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Evaluation of AUSDRISK as a screening tool for lifestyle modification programs: international implications for policy and cost-effectiveness

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ABSTRACT

Objective: To evaluate the current use of Australian Type 2 Diabetes Risk Assessment Tool (AUSDRISK) as a screening tool to identify individuals at high risk of developing type 2 diabetes for entry into lifestyle modification programs.

Research Design and Methods: AUSDRISK scores were calculated from participants aged 40–74 years in the Greater Green Triangle Risk Factor Study, a cross-sectional population survey in 3 regions of Southwest Victoria, Australia, 2004–2006. Biomedical profiles of AUSDRISK risk categories were determined along with estimates of the Victorian population included at various cut-off scores. Sensitivity, specificity, positive predictive value (PPV), negative predictive value, and receiver operating characteristics were calculated for AUSDRISK in determining fasting plasma glucose (FPG) ≥6.1 mmol/L.

Results: Increasing AUSDRISK scores were associated with an increase in weight, body mass index, FPG, and metabolic syndrome. Increasing the minimum cut-off score also increased the proportion of individuals who were obese and centrally obese, had impaired fasting glucose (IFG) and metabolic syndrome. An AUSDRISK score of ≥12 was estimated to include 39.5% of the Victorian population aged 40–74 (916 000), while a score of ≥20 would include only 5.2% of the same population (120 000). At AUSDRISK≥20, the PPV for detecting FPG≥6.1 mmol/L was 28.4%.

Conclusions: AUSDRISK is powered to predict those with IFG and undiagnosed type 2 diabetes, but its effectiveness as the sole determinant for entry into a lifestyle modification program is questionable given the large proportion of the population screened-in using the current minimum cut-off of ≥12. AUSDRISK should be used in conjunction with oral glucose tolerance testing, fasting glucose, or glycated hemoglobin to identify those individuals at highest risk of progression to type 2 diabetes, who should be the primary targets for lifestyle modification.

Key messages

- Type 2 diabetes risk assessment tools should be used in conjunction with fasting glucose, oral glucose tolerance testing, or glycated hemoglobin to determine entry into lifestyle modification programs.
- Cut-off scores of type 2 diabetes risk assessment tools for screening into lifestyle modification programs and further testing should be chosen with knowledge of the proportion of the population at different risk scores.
- Lowering entry criteria for lifestyle modification programs to reduce risk of type 2 diabetes is likely to decrease the impact of the program as well as the cost-effectiveness.

INTRODUCTION

The incidence of type 2 diabetes mellitus is rising globally and the prevalence in Australia is estimated to reach over 2.3 million by 2035.[1] Annual expenditure on diabetes in Australia already amounts to over A $14 billion in direct costs and government subsidies,[2] therefore population and high-risk strategies are required to mitigate future disease burden.

A number of studies aimed at prevention of type 2 diabetes have included only those with disorders of abnormal glucose metabolism.[3–5] Individuals with impaired glucose tolerance (IGT) and impaired fasting glucose (IFG), are among the highest risk for developing type 2 diabetes, with an annual incidence of 5–10% across various categories of IGT or IFG.[6] Such disorders are reversible, and trials have demonstrated that intensive lifestyle modification programs can successfully halt or delay progression to type 2 diabetes in high-risk groups.[3–5]

On the basis of the results of these randomized trials, and the national demonstrator Greater Green Triangle Diabetes Prevention Program (DPP),[7] along with economic modeling, the Council of Australian Governments in 2006 decided to invest in lifestyle modification programs for diabetes prevention.

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The Federal Government's program was targeted at adults aged 40–49 years, and the state and territory programs targeted those aged 50 years and over. National standards for lifestyle modification programs were agreed on, and work started on an Australian tool for risk assessment (Australian Type 2 Diabetes Risk Assessment Tool, AUSDRISK)[8 9] to reflect the ethnic diversity of the contemporary Australian population.[10] AUSDRISK is a 10-item questionnaire that estimates risk of progression to type 2 diabetes over 5 years. Its scoring includes questions based on age, sex, ethnicity, family history of diabetes, history of abnormal glucose metabolism, smoking status, current hypertensive treatment, physical activity, fruit and vegetable consumption, and waist circumference.

