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Effectiveness of the CANRISK tool in the identification of dysglycemia in First Nations and Métis in Canada*

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Abstract

Introduction: First Nations/Métis populations develop diabetes earlier and at higher rates than other Canadians. The Canadian diabetes risk questionnaire (CANRISK) was developed as a diabetes screening tool for Canadians aged 40 years or over. The primary aim of this paper is to assess the effectiveness of the existing CANRISK tool and risk scores in detecting dysglycemia in First Nations/Métis participants, including among those under the age of 40. A secondary aim was to determine whether alternative waist circumference (WC) and body mass index (BMI) cut-off points improved the predictive ability of logistic regression models using CANRISK variables to predict dysglycemia.

Methods: Information from a self-administered CANRISK questionnaire, anthropometric measurements, and results of a standard oral glucose tolerance test (OGTT) were collected from First Nations and Métis participants (n = 1479). Sensitivity and specificity of CANRISK scores using published risk score cut-off points were calculated. Logistic regression was conducted with alternative ethnicity-specific BMI and WC cut-off points to predict dysglycemia using CANRISK variables.

Results: Compared with OGTT results, using a CANRISK score cut-off point of 33, the sensitivity and specificity of CANRISK was 68% and 63% among individuals aged 40 or over; it was 27% and 87%, respectively among those under 40. Using a lower cut-off point of 21, the sensitivity for individuals under 40 improved to 77% with a specificity of 44%. Though specificity at this threshold was low, the higher level of sensitivity reflects the importance of the identification of high risk individuals in this population. Despite altered cut-off points of BMI and WC, logistic regression models demonstrated similar predictive ability.

Conclusion: CANRISK functioned well as a preliminary step for diabetes screening in a broad age range of First Nations and Métis in Canada, with an adjusted CANRISK cut-off point for individuals under 40, and with no incremental improvement from using alternative BMI/WC cut-off points.

Keywords: *CANRISK, Type 2 Diabetes, First Nations and Métis, screening, sensitivity, specificity*

Highlights

- Data from First Nations and Métis participants aged 18 and older in the CANRISK studies were analyzed; 69% of participants were under 40 years old, and 15% had either prediabetes or diabetes.
- Though the standard CANRISK score cut-off point of 33 points achieved expected accuracy in this First Nations and Métis sample aged 40 or over, a lower cut-off point of 21 was shown to be more sensitive for individuals under 40.
- Alternative ethnicity-specific BMI/WC cut-off points did not improve the predictive ability of a logistic regression model using the CANRISK variables.

Introduction

From the 2011 National Household Survey, 4.3% of the Canadian population identified themselves as Aboriginal (First Nations, Inuit, or Métis), with 28% aged 14 years or under and 18.2% aged 15 to 24 years[1]. Studies have demonstrated that the Canadian Aboriginal population is at a higher risk for developing diabetes due to many factors including lifestyle, environmental and genetic.[2]

Over the past century, the Canadian Aboriginal population has been affected by westernized nutritional and lifestyle changes.[3] Traditional foods (game, fish, seafood, edible wild plants) which are high in animal protein and low in fat[4] have been replaced by store-bought foods, which are higher in refined carbohydrates and fat with less protective fiber; all of which have been implicated as major factors in increased diabetes rates in First Nations.[5] Moreover, procurement of store-bought foods reduces physical activity, as it results in less fishing, hunting, trapping and growing of foods.[4,6]

These are all in addition to environmental factors which include less access to

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healthcare[7] and healthy food[8] in many First Nations communities that may contribute to the development of diabetes and its complications, in addition to a delay in diagnosis and preventative treatment.[2] Researchers have suggested that some Indigenous peoples may have genes that promote caloric conservation during times of food shortage.[9] Particular polymorphisms linking obesity and diabetes in small groups of First Nations people have been found to support this hypothesis.[10-12]

The cumulative effects of these factors have resulted in an increased prevalence of diabetes in a variety of First Nations and Métis communities, with an average age standardized prevalence of 21% in individuals 25 years or older.[13] Diabetes is also becoming more prevalent among younger individuals in First Nations populations compared to the general Canadian population.[2,14] Higher complication rates among First Nations, particularly nephropathy and neuropathy, are also exacerbated by the earlier onset of diabetes compared to other Canadians.[15,16] These factors highlight the importance of developing a low-cost and simple screening tool for dysglycemia to address First Nation and Métis populations who are at high risk for type 2 diabetes at an earlier age.[17]

In Canada, a Canadian Diabetes Risk Questionnaire (CANRISK) was developed from a similar tool developed in Finland (FINDRISC).[17] To take into account Canada's multi-ethnic population and other correlates of diabetes, CANRISK included questions about parental ethnicity, education, sex and large birth-weight babies (macrosomia). The published CANRISK tool presents three risk groups: low risk (scores lower than 21), moderate risk (scores 21 to 32), and high risk (scores 33 and higher). CANRISK was developed and validated in a study of 6223 Canadians, the majority of whom were 40 years or older, and 12% of whom were Aboriginal people based on the mother's ethnicity.[17]

