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## Different type 2 diabetes risk assessments predict dissimilar numbers at 'high risk':

a retrospective analysis of diabetes risk-assessment tools

### Abstract

#### Background

Use of a validated risk-assessment tool to identify individuals at high risk of developing type 2 diabetes is currently recommended. It is under-reported, however, whether a different risk tool alters the predicted risk of an individual.

#### Aim

This study explored any differences between commonly used validated risk-assessment tools for type 2 diabetes.

#### Design and setting

Cross-sectional analysis of individuals who participated in a workplace-based risk assessment in Carmarthenshire, South Wales.

#### Method

Retrospective analysis of 676 individuals (389 females and 287 males) who participated in a workplace-based diabetes risk-assessment initiative. Ten-year risk of type 2 diabetes was predicted using the validated QDiabetes<sup>®</sup>, Leicester Risk Assessment (LRA), FINDRISC, and Cambridge Risk Score (CRS) algorithms.

#### Results

Differences between the risk-assessment tools were apparent following retrospective analysis of individuals. CRS categorised the highest proportion (13.6%) of individuals at 'high risk' followed by FINDRISC (6.6%), QDiabetes (6.1%), and, finally, the LRA was the most conservative risk tool (3.1%). Following further analysis by sex, over one-quarter of males were categorised at high risk using CRS (25.4%), whereas a greater percentage of females were categorised as high risk using FINDRISC (7.8%).

#### Conclusion

The adoption of a different valid risk-assessment tool can alter the predicted risk of an individual and caution should be used to identify those individuals who really are at high risk of type 2 diabetes.

#### Keywords

diabetes mellitus, type 2; general practice; primary health care; public health; risk; risk assessment.

### INTRODUCTION

The number of individuals estimated to be living with diabetes in the UK is projected to rise to 3 646 000 by the year 2030, which would see an average increase of 31 000 new cases annually.<sup>1</sup> The National Institute for Health and Care Excellence (NICE) recently introduced guidelines to identify those individuals at 'high risk' of developing type 2 diabetes.<sup>2</sup> These guidelines advocate the use of validated risk-assessment tools, equations, or self-assessment questionnaires to identify high risk individuals.<sup>2</sup> The guidelines further recommend using validated risk scores that take account of routinely collected data in primary care such as the QDiabetes<sup>®</sup> risk calculator<sup>3</sup> or the Cambridge Risk Score.<sup>4</sup> The guidance also states that validated self-assessment questionnaires can be used to identify individuals at high risk, such as the most widely used and validated example, FINDRISC,<sup>5</sup> or the Leicester Risk Assessment.<sup>6</sup>

Comparisons have been made between cardiovascular disease risk equations,<sup>7,8</sup> which have highlighted that a different algorithm can estimate a different value for the 10-year cardiovascular disease

(CVD) risk of an individual. To the authors' knowledge no studies have examined whether adoption of a different validated risk-assessment tool can influence an individual's predicted risk of developing type 2 diabetes. This is significant as those individuals predicted to be at high risk would be eligible for further clinical investigations.<sup>2</sup> The prevention of type 2 diabetes from an economic standpoint in the UK is also a worthy consideration. In 2010–2011 the direct and indirect costs were £8.8 billion and £13.0 billion, which are projected to rise to £15.1 billion and £20.5 billion, respectively, by 2035–2036.<sup>9</sup>

Therefore, the aim of this study was to examine if there were any differences between four commonly used validated risk-assessment tools when applied to the same dataset.

### METHOD

#### Study population

All participants in this study were employees of either the local health board or steel workers within the Welsh region of Carmarthenshire who had received a CVD risk assessment as part of the established Prosiect Sir Gâr workplace-based

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### How this fits in

Type 2 diabetes is one of the greatest public health challenges facing the UK, with an estimated 31 000 new cases being diagnosed each year. At present, however, there is no consensus on which risk assessment tool to use to identify individuals at 'high risk' of developing type 2 diabetes. This research compares four validated risk-assessment tools and examines the number of individuals predicted at high risk. Use of different valid risk-assessment tools can alter the predicted risk of an individual, hence caution should be taken in identification of who really is at high risk of type 2 diabetes.

initiative.<sup>10</sup> The initiative was introduced in 2009 and data collection for this study took place between 2009 and 2012. All current employees over the age of 40 years (if white), or 25 years (if South Asian) with no prior diagnosis of CVD or diabetes were invited to participate in the project. This study focuses on the 676 employees who accepted the invitation of a health assessment, of whom 389 were female and 287 male.