The Federal DPP was discontinued in 2011 due to poor recruitment and other implementation problems.[11] The Victorian Life! program is a statewide DPP established by Diabetes Australia–Victoria in 2007.[12] AUSDRISK was chosen as the screening tool for Life!, with an entry score of ≥15 initially selected, but low recruitment rates led to a decision to lower the entry score to ≥12.[13] The Australian experience with AUSDRISK will be relevant to other countries wanting to develop a national instrument for screening.

Many other risk tools have been developed and validated to predict risk of type 2 diabetes, both in terms of current and future risk. These tools have been demonstrated to be effective and cost-effective in identification of individuals at high risk of developing type 2 diabetes, though their effectiveness may vary across different populations.[14] Using a questionnaire such as AUSDRISK is a practical method to screen for high-risk individuals who might benefit from lifestyle modification, but it has been recommended that those found to be at high risk should also undergo an oral glucose tolerance test (OGTT) or glycated hemoglobin (HbA1c) to determine impairment of glucose metabolism and screen for undiagnosed diabetes.[15 16] Those found to have abnormal glucose metabolism should be invited to participate in lifestyle modification programs, while those with normal glucose metabolism should be provided with lifestyle advice and reassessed in 2–3 years.[15–17]

Best practice for recruitment and screening of individuals into real-world DPP remains uncertain. Given this knowledge gap and the implications for the effectiveness and cost-effectiveness, this paper evaluates the performance of AUSDRISK in identifying suitable candidates for entry into lifestyle modification programs.

RESEARCH DESIGN AND METHODS

Sampling and collection

The Greater Green Triangle Risk Factor Study (GGT RFS) consisted of three cross-sectional surveys of chronic disease risk factors carried out in Southwest Victoria from 2003 to 2006. This data set was chosen as the survey instrument had good agreement with biomedical and lifestyle questions relevant to AUSDRISK. Collection of data has been reported previously.[18 19]

Inclusion and exclusion criteria

Data from survey respondents aged 40–74 years were included for calculating AUSDRISK scores. Individuals who self-reported a previous diagnosis of diabetes, history of treatment with insulin, oral hypoglycemics or both were excluded from the analysis. Those with fasting plasma glucose (FPG) >6.9 mmol/L were included in the study in order to evaluate the ability of AUSDRISK to detect those with undiagnosed diabetes in addition to IFG.

All participants had age and sex data available as they were selected from the electoral roll. Participants who did not have a waist circumference measurement were excluded from analysis, as a score could not be reliably imputed from the survey data.

Treatment of missing values

For AUSDRISK questions not related to waist circumference, missing values were assumed to score zero. A sensitivity analysis comparing total risk scores was undertaken with missing values imputed as zero versus cases excluded if there was at least one missing value.

Conversion of data into risk scores

Survey responses were coded into scores for AUSDRISK from the GGT RFS. Where survey questions did not directly match those of the screening tool, either the most similar question or a combination of questions was used to infer the most likely response. For example, in AUSDRISK question eight related to fruit and vegetable consumption, respondents were considered to score 0 (eat fruit everyday) if they reported eating vegetables or fruit 5–6 times per week or more.

Definition of IFG and MetS

The WHO definition of IFG (6.1–6.9 mmol/L) was used.[20] The metabolic syndrome (MetS) was defined as per International Diabetes Federation (IDF) criteria,[21] with individuals required to have central obesity (defined by waist circumference with ethnicity specific values) plus any two of the following risk factors for diagnosis: raised triglycerides (≥1.7 mmol/L), reduced high-density lipoprotein cholesterol (males, <1.03; females, <1.29 mmol/L), raised blood pressure (systolic BP≥130 or diastolic BP≥85 mm Hg) or raised FPG (≥5.6 mmol/L).

Statistical analyses

All analyses were performed in Stata V.13. Crude baseline demographic and biomedical measures were reported as mean values and SDs. Risk score stratifications were selected according to their reported risks of developing type 2 diabetes.[9] Annual incidence of type 2 diabetes for AUSDRISK categories was estimated using

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the reported risk of progression over 5 years assuming a constant yearly risk.

