of $\geq 25 \text{ kg/m}^2$ and/or family history of diabetes resulted in a cost per case referred to the GP of £14.38-£26.36. Implementing this strategy in half of optometric practices in England would have the potential to identify up to 150,000 new cases of diabetes and prediabetes a year.*

Conclusions: *Optometry practices provide an effective way of identifying people who would benefit from further investigation for diabetes. Effectiveness could be improved further by improving cooperation and communication between optometrists and medical practitioners.*

Keywords: *Type 2 diabetes, screening, optometry*

Introduction

Diabetes and its associated complications place a large burden not only on health services, but on the wider society in terms of social care and loss of productivity due to earlier mortality and illness [1,2]. It is known that improved glycaemic control leads to better outcomes for people with diagnosed diabetes [3, 4]. It is not yet clear whether outcomes are improved with earlier detection of disease through screening, although studies are currently underway to evaluate this [5]. Currently, while universal screening is not felt to be cost effective, targeted screening is recommended [6]. As the prevalence of undiagnosed disease has been calculated to be as high as 50% [7] despite the presence of screening programmes, ways of targeting screening to those at risk of disease who are not accessing current services are increasingly important.

In the UK, screening has traditionally been the preserve of the family doctors [8] though, more recently, pharmacists have developed guidelines for screening [9, 10]. Despite these services many people are still undiagnosed.

The use of random Capillary Blood Glucose (rCBG) tests as the initial step of screening people with known risk factors for diabetes has been used in studies in family doctors practices [5] and can also be used effectively in other locations, such as pharmacies [9, 10] to identify those who would benefit from further investigations who may not attend their doctors' surgeries. It has the benefit that, as fasting is not required, it can be used opportunistically. A pilot study was implemented in optometry (opticians) practices to determine the feasibility of carrying out rCBG screening in this location [11].

Aims

To determine the resource implications and cost effectiveness of using rCBG tests to detect raised blood glucose levels in “at risk” population attending optometry practices.

Materials and Methods

A screening service was implemented in 5 optometry practices in North East England for 4 weeks in each location. Adults attending for sight tests were given a list of risk factors for diabetes, those who reported the presence of at least one risk factor or symptom of diabetes [10] were offered a rCBG test. Risk factors are shown in figure 1. If the optometrist found any ocular findings suggestive of diabetes, a rCBG was also offered. rCBG tests were carried out using a Bayer Contour® meter. This meter uses a 0.6µl sample of whole blood and converts the reading to plasma equivalent. All participants were given the results of the rCBG tests immediately. The risk factors reported were recorded. Those with a rCBG measurement of 6.1mmol/l or more were advised to see their GP for further investigation in line with Diabetes UK/RPSGB guidelines [10]. Participants were sent a postal questionnaire four to six weeks after the screening test to determine whether they had seen their GP, whether any tests had been carried out and if any diagnosis had been given. Full results of screening are detailed elsewhere [11].

Fig 1 Inclusion criteria (from Diabetes UK [10])

Different screening strategies were analysed to determine the cost of screening tests, cost per case of rCBG ≥ 6.1 mmol/l detected and cost per case of diabetes or pre-diabetes detected. The potential resource implications of implementing the service on a local level and countrywide was extrapolated.

Results

1002 adults were screened in a 20 week period. Of these, 318 were found to have a rCBG of ≥ 6.1 mmol/l and so required further investigation.

Of the 318 referred, 138 visited their GP and were investigated further, 24 visited their GP and received no further tests and 66 reported that they did not attend their GP. No response was received from the remaining 90 participants. Of the 138 who were tested, 16 (11.6%) were diagnosed with diabetes or prediabetes.

There was no significant difference in mean rCBG for those responding to the questionnaire and those not (respondents 7.28mmol/l, non-respondents 7.10mmol/l; $p=0.226$). There was also no significant difference between mean rCBG for those attending their GP and being investigated and those who attended but were not investigated (7.49mmol/l and 7.08mmol/l respectively; $p=0.23$).