### Baseline measurements

According to a standard operational policy (SOP) all recruited individuals attended a standardised health assessment that lasted 30–40 minutes. During the session, demographic (date of birth, sex, and postcode of residence) and anthropometric (body mass, height, and waist circumference) data, systolic and

diastolic blood pressure, smoking status, family and medical histories were all recorded. Lifestyle questions were asked regarding dietary habits (fruit and vegetable intake), and current physical activity levels were assessed by the General Practice Physical Activity Questionnaire (GPPAQ<sup>11</sup>). Full details of the health assessment appointment, which took place during normal working hours at the employees' workplace, have been published extensively elsewhere.<sup>10</sup>

### Diabetes risk prediction equations

Risk of developing type 2 diabetes was calculated by entering the relevant variables as detailed in Table 1 into the Cambridge Risk Score, FINDRISC, Leicester Risk Assessment, and QDiabetes validated risk assessments. These four risk-prediction tools all feature in the current NICE guidelines,<sup>2</sup> and are either based on routinely collected data (Cambridge Risk Score, QDiabetes) or from cohorts (FINDRISC, Leicester Risk Assessment). The QDiabetes online algorithm calculates a 10-year percentage (%) value of developing type 2 diabetes, whereas the Leicester Risk Assessment and FINDRISC model are questionnaires based on a scoring system that aligns the individual to a risk category and corresponding 10-year risk of developing type 2 diabetes. The Cambridge Risk Score is calculated using a logistic regression model and uses quintiles to express the likelihood of an individual having undiagnosed diabetes. Individuals calculated in the highest-risk quintile are 22 times more likely to develop type 2 diabetes compared with the bottom-risk quintile.<sup>12</sup>

**Table 1. Included variables of the four validated risk assessments**

	Cambridge Risk Score	FINDRISC	Leicester Risk Assessment	QDiabetes®
Age	Y	Y	Y	Y
Sex	Y	Y	Y	Y
Body mass index	Y	Y	Y	Y
Waist circumference	–	Y	Y	–
Ethnicity	–	–	Y	Y
Family history of diabetes	Y	Y	Y	Y
Smoking status	Y	–	–	Y
Antihypertensive medication	Y	Y	Y	Y
Current steroid treatment	Y	–	–	Y
Social deprivation	–	–	–	Y
Physical activity levels	–	Y	–	–
Fruit and vegetable intake	–	Y	–	–
History of high blood glucose	–	Y	–	–

*Variables entered into each of the four validated risk assessments. Y denotes variable entered into risk assessment.*

**Table 2. Baseline characteristics of study population**

	<b>Males (n= 287)</b>	<b>Females (n= 389)</b>	<b>All individuals (n= 676)</b>
Age, years <sup>a</sup>	49 [44–53]	49 [44–54]	49 [44–54]
Height, m <sup>b</sup>	1.76 ± 0.02	1.61 ± 0.03	1.67 ± 0.04
Body mass, kg	88.6 ± 14.7	70.7 ± 13.3	78.3 ± 16.5
Body mass index, kg/m <sup>2b</sup>	28.3 ± 1.7	26.6 ± 1.9	27.3 ± 1.9
Waist circumference, cm	100.9 ± 11.1	89.6 ± 12.5	94.4 ± 13.2
Systolic blood pressure, mmHg <sup>b</sup>	128 ± 5	126 ± 6	127 ± 6
Diastolic blood pressure, mmHg	85 ± 9	82 ± 9	83 ± 9
Family history of diabetes, first degree	69 [24.0]	121 [31.1]	190 [28.1]
Physically active or moderately active, GPPAQ	247 [86.0]	240 [61.7]	487 [72.0]
Cambridge Risk Score <sup>a</sup>	0.215 [0.079–0.370]	0.052 [0.023–0.160]	0.105 [0.036–0.258]
FINDRISC, points <sup>a</sup>	8 [6–11]	9 [6–12]	8 [6–11]
Leicester Risk Assessment, points <sup>a</sup>	13 [9–18]	9 [5–14]	10 [5–15]
QDiabetes <sup>®</sup> , % <sup>b</sup>	6.4 ± 2.4	3.4 ± 1.4	4.5 ± 1.9

Data represented as mean ± standard deviation [SD]. <sup>a</sup>Data represented as median (interquartile range). <sup>b</sup>Data represented as geometric mean ± approximate SD. Discrete variables represented as numbers with percentages in brackets. GPPAQ = General Practice Physical Activity Questionnaire.