Proportions of the sample population were stratified by risk score, sex and age group. Estimates of the population in Victoria, Australia, were made at different cut-off scores using the estimated resident population in Victoria at 30 June 2014.[22] Sensitivity, specificity, positive predictive value (PPV), and negative predictive value were calculated for FPG≥6.1 mmol/L and stratified by risk score. Receiver operating characteristics (ROC) are also presented.

RESULTS

Of 1690 respondents in the GGT RFS, 1393 fulfilled age criteria. Of those, 129 were excluded due to lack of waist circumference measurements and a further 75 were omitted due to established diagnosis of diabetes, its treatment, or both. There was no significant difference between mean AUSDRISK scores when missing values were imputed as zero versus cases with missing values excluded from analysis. The results reported here are for those where missing values were assumed to score zero. Overall, AUSDRISK scores were calculated for 1189 individuals. Males were older than females and comprised a smaller proportion of the overall sample (table 1).

Overall, IFG prevalence was 4.7% (males 6.7%; females 2.9%). Mean body mass index (BMI) was similar in the overweight range for both genders (table 1). The MetS was present in 40.5% of males and 32.6% of females. Diabetic and cardiovascular risk factors, except total and low-density lipoprotein cholesterol, and also the presence of MetS demonstrated a significant linear trend when stratified by AUSDRISK group according to approximate risk of progression to diabetes (table 2).

Use of higher cut-off scores demonstrated increases in mean values of key diabetic risk factors (weight, BMI, waist circumference, FPG) (table 3).

The proportion of individuals included at different AUSDRISK cut-offs increased with age (table 4). Nearly 40% of the Victorian population aged 40–74 years was estimated to have an AUSDRISK score of 12 or more, falling to approximately 5.2% at a cut-off score of 20 or higher (table 4).

After an AUSDRISK cut-off of ≥14, the sum of sensitivity and specificity for detecting FPG≥6.1 mmol/L began to decline (table 5). ROC for detecting FPG≥6.1 mmol/L was 0.76 (95% CI 0.70 to 0.81).

Table 1 Characteristics of GGT RFS sample aged 40–74 years with a calculated AUSDRISK score

Variable	N	Mean	(SD)
Males			
Age (years)	561	58.2	(9.5)
Weight (kg)	560	87.6	(16.1)
BMI (kg/m²)	560	28.5	(4.9)
Waist circumference (cm)	561	100.4	(12.7)
FPG (mmol/L)	519	5.4	(0.6)
Total cholesterol (mmol/L)	547	5.4	(1.0)
HDL (mmol/L)	547	1.3	(0.4)
LDL (mmol/L)	534	3.3	(0.9)
Triglycerides (mmol/L)	547	1.7	(1.1)
Systolic BP (mm Hg)	561	135.2	(19.0)
Diastolic BP (mm Hg)	561	80.5	(10.8)
AUSDRISK value	561	12.9	(4.5)
Females			
Age (years)	628	56.9	(9.5)
Weight (kg)	628	74.9	(16.1)
BMI (kg/m²)	625	28.5	(6.1)
Waist circumference (cm)	628	89.8	(14.3)
FPG (mmol/L)	586	5.2	(0.5)
Total cholesterol (mmol/L)	600	5.6	(1.0)
HDL (mmol/L)	600	1.6	(0.4)
LDL (mmol/L)	597	3.3	(1.0)
Triglycerides (mmol/L)	600	1.5	(0.7)
Systolic BP (mm Hg)	628	131.1	(19.7)
Diastolic BP (mm Hg)	626	75.4	(10.6)
AUSDRISK value	628	10.3	(4.7)

AUSDRISK, Australian Type 2 Diabetes Risk Assessment Tool; BMI, body mass index; BP, blood pressure; FPG, fasting plasma glucose; GGT RFS, Greater Green Triangle Risk Factor Study; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

DISCUSSION

Apart from the original Australian Diabetes, Obesity and Lifestyle study from which AUSDRISK was created,[8] to the best of our knowledge, our study is the first that applies a detailed analysis of the risk tool to an Australian population to define different risk categories. We have evaluated AUSDRISK as a screening tool for lifestyle modification programs in Australia and found some important limitations that have international implications for policy and cost-effectiveness of such programs. Increases in AUSDRISK score categories were accompanied by increases in key biological risk factors for type 2 diabetes (table 2). Accordingly, using higher cut-off scores resulted in a higher proportion of individuals with obesity, central obesity, IFG and the MetS. These findings highlight the need to select a strategy for screening individuals into lifestyle modification programs to ensure that those who will benefit most are recruited.