If full follow up had been achieved, with all participants attending their GP for further tests and reporting the results back to the investigators, and assuming the same underlying detection rate of 11.6%, 37 new cases of diabetes and prediabetes could have been detected. Thus the rate of undiagnosed diabetes and prediabetes lay between 1.6% and 3.7%.

Cost of single test

The cost of carrying out a single blood glucose test has three aspects; cost of the equipment, the cost of the time taken to administer the test and cost of training.

Equipment and time costs per test are fixed for each test no matter how many are carried out. The cost of materials was calculated to be £0.63 (12) and the time to be £9 (assuming a 15 minute consultation with an optometrist).

Training costs vary depending in how many professionals attend training at a time and how many rCBG tests each can performed between reaccreditation points. 1002 tests were carried out over the 20 weeks period with rCBG testing carried out on 120 days. The mean number of tests carried out per day was 8.35. Between 1 and 3 optometrists were in a practice carrying out sight tests each day, with the equivalent of 212.5 optometrists days testing occurring in the study period. The mean number of tests carried out each day per optometrist was 4.72.

If it is assumed that an optometrist works 240 days a year, 1133 rCBG tests would be carried out by one person during the course of one year. If a one-day training course is required to validate an individual for 2 years, training one person will allow 2266 tests to be carried out over a 2 year period. If 10 optometrists attend one one-day training session, the cost of developing the course materials and running the course will be shared between 22660 rCBG tests. Taking into account the cost of organising and running a training day (£1000) and including locum cover for the ten optometrists attending the training (£500 per optometrist), the cost of training per rCBG that will be carried out will be £0.26 leading to an estimated total cost for carrying out a rCBG test of £9.90.

By far the most important cost component of the screening test is the optometrists' time, costing is not sensitive to variation in the other cost components.

We carried out 1002 rCBG tests, which subsequently led to 318 people being identified who would benefit from further investigations as they had a rCBG of ≥ 6.1 mmol/l. This results in a cost per case requiring further investigation detected of £32. 16 diagnosed with diabetes or pre-diabetes from visiting the GP, providing a cost per case of hyperglycaemia detected of £620.

Assuming the same detection rate and testing all 318 people identified, the cost per case of hyperglycaemia detected would be reduced to £268.

Cost of different screening strategies

A range of different strategies to identify those at risk who would benefit from screening have been explored. Hoerger et al. suggested that the most cost effective strategy would be to screen only hypertensive people aged between 55 and 75 years [13]. This strategy would have reduced the number of test carried out in our population to 163, 67 (41.1%) would have had a rCBG of ≥ 6.1 mmol/l.

A logistic regression analysis of the risk factors used in this screening programme showed that age, family history and BMI increased the likelihood of having a rCBG measurement of 6.1mmol/l or more, while female gender reduced the likelihood of referral for further investigations [11]. If we chose a strategy of screening only those aged 40 and over with either a family history of diabetes, a BMI of 25kg/m^2 or both, we would have tested 507 of the participants, of which 193 (38.1%) would require further investigation.

It has been suggested that screening asymptomatic people for diabetes is not worthwhile (14). 53.0% of the participants reported symptoms, some of who did not report having any other risk factors. Many of them reported not having been screened previously. If

optometrists' practices are used in order to find "hard to reach" subjects not presenting to other providers, then screening those who report having symptoms may be an obvious step. If we had screened those aged 40 years and over with at least one of the following: a family history of diabetes, a BMI of $25\text{kg}/\text{m}^2$ or symptoms, we would have tested 675 people, 237 (35.1%) of who had a rCBG of $6.1\text{mmol}/\text{l}$ or more.