While Aboriginal people were overrepresented in this initial sample, the effectiveness of CANRISK in identifying dysglycemia (prediabetes and diabetes) has not been ascertained specifically for the First Nations and Métis population. Furthermore, data from several studies indicate that body mass index (BMI) and waist circumference (WC) are important predictors of diabetes[15,18,19], and First Nations and Métis people in Canada have high rates of obesity[15] and similar distributions of serum glucose at significantly lower body mass index (BMI) values compared with Europeans.[20] A similar serum glucose level is associated with a BMI level of 30 kg/m^2 for a European and as low as 21.8 kg/m^2 for a First Nations person.[20] Since CANRISK was developed using the World Health Organization (WHO) standard cut-off points for WC and BMI, it is prudent to examine whether lower BMI and/or WC cut-off points may provide a more accurate risk assessment specific to First Nations and Métis. Interestingly, the Australian diabetes risk assessment tool (AUSDRISK) includes alternative WC cut-offs points validated for the Australian Aboriginal population.[21] Additionally, alternative BMI cut-offs recommended by the WHO for Asians were found to have better accuracy in identifying obesity within this population.[22,23]

Primary and secondary aims

The primary aim of this paper was to assess the effectiveness of the current CANRISK tool and cut-off points in detecting dysglycemia in both older (40 years and older) and younger (under 40 years old) First Nations and Métis participants. A secondary aim was to compare the predictive ability of logistic models using CANRISK variables, with alternative WC and BMI cut-off points, for assessing the odds of dysglycemia in a First Nations and Métis sample.

Methods

As part of the validation of CANRISK, the Public Health Agency of Canada (PHAC) collected data from a large sample of Canadians across Canada over two phases of data collection. The current study comprises a sub-sample from this data set, pooled over both phases of data collection, by specifically including only First Nations and Métis participants (n = 1469).

In Phase 1 (2007 to 2011) and Phase 2 (2013 to 2014) of the CANRISK study, residents aged 18 and over, from seven provinces (British Columbia, Saskatchewan, Manitoba, Ontario, New Brunswick, Nova Scotia and Prince Edward Island) and two territories (Yukon and Nunavut) in Canada, of unknown diabetes status, were invited to participate in a dysglycemia risk assessment study. In Phase 1, most participants were over 40 years and recruited during their visits at community health centres, although some were recruited via mailouts from community health centres and regional health authorities.[17] Phase 2 of recruitment was specifically aimed at younger participants aged 20 to 39 among some high-risk ethnic populations including First Nations and Métis. In Phase 2, radio announcements, social media, posters, brochures and pamphlets were added to advertise participant recruitment. Local public health nurses could be contacted for recruitment questions. Those who already had a diagnosis of diabetes or were pregnant, or were unable to complete the CANRISK questionnaire in English or French were excluded. Participants in Phase 2 received a $50 food voucher for local grocery stores as compensation in Nunavut, Yukon, and Saskatoon data collection sites, and $50 cash compensation at the Vancouver site.

In order to ensure participants of First Nations and Métis heritage, data were collected in several communities with a high proportion of First Nations and Métis residents in conjunction with local health authorities. The highest numbers of First Nations and Métis participants were recruited through collaboration with the Yukon Department of Health and Social Services and the Saskatoon Health Region. In accordance with the Tri-Council requirements of conducting research in Aboriginal communities, ethics approvals were granted by the Health Canada/PHAC Research Ethics Board and by each local research ethics office or board. The First Nations and Métis subgroup of the CANRISK study population was used for this analysis. Participants who identified one or more parents of First Nations or Métis origin were retained in the analysis. In Phase 1, the data collection grouped those of First Nations, Métis and Inuit heritage into a single variable of Aboriginal heritage, which we were unable to separate. We ascribed First Nations and Métis ethnicity to all participants from Phase 1 who were recruited from the Saskatoon site and who self-identified as having Aboriginal heritage. As less than 1% of the Aboriginal population identifies as Inuit in Saskatoon[24], we are confident that the number of Inuit participants that misclassified as First Nations and Métis is minimal.