For countries wishing to develop a national DPP, to determine the cut-off points for screening tools requires knowledge of the proportion of the population that will screen positive, and a minimum entry score should be selected to identify a feasible proportion of the population it is intended to reach (table 4). Based on our estimates, the current requirement of AUSDRISK≥12 would translate into 39.5% (916 000) of Victorians aged 40–74 years being eligible to participate in the Life! program. Increasing the minimum score to ≥20 reduces this proportion to 5.2% (120 000). Using previously reported prevalence of IGT (13.0%) and IFG (7.4%) in Australia among adults aged 40–74 years,[23]

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Table 2 Diabetic and cardiovascular risk factors in GGT RFS by sex and AUSDRISK category

	AUSDRISK category					
	0–5	6–8	9–11	12–15	16–19	20–36
Annual incidence of type 2 diabetes (%)	**0.2**	**0.4**	**0.7**	**1.5**	**3.0**	**7.8**
Males						
Number of observations (%)	10 (1.8)	77 (13.7)	180 (32.1)	134 (23.9)	107 (19.1)	53 (9.5)
Age (years)	41.8	47.8	57.2	61.0	61.5	65.5
Weight (kg)	87.7	81.5	81.6	84.5	97.2	105.1
BMI (kg/m^2)	27.9	26.1	26.6	27.6	31.5	34.6
Waist circumference (cm)	92.2	91.6	94.4	98.8	110.6	118.8
FPG (mmol/L)	5.2	5.2	5.2	5.3	5.6	5.8
Total cholesterol (mmol/L)	5.2	5.7	5.6	5.4	5.1	5.0
HDL (mmol/L)	1.4	1.4	1.4	1.3	1.2	1.2
LDL (mmol/L)	3.2	3.6	3.5	3.3	3.1	2.9
Triglycerides (mmol/L)	1.3	1.5	1.6	1.7	1.9	2.0
Systolic BP (mm Hg)	120.4	124.5	130.2	137.2	143.2	149.3
Diastolic BP (mm Hg)	79.3	80.3	79.3	79.4	82.4	84.0
MetS (%)	11.1	14.7	26.8	41.6	64.9	83.3
Females						
Number of observations (%)	98 (15.6)	161 (25.6)	117 (18.6)	154 (24.5)	75 (11.9)	23 (3.7)
Age (years)	46.3	56.1	56.7	61.3	61.6	65.0
Weight (kg)	65.2	67.5	74.1	80.0	88.8	92.4
BMI (kg/m^2)	24.2	25.6	28.1	30.7	34.0	36.5
Waist circumference (cm)	77.8	81.6	88.0	96.9	104.6	113.2
FPG (mmol/L)	4.9	5.0	5.1	5.2	5.5	5.7
Total cholesterol (mmol/L)	5.1	5.8	5.5	5.9	5.5	5.3
HDL (mmol/L)	1.8	1.8	1.6	1.6	1.4	1.4
LDL (mmol/L)	2.8	3.4	3.2	3.5	3.2	3.1
Triglycerides (mmol/L)	1.0	1.2	1.5	1.8	1.9	1.9
Systolic BP (mm Hg)	117.0	126.3	132.0	137.8	141.1	141.2
Diastolic BP (mm Hg)	71.7	74.3	77.3	76.7	77.8	73.4
MetS (%)	4.4	11.8	28.3	53.1	64.7	89.5

AUSDRISK, Australian Type 2 Diabetes Risk Assessment Tool; BMI, body mass index; BP, blood pressure; FPG, fasting plasma glucose; GGT RFS, Greater Green Triangle Risk Factor Study; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MetS, metabolic syndrome.

approximately 154 000 and 87 000 Victorians in this age group would be expected to have IGT and IFG, respectively. From 2007 to 2011, Life! received 29 000 referrals with 8412 initiating the program, and 3114 completed session 1 and session 6.[12] Life! was recently reported to have received an updated total of 59 000 referrals.[24] Given these numbers, the impact of the Life! program has likely been diluted by targeting those at comparatively lower risk of developing type 2 diabetes (ie, AUSDRISK≥12), and would have a greater impact if delivered exclusively to those with abnormal glucose metabolism.