A comparison of the strategy used and the three alternative strategies for identifying people to undergo screening and the potential yield of people diagnosed with diabetes or pre-diabetes and the costs associated with each strategy are shown in table 1. The lower limit of the yield is calculated from actual rate found and the upper limit from potential yield with full follow up assuming the same underlying detection rate in those who were not tested or did not respond to the questionnaire.

Table 1 - Comparison of 4 strategies for identifying people at risk to undergo screening

Analysis of costs associated with people undertaking screening

The cost of the time taken to administer the screening tests is the most significant factor affecting the total cost of screening. The cost of £10.14 per screening test assumes that the whole procedure would be carried out by an optometrist. This is the most expensive option. It should be possible for optical assistants to carry out some of the paperwork prior to the test. Currently optical assistants collect information from the patients and carry out some routine screening tests for optometrists. If the assistant was to carry out the screening alone, the cost of the time to perform the test would be £4.50 (assuming £18 per hour for optical assistants): a reduction of £4.50 a test. If the 15 minutes taken for the test is broken down into 10 minutes with the optical assistant and 5 minutes with the optometrist, the cost of time is reduced from £9 with the optometrist only to £6; a reduction of £3 per test. The cost of training would also vary; while the cost of running the training would remain the same at £1000, the cost of locum cover would vary. If it is assumed that one training course allow 22660 tests to be carried out over a 2 year period as calculated previously, for 10 assistants to undertake the training would cost £2,500 in cover, compared with £5,000 for 10 optometrists, resulting in a training cost per test of £0.15. If both optometrists and assistants carry out the tests, both would need to attend training. If 10 optometrists and 10 assistants attended each course, again allowing 22660 tests to be performed over 2 years, the cost of cover would increase to £7,500, while course development and materials remains at £1000, resulting in training costs of £0.38 per test.

If the screening strategy of offering tests to only those who are over 40 years with either a family history of diabetes or a BMI of 25kg/m^2 is used, the cost per test would be reduced to

£7.26 using both optometrists and assistants. This reduces the cost per case of rCBG ≥ 6.1 mmol/l detected to £18.88. This can be further reduced to £14.38 if only assistants perform the tests. Table 3 shows details of the costs of screening by different people with the practice if a strategy of screening those aged 40 years and over with a BMI of 25kg/m^2 or more or a family history of diabetes.

Table 2 – One way sensitivity analysis of costs of screening if tests are carried out by different people within optometry practices

Resource and economic implications of screening

Screening those aged 40 years or over with a BMI of 25kg/m^2 and over or a family history of diabetes or both appears to be a cost effective method of screening for diabetes in optometric practices. If we had used this method, the number of tests carried out in the 20 week period would have been reduced from 1002 costing £9,920 to 507 costing £5,140. This would be further reduced to £3,680 if optical assistants performed screening in conjunction with the optometrist.

Using this strategy to identify those who would benefit from screening resulted in 25 screening tests each week. We used several different sized practices, with different numbers of optometrists testing and with different opening times. For the purposes of this analysis, it is assumed that the participating practices are typical and that optometrists and optical assistants carry out the procedure. If, on average, 25 screening tests are carried out in a practice each week, with a practice testing for 50 weeks of the year, a single practice would carry out 1250 tests at £7.26 each costing £9,075 in total. If a new case of diabetes or pre-diabetes was detected, on average, every 46 tests, a single practice would potentially

discover 27 new cases each year. With improved communication and follow up this could be improved to 62 cases.

We used practices located in three different Primary Care Trusts (PCTs): County Durham, Redcar & Cleveland and Hartlepool. Hartlepool PCT has a population base of 91,000 [15], Redcar & Cleveland a population of 139,500 [16] and County Durham 504,900 [17]. There are 9 optometry practices in Hartlepool, 11 in Redcar & Cleveland and 54 in County Durham; approximately 1 practice for every 10,000 people. The approximate costs for extending the service to the whole of England has been estimated assuming a population of 51 million and one practice serving 10,000 people. If the cost per test is £7.26 and 1,250 tests are carried out per year by each practice, there is the potential to carry out 6,375,000 screening tests in England costing £46,282,500. If the lower limit for the yield of new cases of diabetes or pre-diabetes is one found for every 46 rCBG tests, around 138,000 new cases could be found in a year. If full follow up could be achieved this would increase to over 300,000.