**Data analysis**

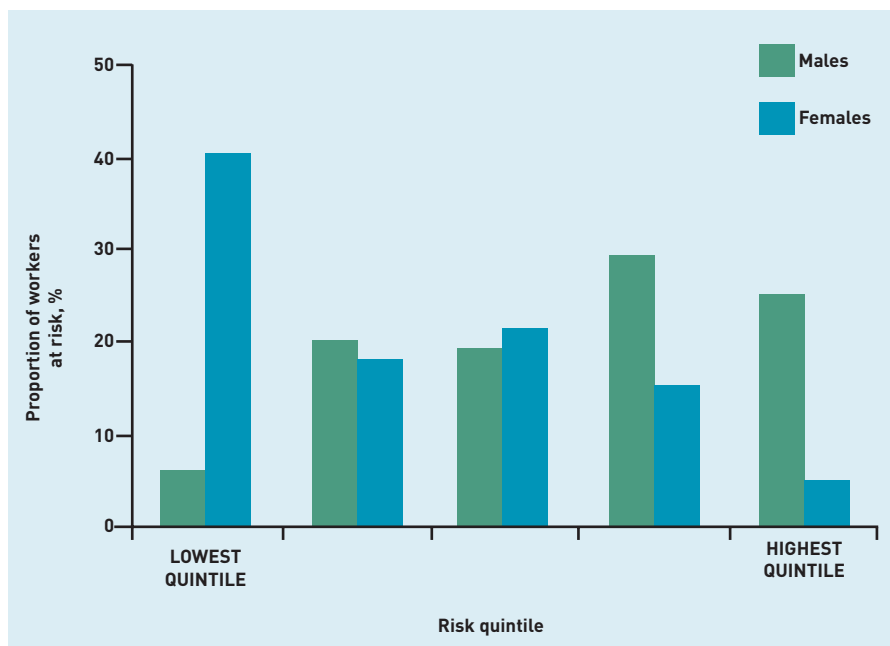
The focus of the analysis within this study was to compare four validated and routinely used diabetes risk-assessment tools. Within the analysis, it was chosen to stratify the samples by age. Statistical analysis was performed using SPSS software (version 19) with significance set at  $P < 0.05$ . Normality of data was assessed by one-sample Kolmogorov–Smirnov test. Homogeneity of variance was determined by Levene’s statistic and one-way analysis of variance (ANOVA) with post-hoc Bonferroni correction factor used to locate

any differences within groups.  $\chi^2$  analysis with  $\alpha$  set at 0.05 was performed to analyse differences between the proportions of individuals predicted at high risk. Body mass, waist circumference, and diastolic blood pressure data are represented as mean ± SD. Height, body mass index (BMI), systolic blood pressure, and QDiabetes scores did not have a normal distribution. These datasets were consequently log transformed for analysis and represented as the geometric mean and approximate standard deviation. Age, FINDRISC, Leicester Risk Assessment, and Cambridge Risk Score data did not have a normal distribution after log transformation, and these data are represented as median and interquartile range. Kruskal–Wallis and Mann–Whitney tests were used to analyse FINDRISC, Leicester Risk Assessment, and Cambridge Risk Score data.

**RESULTS**

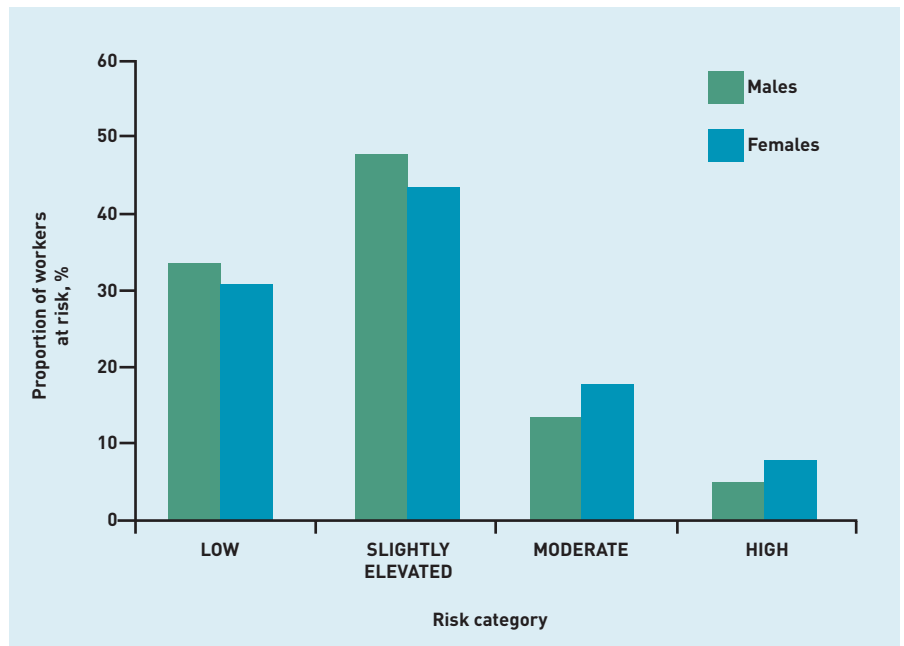
**Baseline characteristics**

Table 2 documents the baseline characteristics of the study population. As a result of the eligibility criteria, the median age of the workers was 49 years. Both the male and female cohorts of workers were found to be ‘overweight’ with mean BMI values of  $28.3 \pm 1.7$  and  $26.6 \pm 1.9$  kg/m<sup>2</sup>, respectively. The baseline characteristics also demonstrate evidence of ‘central obesity’ in the workforces, with the male and female average waist circumference values observed to be above the 94 cm and 80 cm thresholds.<sup>13</sup> The risk prediction categories for the males and females were ‘Slightly



**Figure 1. Proportion of males and females in each associated risk quintile in the Cambridge Risk Score.**

Figure 2. Proportion of males and females in each associated risk category in the FINDRISC model.