Risk assessment and data gathering procedures

There were two different data gathering procedures, depending on the data collection phase (first or second). During the first

phase, data gathering began at the time of recruitment with informed consent and instructions to arrive at the data collection site on a different day in a fasting state. Once at the data collection site, CANRISK was self-administered, and anthropometric measurements and two venous blood samples were collected on-site to determine glycemic status (see details below, the oral glucose tolerance test or OGTT); both of which were performed by nurses or health professionals. During the second data collection phase, however, informed consent was collected, as well as CANRISK scores and anthropometric measurements, all during the initial visit. Participants were then instructed to arrive at the blood collection site on a different day in a fasting state in order to collect the same two venous blood samples (to determine glycemic status by OGTT). Anthropometric measurements were taken in a standardized way after all project staff had received training. Participants were weighed using a digital standing scale without shoes and dressed in indoor clothing. A standardized tape measure attached to the wall was utilized for height and the minimum circumference between the umbilicus and xiphoid provided the WC measurements.

The CANRISK tool collected information on sex, age, mother and father's ethnicity, self-reported physical activity (such as brisk walking for at least 30 minutes each day), self-reported daily fruit and vegetable consumption, history of high blood pressure, history of high blood glucose, family history of diabetes, and education.[17] The full CANRISK tool can be found here: http://healthycanadians.gc.ca/en/canrisk?utm_source=VanityURL&utm_medium=URL&utm_campaign=publichealth.gc.ca/canrisk. Individual CANRISK scores were generated for each participant according to the publicly available CANRISK tool.[25] Since the CANRISK tool was intended for participants over the age of 40, the reference group (zero points) for age was 40 to 44 years. As such, the participants in the present study under the age of 40 were also assigned zero points for age-related risk.

Participants' glycemic status was determined using a standard oral glucose tolerance test (OGTT) procedure, which includes fasting plasma glucose (FPG) and a plasma glucose 2 hours after a 75-g glucose challenge (2hPG), as recommended by the WHO and Canadian Diabetes Association (CDA) 2013 guidelines.[26,27] An individual was classified as having pre-diabetes if they had a FPG level of 6.1 to < 7.0 mmol/L, and/or a 2hPG of 7.8 to 11.0 mmol/L. An individual was classified as having diabetes if they had a FPG level of 7.0 mmol/L or higher, and/or a 2hPG of higher than 11.0 mmol/L. Dysglycemia, a positive OGTT, referred to an individual having a FPG level ≥ 6.1mmol/L and/or a 2hPG of ≥ 7.8 mmol/L.

Data analysis

Descriptive analyses were conducted in order to describe participant characteristics. Glycemic status according to their OGTT results was also described. Logistic regression with all covariates from CANRISK was performed using SAS 9.3, with presence or absence of dysglycemia as the outcome variable. Reference categories were based on the previously validated CANRISK model which best represented good health.[27] Four logistic regression models were conducted using CANRISK standard and alternative [28-30] WC and BMI cut-off points as described below. Models were then compared for model fit using a Receiver Operator Characteristic (ROC) Curve measuring the area under the curve (AUC) and the Hosmer Lemeshow Goodness of Fit test.[31]

In the CANRISK tool, standard BMI cut-off points were < 25 kg/m^2 (underweight and normal weight; reference), 25 to 29.9 kg/m^2 (overweight), 30 to 34.9 kg/m^2 (obesity class 1) and 35+ kg/m^2 (obesity classes 2 and 3)[17]; standard WC cut-off points were small (male < 94 cm and female < 80 cm; reference), medium (male 94 to 102 cm and female 80 to 88 cm) and large (male > 102 cm and female > 88 cm).[17] The alternative Aboriginal cut-off points for BMI from AUSDRISK[17] were: < 23 kg/m^2 (underweight and normal weight; reference), 23 to < 27.5 kg/m^2 (overweight) and 27.5 kg/m^2 or higher (obese). Alternative WC cut-off points recommended for Asians by the WHO[22,23] were: small (male < 90 cm, female < 80 cm; reference), medium (male 90 to 100 cm, female 80 to 90 cm) and large (male > 100 cm, female > 90 cm).

The sensitivity, specificity, positive predictive value and accuracy rates were determined using the original CANRISK score risk categories ("Slightly Elevated Risk" cut-off point ≥ 21, and "High Risk" cut-off point ≥ 33)[24] for the whole sample, for those under 40 years, and those 40 years or older. Sensitivity was defined as the proportion of people who had a positive CANRISK score among those with a positive OGTT result. Specificity was the proportion of people who had a negative CANRISK score among those with a negative OGTT result. The positive predictive value (PPV) was defined as the probability that subjects with a positive CANRISK result truly had dysglycemia as determined by a positive OGTT. The negative predictive value (NPV) was the probability that subjects with a negative CANRISK result truly did not have dysglycemia as determined by a negative OGTT result. Both positive and negative predictive values are affected by the underlying prevalence of the condition, while sensitivity and specificity scores are independent of prevalence. The accuracy rate was the number of confirmed positive CANRISK scores and the number of confirmed negative CANRISK scores out of the total number of participants. These measurements were calculated to identify if the current CANRISK cut-off points could be used in a primarily younger First Nations and Métis population.