These estimates assume all practices will offer the screening tests. However, this is unlikely to be case. If half the practices in England take up the screening programme offering screening to those aged 40 years and over with either family history of diabetes or a BMI of 25kg/m² or more, the total cost for one year of screening would be just over £23 million, with a lower limit of nearly 70,000 new cases of diabetes or pre-diabetes discovered. With improved follow up this would be up to 15,000.

The costs to the PCTs are shown in table 3, assuming 50% of practices participate and optical assistants and optometrists perform the tests.

Table 3 - Costs to PCT and England of screening those aged 40 years or over with one of the following risk factors: BMI of 25kg/m² and over, a family history of diabetes if 50% take up and optical assistants and optometrists carry out tests

Discussion

Under a range of models and assumptions, optometrists screening appears to be a cost-effective modality for identifying diabetes and prediabetes in hard to reach populations not accessing general practice.

An Australian pharmacy study, using similar methods and equipment estimated the price per test to be Aus\$11.83 (£7.48; 2007 prices, 1Aus\$=£0.63) [18]. This used a combination of assistant and pharmacist carrying out the procedure with the time broken down into 10 minutes with a pharmacy assistant and 5 minutes with the pharmacist. An analysis of the use of rCBG as a method of opportunistic screening at US physicians offices calculated the cost per test to be \$32.68 (£21.85; 2007 prices, 1\$=£0.67) [19]. As yet the cost of screening for diabetes in the UK as part of the National Health checks has not been determined. When this data are available it would be possible to compare the costs of screening using these different methods although they may access different populations.

The cost to the practice of carrying out each test would be less than £10 with most of this being the cost of professional time. The equipment to carry out the testing costs less than £1 per test, and does not require a large initial investment. It also does not require a great deal of space to be stored, when compared with other equipment that optometry practices often use for other screening services, such as field machines for glaucoma screening and fundus cameras. The use of time is the major consideration for the practices, both the time

for carrying out the testing and time involved in training. Training time could be covered in an initial one day training session followed by a half day re-accréditation after two years. We have considered the costs involved in the initial two years of screening. Further evaluation of the cost of reaccréditation and re-screening frequencies will have to be considered in future work to determine long-term strategies and costs.

In our study, we were unselective about who to include in the screening programme and used a large number of risk factors, with a minimum of one to be present to be included in the study. Had we used fewer risk factors and been more selective about who we included in the screening we could have reduced the number of screening tests carried out. This increases the overall cost per test, but decreases the cost per case detected and may mean that some of those who were diagnosed would not have participated in the study and have been missed.

While the National Screening Committee does not recommend universal screening, they do suggest that targeting “at risk” groups is justified [6]. Different strategies have been suggested at identifying at risk groups. Screening people with hypertension may be an effective and cost effective screening strategy in some situations [13]. However it relies on the diagnosis of hypertension. If an individual is aware of the diagnosis, it is likely that they are accessing healthcare via their family doctor. While this method of deciding who to screen may be cost-effective in medical practices, if we are to find those hard to reach people who are not regularly accessing other services, this would not be an effective strategy to use in optometrists’ practices.

Logistic regression showed the BMI of $25\text{kg}/\text{m}^2$ or more, family history of diabetes and increased age increased the likelihood of having a rCBG of $6.1\text{mmol}/\text{l}$ or more [11]. None of these risk factors require the participants to have previously attended a GP. Though people may misreport their weight and height [20,21], resulting in underreporting of obesity levels, over 40% of participants in our study reported that they had a BMI of $25\text{kg}/\text{m}^2$ or more, suggesting that people are willing to report this as a risk factor[11]. Only screening those aged 40 years or more with either a family history of diabetes or self reported BMI of $25\text{kg}/\text{m}^2$ or more would have halved the number of tests carried out, and identified around two thirds of those who were diagnosed with hyperglycaemia following participation in the study.