Elevated', 'Increased', and 'Low' using FINDRISC, Leicester Risk Assessment, and QDiabetes, respectively. The median values of male workers were calculated to be in the fourth quintile (second highest) and the women in the second quintile (second lowest) when entered into the Cambridge Risk Score.

#### Risk prediction categories

Figures 1–4 illustrate the proportion of sexes in each of the risk categories or quintiles after the adoption of the four validated risk assessments. Most males

(54.7%) were predicted in the highest two risk quintiles, whereas most females (58.4%) were predicted in the lowest two risk quintiles when the Cambridge Risk Score was used (Figure 1). The FINDRISC tool predicted the highest proportion of males (47.7%) and females (43.5%) in the 'Slightly Elevated' prediction category (Figure 2). The greatest numbers of males and females again were calculated in the same category when the Leicester Risk Assessment was adopted, with proportions of 57.5% and 44.2%, respectively, in the

Figure 3. Proportion of males and females in each associated risk category in the Leicester Risk Assessment.

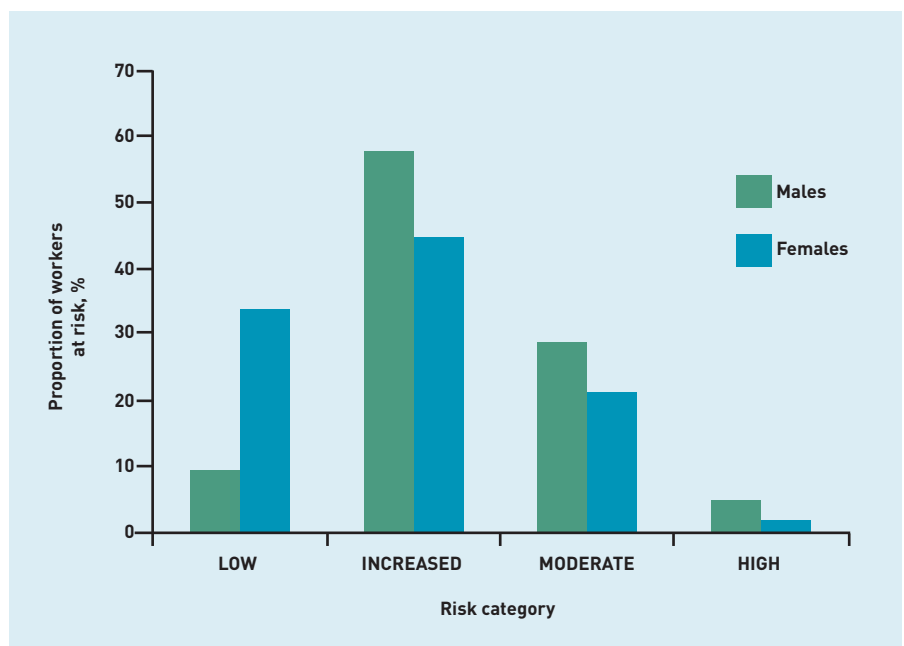
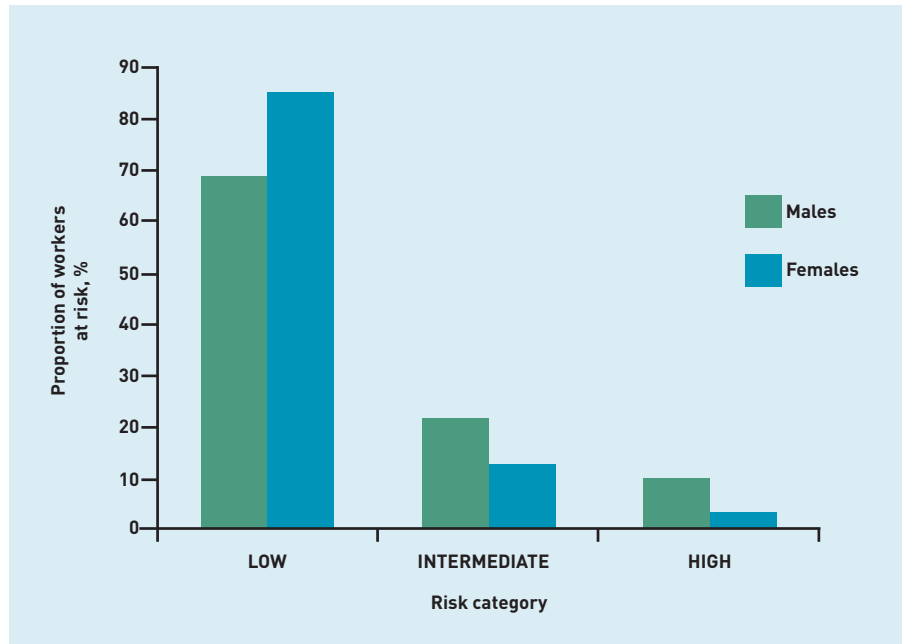


Figure 4. Proportion of males and females in each associated risk category in the QDiabetes® model.