As the prevalence of IFG in our sample (4.7%) and the Australian population[23] is relatively low, even at a cut-off of AUSDRISK≥20, the PPV for detecting FPG≥6.1 mmol/L was 28.4%. Although 2 h postglucose load data was not collected in this study, with the prevalence of IGT or IFG previously estimated at 16.4%,[23] the expected PPV for detecting IGT or IFG would be slightly greater than that for IFG alone. These results demonstrate that a diabetes risk assessment tool alone cannot be used to determine glucose metabolism status, and additional testing with OGTT, fasting glucose, or HbA1c is required for those who are identified to be at elevated risk of progressing to type 2 diabetes, as suggested by international guidelines.[15 16] Previous research has also demonstrated that this two-stage screening strategy is a more cost-effective method to identify individuals with undiagnosed diabetes, IFG and IGT than laboratory testing alone.[25] Even though clinicians may opt to proceed directly to laboratory testing, setting an appropriate and cost-effective cut-off score for entry to lifestyle modification programs is important, given that Life! has seen a significant proportion of individuals recruited through a variety of methods not involving physicians or other health professionals.[12]

Early involvement of family physicians represents an important opportunity to identify additional comorbidities and chronic disease risk factors. Our results demonstrate that a significant proportion of individuals at high risk of progressing to type 2 diabetes also have key cardiovascular risk factors including hypertension, hypercholesterolemia, and MetS (table 3). Previous research has demonstrated the existence of treatment gaps in treatment of hypertension and dyslipidemia among those participating in lifestyle modification programs.[26]

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Table 3 Characteristics of GGT RFS participants included at different AUSDRISK cut-off values by sex

	AUSDRISK cut-off					
	Males			Females		
	≥12	≥16	≥20	≥12	≥16	≥20
Age (years)	62.0	62.8	65.5	61.7	62.4	65.0
Weight (kg)	92.8	99.8	105.1	83.8	89.7	92.4
BMI (kg/m^2)	30.3	32.5	34.6	32.2	34.6	36.5
25 to <30 (%)	42.5	29.4	17.0	30.6	21.4	21.7
≥30 (%)	46.6	68.1	83.0	61.1	75.5	78.3
Waist circumference (cm)	106.7	113.3	118.8	100.6	106.6	113.2
Male 94 to <102; female 80 to <88 (%)	18.7	5.6	1.9	4.8	3.1	0.0
Male ≥102; female ≥88 (%)	71.4	92.5	98.1	90.1	94.9	100.0
FPG (mmol/L)	5.5	5.7	5.8	5.4	5.6	5.7
6.1–6.9 (%)	11.2	13.4	20.8	4.4	3.5	10.5
≥7.0 (%)	3.4	5.6	8.3	2.2	5.8	5.3
Total cholesterol (mmol/L)	5.2	5.1	5.0	5.7	5.5	5.3
≥5.5 (%)	42.2	36.9	30.2	56.4	48.0	34.8
HDL (mmol/L)	1.3	1.2	1.2	1.5	1.4	1.4
Male <1.0; female <1.3 (%)	15.7	20.0	20.8	22.6	27.6	34.8
LDL (mmol/L)	3.2	3.0	2.9	3.4	3.2	3.1
≥3.5 (%)	35.4	31.9	26.4	40.9	33.7	13.0
Triglycerides (mmol/L)	1.8	1.9	2.0	1.8	1.9	1.9
≥2.0 (%)	30.3	35.6	41.5	33.7	42.9	43.5
Systolic BP (mm Hg)	141.6	145.2	149.3	139.1	141.1	141.2
≥140 (%)	52.0	59.4	69.8	44.4	50.0	52.2
Diastolic BP (mm Hg)	81.4	83.0	84.0	76.7	76.8	73.4
≥90 (%)	23.1	26.9	28.3	11.9	12.2	4.4
MetS (%)	57.3	71.1	83.3	59.6	70.1	89.5

AUSDRISK, Australian Type 2 Diabetes Risk Assessment Tool; BMI, body mass index; BP, blood pressure; FPG, fasting plasma glucose; GGT RFS, Greater Green Triangle Risk Factor Study; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MetS, metabolic syndrome.