An argument made against screening is that there is insufficient evidence that testing asymptomatic people is worthwhile [19]. This assumes that people with symptoms will seek out medical attention. However, over half the participants reported symptoms in response to a questionnaire and only a quarter of participants reported that they had been tested for diabetes previously [11]. People with mild symptoms may not be attending their GP as they may not realise that their symptoms may be indicative of diabetes, or that they do not perceive their symptoms as being serious enough to warrant medical attention. Including symptoms in the strategy to identify those at risk, along with age, BMI and family history was shown to be more cost effective than unselected screening (as shown in the baseline analysis in table 1). It is more expensive than the other more selective strategies (age and hypertension and age, BMI and family history), but it identifies more people who have diabetes or pre-diabetes.

The cost per case of diabetes or pre-diabetes diagnosed using the four strategies considered ranged from £112 to £620, depending on the strategy used and who within the practice performed the test, while the cost per case of rCBG of 6.1mmol/l or more detected, as recommended by Diabetes UK [10], ranged from £14 to £32

Limitations

Two factors could improve the cost effectiveness of these screening methods: firstly, recognition of the need to diagnosis pre-diabetic hyperglycaemia which currently appears to be under-diagnosed: and secondly, both professions, optometrists and GPs, to work together towards the same goals. We know that some people attended the GP, but were not investigated further. To calculate the upper limits for the number of people with undetected hyperglycaemia it has been assumed that the underlying rate of undiagnosed disease is the same for both those who reported that they were tested by their GP, those not tested and those who did not respond to the questionnaire. We know that the mean rCBG of respondents and non-respondents are not significantly different.

The extrapolation of the costs and potential new cases of diabetes and prediabetes discovered through this screening method assumes that the sample population is representative of the population of England. We recognise that the population in this study was small, limited to one area of England and predominantly white and this will influence the prevalence of hyperglycaemia. Diabetes is known to more common in the South Asian population. Current recommendations are that this population is screened at a younger age than the white population. This has not been considered in the examination of the different screening strategies as there were insufficient numbers of Black or South Asian participants

in the study to draw any conclusions. In this evaluation we have only considered the cost of screening to the optometrist. We realise that implementing a screening service would result in costs to the GP in terms of time and fasting blood tests and then costs in the longer term to the health service as a whole in terms of medication, follow up care and treatment of complications. The longer term cost of complications in screen detected diabetes compared with diabetes detected in the course of routine practice is not yet known. When this becomes available the full cost of screening services can be evaluated.

Conclusions

Screening in optometry practices has similar cost implications to screening in pharmacies [18] and has the potential to provide services to people who do not utilise services elsewhere. It can provide an effective method for identifying those who would benefit from further investigations, who may not present elsewhere.

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Competing interests

There are no competing interests

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Fig 1 Inclusion criteria (from Diabetes UK [10])

- A. White aged over 40 years or black, Asian and minority ethnic groups aged over 25 with first degree family history of diabetes
- B. White aged over 40 years or black, Asian and minority ethnic groups aged over 25 with BMI of 25 kg/m² and above
- C. Waist measurement of ≥94cm (≥37 inches) for white men aged over 40 years and black men aged over 25 years and ≥90cm (35 inches) for Asian men aged over 25, and ≥80cm (31.5 inches) for white women aged over 40 years and black and Asian women aged over 25 years.
- D. People who have ischaemic heart disease, cerebrovascular disease, peripheral vascular disease or treated hypertension
- E. People who are known to have impaired glucose tolerance or impaired fasting glycaemia
- F. People with severe mental illness (SMI)
- G. People with raised cholesterol
- H. Women who have had gestational diabetes who have tested normal following delivery
- I. Women who have given birth to a baby weighing more than 4kg (8lb 8oz)
- J. Women with polycystic ovary syndrome
- K. People experiencing symptoms of diabetes (Increased thirst, going to the toilet all the time, extreme tiredness, weight loss, genital itching or regular episodes of thrush, slow healing of wounds, blurred vision)
- L. Ocular signs/symptoms of diabetes – dot/blot haemorrhages, recurrent infections, variable refraction, complaints of visual disturbances, early appearance of cataract.