'Increased' risk category (Figure 3). Finally, the males (68.6%) and females (84.6%) were found to have the greatest proportions in the 'Low' risk category using the QDiabetes tool (Figure 4).

#### Individuals at high risk

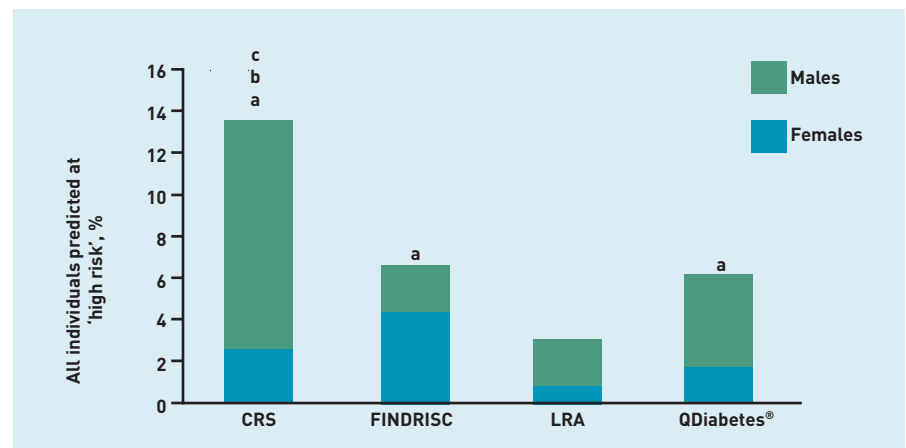
In terms of the proportion of individuals predicted to be at high risk by each of the validated risk assessments, the Cambridge Risk Score categorised the highest proportion of all individuals (13.6%), followed by FINDRISC (6.6%), QDiabetes (6.1%), and, finally, the Leicester Risk Assessment, which was the most conservative risk tool (3.1%) (Figure 5). After further examination by sex analysis, it was found that more males (Figure 6) were categorised as high risk using either the Cambridge Risk Score (25.4%) or QDiabetes (9.8%) tools versus

either the Leicester Risk Assessment (4.8%) or FINDRISC (4.9%) assessments. A greater percentage of females, however, were categorised as high risk using the FINDRISC assessment (7.8%) compared with QDiabetes (3.3%) or the Leicester Risk Assessment (1.8%) (Figure 7). In addition, all of the risk assessments other than FINDRISC predicted a greater proportion of males at high risk compared with their female counterparts.

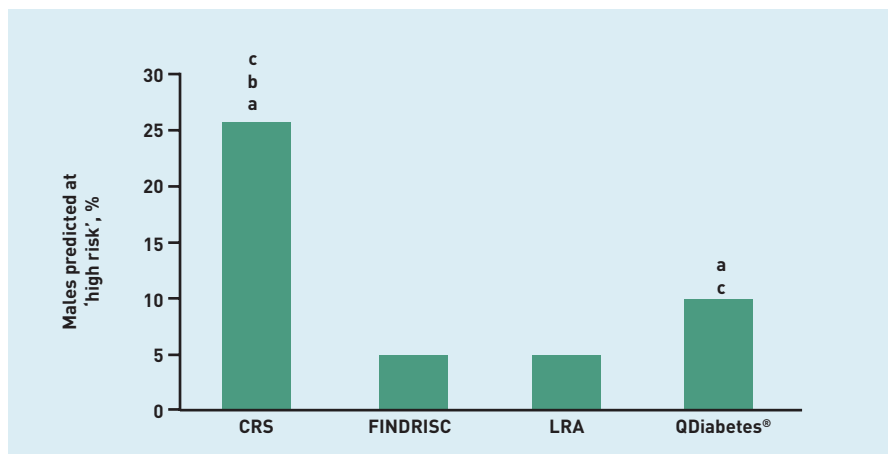
#### Changes in risk score after age stratification

From the outset, it was decided to examine the cohorts by five predetermined age groups (<45 years, 45–49 years, 50–54 years, 55–59 years, ≥60 years; Table 3). Female predicted risk increased from  $1.8 \pm 0.7\%$  to  $6.1 \pm 2.1\%$  in the QDiabetes model where