Therefore, in addition to lifestyle modification, addressing these risk factors is essential to reducing future disease burden, as cardiovascular disease contributes disproportionately to the morbidity as a result of diabetes.[27]

The baseline risk of diabetes among participants in lifestyle modification programs has important implications for the cost-effectiveness. Those at highest risk of progressing to type 2 diabetes represent the greatest potential for absolute reduction of incident cases of type 2 diabetes. A meta-analysis of 30 studies found that annual rate of progression to diabetes was 10–15% in those with IGT and IFG, 4.4–6.4% in those with isolated IGT, and 6.1–9.2% in those with isolated IFG.[6] These values are similar to the estimated annual rate of progression to type 2 diabetes for those scoring AUSDRISK≥20 (7.8%). Eligibility requirements for Life! should therefore include those with IGT, IFG, or both.

On the basis of the results of the Finnish Diabetes Prevention Study (DPS)[28 29] and the US DPP,[5 30] the Life! program was estimated to potentially reduce risk of progression to type 2 diabetes by 21–39% at 8 months.[12] However, these results are not necessarily generalizable to Life!, as participants in both the Finnish and US studies had diagnosed IGT. Even if the relative risk reduction is similar among risk groups, a lower baseline risk translates to decreased absolute risk reduction and therefore decreased cost-effectiveness.

A cost-effectiveness analysis is required to assess the economic implications of various entry requirements into lifestyle intervention programs. Multiple studies have reported lifestyle modification programs to be cost-effective in participants with IGT or IFG.[31–33] However, cost-effectiveness of lifestyle modification programs has not been reported in individuals without abnormal glucose metabolism but nonetheless are at elevated risk of developing type 2 diabetes.

A limitation of our study is lack of OGTT or HbA1c data. As stated above, based on the prevalence of IFG and IGT, the PPV for detecting IGT would be expected to greater than that for IFG. While there is overlap between those with IGT and IFG, there remains a significant proportion of individuals with IGT who have normal FPG values.[23] Our study therefore does not wholly evaluate the ability of AUSDRISK to identify individuals who would benefit from lifestyle modification programs. Further study is warranted on the performance of AUSDRISK in the detection of IGT, elevated HbA1c, and undiagnosed diabetes where OGTT and HbA1c data are available from an Australian population. This research would complement our current study to identify a suitable AUSDRISK cut-off score for entry into

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Table 4 Proportion of GGT RFS included at different AUSDRISK cut-off values by age and sex

Age (years)	N	AUSDRISK cut-off ≥12	≥14	≥16	≥18	≥20
Males						
40–49	128	23.4	14.1	7.0	1.6	0.0
50–59	184	46.7	32.1	25.0	14.1	4.3
60–69	170	68.2	55.9	42.9	26.5	18.8
70–74	79	78.5	55.7	40.5	26.6	16.5
Total	561	52.4	38.5	28.5	16.8	9.4
Females						
40–49	182	14.8	9.3	5.5	0.5	0.5
50–59	189	36.5	21.7	13.8	5.3	2.6
60–69	187	60.4	38.5	22.5	8.0	4.8
70–74	70	61.4	52.9	28.6	12.9	11.4
Total	628	40.1	26.6	15.6	5.6	3.7
Overall						
40–49	310	18.4	11.3	6.1	1.0	0.3
50–59	373	41.6	26.8	19.3	9.7	3.5
60–69	357	64.1	46.8	32.2	16.8	11.5
70–74	149	70.5	54.4	34.9	20.1	14.1
Total	1189	45.9	32.2	21.7	10.8	6.4
Population estimates in Victoria, Australia, aged 40–74 years						
Number of persons (000s) (95% CI)		916 (859 to 974)	637 (583 to 690)	425 (379 to 472)	208 (174 to 243)	120 (93 to 146)
Proportion of population (95% CI)		39.5 (37.0 to 42.0)	27.5 (25.2 to 29.8)	18.3 (16.3 to 20.4)	9.0 (7.5 to 10.5)	5.2 (4.0 to 6.3)

Data are percentages unless otherwise stated.
AUSDRISK, Australian Type 2 Diabetes Risk Assessment Tool; GGT RFS, Greater Green Triangle Risk Factor Study.