Table 1 - Comparison of 4 strategies for identifying people at risk to undergo screening

	Strategy for identifying those to be screened			
	All Participants	55-75yrs and hypertension	≥40years with BMI of ≥25kg/m ² and/or Family history of diabetes	≥40years with at least one of BMI of ≥25kg/m ² , Family history of diabetes, or symptoms
Number of tests	1002	163	507	675
Tests per optometrist per day	4.73	0.77	2.39	3.18
rCBG ≥6.1mmol/l (% of those tested)	318 (31.7%)	67 (41.1%)	193 (38.1%)	237 (35.1%)
Diagnosed with a hyperglycaemic condition (% of all participants diagnosed)	16	6 (37.5%)	11 (68.8%)	14 (87.5%)
Diabetes	7	2 (28.6%)	4 (57.1%)	6 (85.7%)
Prediabetes	9	4 (44.4%)	7 (77.8%)	8 (88.9%)
No of potential cases of hyperglycaemia assuming full follow up	37	14	25	32
Number of screening tests per case of rCBG ≥6.1mmol/l detected	3.2	2.4	2.6	2.8
Range of number of screening tests per case of hyperglycaemia diagnosed	27.1 - 62.6	11.6 - 27.2	20.3 - 46.1	21.1 - 48.2
Cost per test	£9.90	£11.20	£10.14	£10.02
Cost per case of rCBG ≥6.1mmol/l detected	£31.68	£26.88	£26.36	£28.06
Cost per case of diabetes/prediabetes diagnosed	£268 - £620	£130 - £304	£206 - £467	£211 - £483

Table 2 – One way sensitivity analysis of costs of screening if tests are carried out by different people within optometry practices

	Testing by optometrists	Testing by optometrists and optical assistant	Testing by optical assistants
Cost of time	£9.00	£6.00	£4.50
Cost of Training	£0.26	£0.38	£0.15
Cost per test	£10.14	£7.26	£5.53
Cost per case of rCBG ≥ 6.1 mmol/l detected	£26.36	£18.88	£14.38
Cost per case of diabetes/pre-diabetes diagnosed	£205.64 - £467.36	£147.38 - £334.69	£112.26 - £254.93
Cost of screening in England	£32,321,250	£23,141,250	£17,626,875

Table 3 - Costs to PCT and England of screening those aged 40 years or over with one of the following risk factors: BMI of 25kg/m² and over, a family history of diabetes if 50% take up and optical assistants and optometrists carry out tests

	Hartlepool	Redcar & Cleveland	County Durham	England
Population	91,000	139,500	504,900	51,000,000
Number of optometry practices	9	11	54	5,100
Number of practices offering screening (assume 50%)	4	5	27	2,550
No of screening tests each year (1250 per practice per year)	5,000	6,250	33,750	3,187,500
Cost to PCT for screening in all practices for 1 year ⁺	£36,300	£45,375	£245,025	£23,141,250
Potential new diagnoses of diabetes/pre-diabetes per year*	108 - 246	136 - 308	732 – 1,663	69,143 – 157,020

⁺ Cost per screening test £7.26 (assuming 5 minutes with optometrist and 10 minutes with optical assistant)

*Assumes 1 case diagnosed for every 46.1 test for lower limit, 1 case diagnosed for every 20.3 tests for upper limit