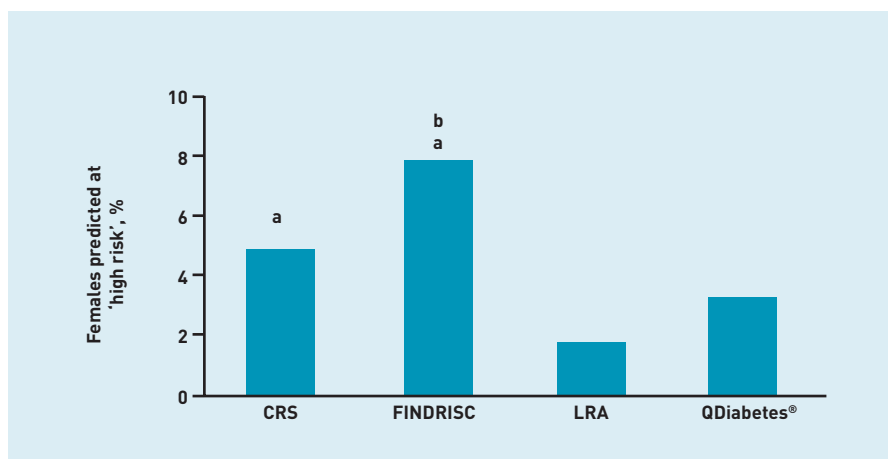
Figure 5. Proportion of individuals predicted to be at high risk of developing type 2 diabetes: all individuals. <sup>a</sup>Denotes higher proportion than Leicester Risk Assessment. <sup>b</sup>Denotes higher proportion than QDiabetes®. <sup>c</sup>Denotes higher proportion than FINDRISC ( $P < 0.05$ ). CRS = Cambridge Risk Score. LRA = Leicester Risk Assessment.



**Figure 6. Proportion of individuals predicted to be at high risk of developing type 2 diabetes: male individuals.** <sup>a</sup>Denotes higher proportion than Leicester Risk Assessment. <sup>b</sup>Denotes higher proportion than QDiabetes<sup>®</sup>. <sup>c</sup>Denotes higher proportion than FINDRISC (*P*<0.05). CRS = Cambridge Risk Score. LRA = Leicester Risk Assessment.



**Figure 7. Proportion of individuals predicted to be at high risk of developing type 2 diabetes: female individuals.** <sup>a</sup>Denotes higher proportion than Leicester Risk Assessment. <sup>b</sup>Denotes higher proportion than QDiabetes<sup>®</sup>. <sup>c</sup>Denotes higher proportion than FINDRISC (*P*<0.05). CRS = Cambridge Risk Score. LRA = Leicester Risk Assessment.



risk prediction was higher than <45 years in subsequent age groups and increased again in the ≥60 years group compared

with the 45–49 years group. The female risk categories in the oldest age group were 'moderate' and 'slightly elevated' compared with the 'low' risk category of the <45 years age group in the Leicester Risk Assessment and FINDRISC questionnaires, respectively. The risk quintile of the Cambridge Risk Score increased from the lowest risk quintile in the <45 years age group to the middle quintile in the ≥60 years group. The predicted 10-year risk of the male employees increased from 'low' (3.8 ± 1.4%) to 'intermediate' (11.0 ± 3.0%) risk after adoption of the QDiabetes model. The risk quintiles of the male individuals increased from the middle quintile (<45 years) up to the highest-risk quintile in the Cambridge Risk Score, and the risk categories increased from 'low' to 'slightly elevated' in the FINDRISC model across the age groups. The Leicester Risk Assessment category was already at 'increased' risk in the youngest age group of the male cohorts and incremental rise in total points scored resulted in the oldest age group classified in the upper limits of the 'moderate' risk category.

**Table 3. Changes in diabetes risk prediction scores following age stratification**

	<45 years	45–49 years	50–54 years	55–59 years	≥60 years
<b>Females</b>	<i>n</i> = 99	<i>n</i> = 109	<i>n</i> = 87	<i>n</i> = 65	<i>n</i> = 29
Cambridge Risk Score <sup>a</sup>	0.023 (0.014–0.102)	0.057 (0.022–0.159) <sup>b</sup>	0.092 (0.036–0.191) <sup>b,c</sup>	0.052 (0.030–0.180) <sup>b</sup>	0.167 (0.036–0.288) <sup>b,c,d</sup>
FINDRISC, points <sup>a</sup>	6 (4–9)	9 (6–12) <sup>b</sup>	9 (7–12) <sup>b</sup>	9 (7–12) <sup>b</sup>	10 (7–13) <sup>b</sup>
Leicester Risk Assessment, points <sup>a</sup>	5 (2–9)	7 (0–12)	12 (8–17) <sup>b,c</sup>	10 (8–17) <sup>b,c,d</sup>	16 (9–20) <sup>b,c,d</sup>
QDiabetes <sup>®</sup> , % <sup>f</sup>	1.8 ± 0.7	3.5 ± 1.5 <sup>b</sup>	4.7 ± 1.8 <sup>b</sup>	4.3 ± 1.5 <sup>b</sup>	6.1 ± 2.1 <sup>b,c</sup>
<b>Males</b>	<i>n</i> = 81	<i>n</i> = 88	<i>n</i> = 63	<i>n</i> = 39	<i>n</i> = 16
Cambridge Risk Score <sup>a</sup>	0.107 (0.048–0.228)	0.220 (0.103–0.328) <sup>b</sup>	0.223 (0.087–0.472) <sup>b</sup>	0.318 (0.228–0.431) <sup>b,c</sup>	0.361 (0.192–0.670) <sup>b,c,d</sup>
FINDRISC, points <sup>a</sup>	6 (3–8)	9 (6–11) <sup>b</sup>	9 (6–11) <sup>b</sup>	10 (8–12) <sup>b,c</sup>	10 (8–12) <sup>b</sup>
Leicester Risk Assessment, points <sup>a</sup>	10 (8–13)	11 (8–15)	15 (13–20) <sup>b,c</sup>	17 (14–20) <sup>b,c</sup>	21 (16–25) <sup>b,c,d</sup>
QDiabetes <sup>®</sup> , % <sup>f</sup>	3.8 ± 1.4	6.6 ± 2.3 <sup>b</sup>	7.9 ± 2.6 <sup>b</sup>	10.0 ± 3.0 <sup>b</sup>	11.0 ± 3.0 <sup>b</sup>