Life! or any subsequent national DPP. Analysis of AUSDRISK performance in relation to detecting elevated HbA1c levels is particularly significant given the future transition away from performing OGTT and towards HbA1c and FPG testing.

Data in the GGT RFS was collected in Southwest Victoria from 2004 to 2006. There were no systematic differences in the prevalence of IFG, MetS, and obesity among age and gender groups to those reported in the Victorian Health Monitor, a cross-sectional population health measurement survey collected between May 2009 and April 2010.[34] This suggests our sample for the purpose of these analyses remains a satisfactory indicator of population health characteristics in Victoria.

This paper has focused exclusively on the performance of AUSDRISK as a screening tool to identify those who would benefit from a lifestyle modification programs to prevent type 2 diabetes. It is important to consider that an effective screening method is only one aspect of implementing lifestyle modification programs to stop or delay the progression to type 2 diabetes. Lifestyle modification programs need to demonstrate

Table 5 Characteristics of AUSDRISK using various cut-off values for detecting abnormal fasting glucose

FPG≥6.1 mmol/L				
AUSDRISK cut-off	Sensitivity	Specificity	PPV	NPV
≥12	81.3 (70.7 to 89.4)	57.7 (54.6 to 60.7)	12.3 (9.5 to 15.5)	97.7 (96.2 to 98.7)
≥13	74.7 (63.3 to 84.0)	63.8 (60.8 to 66.7)	13.1 (10.0 to 16.6)	97.2 (95.6 to 98.3)
≥14	68.0 (56.2 to 78.3)	71.6 (68.7 to 74.3)	14.8 (11.2 to 19.0)	96.8 (95.3 to 98.0)
≥15	61.3 (49.4 to 72.4)	76.4 (73.7 to 79.0)	15.9 (11.9 to 20.7)	96.4 (94.9 to 97.6)
≥16	53.3 (41.4 to 64.9)	81.7 (79.1 to 84.0)	17.5 (12.8 to 23.0)	96.0 (94.5 to 97.2)
≥17	45.3 (33.8 to 57.3)	86.3 (84.1 to 88.4)	19.4 (13.8 to 26.1)	95.6 (94.1 to 96.8)
≥18	34.7 (24.0 to 46.5)	91.7 (89.9 to 93.4)	23.4 (15.9 to 32.4)	95.1 (93.5 to 96.3)
≥19	28.0 (18.2 to 39.6)	94.6 (93.0 to 95.9)	27.3 (17.7 to 38.6)	94.7 (93.2 to 96.0)
≥20	25.3 (16.0 to 36.7)	95.3 (93.9 to 96.5)	28.4 (18.0 to 40.7)	94.6 (93.1 to 95.9)

Data are % (95% CI).
AUSDRISK, Australian Type 2 Diabetes Risk Assessment Tool; FPG, fasting plasma glucose; NPV, negative predictive value; PPV, positive predictive value.

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effectiveness in reducing the progression to type 2 diabetes, and promote sustainable lifestyle changes so that effects are persistent in the long term. Moreover, lifestyle modification programs represent one part of a targeted approach to reducing the burden of type 2 diabetes, that ideally should be accompanied by a range of population-level approaches to diabetogenic environments.[35 36] Where lifestyle medication programs are not available, screening individuals for risk of developing type 2 diabetes remains warranted, provided that simple lifestyle advice is provided and appropriate follow-up testing for those at high risk is offered, where appropriate.

Our findings indicate that revisiting entry criteria into Life! is timely. Relying on AUSDRISK at a relatively low cut-off, while recruiting large numbers of people, hinders the long-term effectiveness of the program. A multifaceted approach is required. Initial screening with AUSDRISK, followed by OGTT, fasting glucose, or HbA1c for those at high risk to detect IFG, IGT, and undiagnosed diabetes is needed. Those with IFG and IGT should be invited into Life!, while those at high risk but with normal glucose metabolism should be offered lifestyle information and rescreened in the following 3 years. To reliably establish and justify these thresholds, economic modeling is required to determine the most effective strategy.

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