<sup>a</sup>Data represented as median and interquartile range. <sup>b</sup>Denotes significantly different from <45 years. <sup>c</sup>Denotes significantly different from 45–49 years. <sup>d</sup>Denotes significantly different from 50–54 years. <sup>e</sup>Denotes significantly different from 55–59 years (*P*<0.05). <sup>f</sup>Data represented as geometric mean ± approximate SD.

## DISCUSSION

### Summary

This study examined whether the adoption of a different validated risk-assessment tool would alter an individual's predicted risk of type 2 diabetes. The main findings from this study demonstrated that the risk of an individual developing type 2 diabetes was dependent on which risk-assessment tool was used. It was observed that over one-quarter of males were predicted to be in the highest-risk quintile when the Cambridge Risk Score was used. This value was a fivefold increase compared with the Leicester Risk Assessment and FINDRISC questionnaires, and more than double the amount of individuals categorised as high risk using the QDiabetes risk assessment. In the female cohort, double the amount of individuals were again categorised as high risk using the QDiabetes tool compared with the Leicester Risk Assessment. The FINDRISC model, however, predicted the greatest proportion of females at high risk (7.8%).

### Strengths and limitations

One of the main strengths of this research is that the study population is representative of the current working demographic in Carmarthenshire, South Wales, who volunteered to participate in a workplace-based diabetes risk assessment. The details of these employees would not be routinely available if not for the Prosiect Sir Gâr initiative and therefore this information provides an insight into the current diabetes 'risk' of the workforce in Wales.

This study is also the first to compare directly the proportion of individuals that was predicted to be at high risk by four validated and routinely used risk assessments. The risk assessments were chosen in this study primarily because they feature in the NICE guidance,<sup>2</sup> and also have five common risk variables (age, sex, BMI, family history of diabetes, and currently prescribed antihypertensive medication; Table 1) that make direct comparisons feasible.

One of the limitations to this study and also to the current literature is that, unlike in validated CVD risk prediction algorithms,<sup>8</sup> no prospective studies have compared diabetes risk prediction models to measure the accuracy and false-positive rates of these current models. Thus, this admission from the current literature offers a suggestion for important future research.

### Comparison with existing literature

It is acknowledged that in the development and validation stages of some of the risk

assessment models included in this study some comparisons have been previously made between the risk-assessment tools. During the validation of the QDiabetes model, comparisons were made with the Cambridge Risk Score. This validation demonstrated that the QDiabetes model improved discrimination; however, because the Cambridge Risk Score does not give a prediction of absolute risk, calibration measures between the two risk scores could not be determined.<sup>3</sup> The inclusion of ethnicity in the QDiabetes model could explain these differences, with previous research concluding that ethnic-specific cut points need to be established when using the Cambridge Risk Score in a multi-ethnic population.<sup>14</sup> Ethnic group is an important consideration in the FINDRISC model, which was developed in a white population. There is a tendency for diabetes risk questionnaires developed in white populations to underperform in multi-ethnic populations,<sup>15</sup> and this observation provided the rationale for the Leicester Risk Assessment, which was based on the FINDRISC example<sup>2</sup> and validated for use in a multi-ethnic population in the UK.<sup>6</sup> Interestingly, in comparison with the FINDRISC model, a score of  $\geq 16$  on the Leicester Risk Assessment increased the number of individuals identified with impaired glucose regulation rather than a score of  $\geq 9$ , which was indicative of drug-treated diabetes using the FINDRISC questionnaire.<sup>2</sup> This offers a suggestion of why differences were observed in the numbers of individuals predicted to be high risk between these two risk assessments.

Other previous research has established that the Cambridge Risk Score had no advantage in identifying diabetes risk compared with BMI alone.<sup>16</sup> This finding demonstrates the importance of waist circumference in predicting diabetes risk, especially given that previously evidence has demonstrated a clear association between 'central obesity' (waist circumference of  $\geq 102$  cm in males and  $\geq 88$  cm in females) and diabetes risk, regardless of BMI values.<sup>17</sup>

### Implications for research and practice

The findings from this study raise a question about the validated risk assessments currently advocated by NICE and the correct approaches to reduce the ever-increasing prevalence of type 2 diabetes in the UK.<sup>2</sup> There are three apparent options in terms of risk-assessment tools that can be taken from the present observations. First, an aggressive approach could be taken by favouring the Cambridge Risk Score. Although the limitation of this model has

been discussed, this approach potentially could benefit males who develop type 2 diabetes at a lower BMI value than their female counterparts.<sup>18,19</sup> The second method could be taking a conservative approach by prioritising adoption of the Leicester Risk Assessment, which also allows layperson completion. This risk tool did predict the lowest proportion of males, females, and, subsequently, all participants at high risk of developing type 2 diabetes, however, which could overlook some at-risk individuals. The third, more practical, and cost-effective approach would be to use one of the two tools that predicted ~6% of all participants at high risk, either FINDRISC or QDiabetes.

Interestingly, lifestyle intervention through exercise and diet has been proven to prevent type 2 diabetes in high-risk individuals,<sup>20</sup> and has also been shown to be more effective than metformin at reducing the incidence of diabetes in a group of high-risk individuals with impaired glucose regulation.<sup>21</sup> This intervention focused on weight loss of at least 7% and individuals partaking 150 minutes of physical activity per week.<sup>21</sup> Impaired fasting glucose (IFG) where concentrations are  $\geq 6.1$  mmol/L<sup>1</sup> have also shown strong associations with individuals developing type 2 diabetes compared with those individuals with fasting blood glucose below this threshold value.<sup>22,23</sup> Only the FINDRISC tool accounts for physical activity and history of high blood glucose, both of which are positive aspects to the questionnaire. However as discussed previously, the FINDRISC tool does not account for ethnic group, which is fine if the population is European, but with a large South Asian population in the UK reservations should be given to prioritising this assessment. Moreover, since the introduction in 2011 of HbA1c as a diagnostic criterion for type 2 diabetes,<sup>24</sup> the performance of FINDRISC has reduced.<sup>25</sup>

From a clinical standpoint, given the discrepancies in the numbers of predicted high risk individuals, a more practical approach would be to focus more on isolated risk factors (for example, adverse family histories, physical inactivity, elevated waist circumference), irrespective of diabetes risk prediction values. There is merit for everyone to benefit from lifestyle advice that reinforces the benefits of regular physical activity and a balanced diet, rather than wait for the individual to be deemed high risk. This strategy also has the potential to convert those individuals currently predicted at 'intermediate' or 'increased' risk to 'low' risk. Nevertheless, while diabetes risk assessments remain the recommended primary tool to identify individuals at high

risk,<sup>2</sup> the risk assessments that include waist circumference as a risk factor should be prioritised in primary care and prevention because of the overwhelming evidence of 'central obesity' being a better indicator of diabetes risk than BMI.<sup>17,26</sup>

A further finding was no significant concomitant relationship between age and changes in risk scores, with no apparent rise in diabetes risk prediction from 50 years old in males and females. This is somewhat surprising given the inclusion of age as a risk factor and the varying weightiness by coefficient in each of the diabetes risk assessments.<sup>3-6</sup> This finding is important, however, as it provides additional evidence to the current targeted age groups as documented in current government guidelines,<sup>2</sup> and potentially offers a suggestion to slightly amend this documentation to target those individuals aged  $\geq 50$  years instead, while still providing lifestyle advice to adults aged  $< 50$  years old. In addition, epidemiological research has previously reported that diabetes risk increases with age, with one explanation being that glycaemic control as reflected in HbA1c scores revealed a significant increase from 50 years onwards.<sup>27</sup>

Unfortunately, it seems that in the 10 years since the FINDRISC model was introduced, and despite new models for predicting risk of type 2 diabetes being introduced in great numbers globally and annually with an increase of focus on layperson completion (for a review, see Noble and colleagues<sup>28</sup>), discrepancies remain in numbers of individuals at high risk. The changes in diagnostic criteria for diabetes, which now incorporate HbA1c values, also have been shown to reduce performance in some of the more established diabetes prediction tools. Encouragingly, an emerging model has been developed recently that has accounted for these diagnostic changes involving HbA1c in its predictive capability.<sup>29</sup> Differences were observed in predicted high risk individuals using the currently advocated risk assessments, and therefore caution should be addressed when categorising such individuals at high risk. In primary care, until a consensus is made on the diabetes risk prediction 'model of choice', more focus should be on isolated risk factors, especially regarding lifestyle choices and evidence of 'central obesity' irrespective of diabetes risk prediction score. Furthermore, with the change in diagnostic criteria, it is also important that any new risk prediction assessments allow for these in their respective algorithms.

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### Ethical approval

Prosiect Sir Gâr and this subsequent study were approved by Dyfed Powys local research ethics committee (reference number: 11/WA/0101).

### Provenance

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### Competing interests

The authors have declared no competing interests.

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