Results

A total of 1479 First Nations and Métis individuals participated in the CANRISK study; 834 individuals from phase 1 and 645 from phase 2. The study sample was 57% female, and 69% were aged 18 to 39 years (see Table 1). Less than 10% had obtained a college or university degree, and 46% had some high school education or less. Using CANRISK BMI and alternative cut-off points, 73% and 80% were considered overweight or obese, respectively. Likewise, 68% and 69% were in the highest CANRISK WC and alternative cut-off point category, respectively. Fifteen percent of participants had pre-diabetes or diabetes according to standard cut-off points applied to their OGTT results (see Table 2).

Table 3 provides the odds ratios from four adjusted logistic regression models using CANRISK variables. The sample size for the logistic regression models was reduced from 1479 to 1373, as 7% of the sample had a missing value on at least one of the variables. Model A used the CANRISK standard BMI and WC cut-off points. Model B used original BMI but alternative WC cut-off points based on the alternative Aboriginal cut-off points used in the AUSDRISK.[28] Model C used original WC but alternative BMI cut-off points based

TABLE 1
Study sample characteristics

Characteristics	Sample	Proportion (%)	Missing
Sex			
Female	847	57.3	0
Male	632	42.7	
Age			
18–29	536	36.2	0
30–39	479	32.4	
40–44	140	9.5	
45–54	206	13.9	
55–64	88	6.0	
65+	30	2.0	
BMI (kg/m²) – CANRISK cut-off points			
Normal/Underweight (< 25)	400	27.1	0
Overweight (25–29.9)	474	32.1	
Obese, non-morbid (30–34.9)	350	23.7	
Obese, morbid (≥ 35)	255	17.2	
BMI (kg/m²) – Alternative cut-off points			
Normal/Underweight (< 23)	300	20.3	0
Overweight (23 to < 27.5)	357	24.1	
Obese (≥ 27.5)	822	55.6	
WC – CANRISK cut-off points			
Male < 94, Female < 80	263	18.0	16
Male 94–102, Female 80–88	209	14.3	
Male > 102, Female > 88	991	67.7	
WC – Alternative cut-off points			
Male < 90, Female < 80	195	13.3	16
Male 90–100, Female 80–90	261	17.8	
Male > 100, Female > 90	1007	68.8	
Daily brisk physical activity			
Yes	1061	71.9	4
No	414	28.1	
Daily consumption of fruit/vegetable			
Yes	778	52.6	1
No	700	47.4	
High blood pressure			
Yes	252	17.1	4
No	1223	82.9	
High blood sugar			
Yes	172	88.3	5
No	1302	11.7	

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on WHO recommendations for Asians.[29,30] Finally, Model D used both alternative WC and BMI cut-off points. All four logistic regression models passed the Hosmer-Lomeshow goodness of fit test with p values ranging from 0.35 to 0.75 (see Table 3). Each model also showed good predictive ability for dysglycemia, with similar AUCs of approximately 0.75. In other words, using alternative BMI and/or WC cut-off points did not improve the predictive ability of the model as the AUC was no different than the Model with original BMI and WC cut-off points.

Predictive ability statistics of CANRISK by age group, including sensitivity and specificity are presented in Table 4. Using the "high risk" cut-off point of 33, the sensitivity and specificity were 68% and 63% in those aged 40 or over; and in those aged under 40, it was 27% and 87%, respectively. However, when using the "slightly elevated risk" CANRISK cut-off point of 21, the sensitivity was improved to 77%, and the specificity was reduced to 44%, in those aged below 40 years.

For those 40 and older, the PPV was 38% and the NPV was 86% at the original cut-off point of 33. For those under 40, the PPV was 18% and the NPV was 92% with an overall accuracy of 81% at the original CANRISK cut-off point of 33, whereas the PPV was 13% and NPV 95% with an overall accuracy of 47% using the alternative, more sensitive, CANRISK cut-off point of 21.

Discussion

In order to determine if ethnicity-specific cut-off points for BMI and WC model would better predict dysglycemia risk among First Nations and Métis Canadians, three logistic regression models using alternative BMI and/or WC cut-off points, in addition to a model using the original CANRISK cut-off points, were performed. However, contrary to what was hypothesized, alternative BMI and/or WC cut-off points did not improve model fit. Though each model had good predictive ability (75%), the alternative models did not more accurately predict dysglycemia risk beyond what was found in the original model. Our results suggest that current BMI and WC cut-off points used in the CANRISK tool are appropriate for use in a Canadian First Nations and Métis population.

TABLE 1 (continued)
Study sample characteristics

Characteristics	Sample	Proportion (%)	Missing
Number of primary relatives with diabetes			
0	685	49.1	
1	424	30.4	
2	217	15.6	85
3	63	4.5	
4	5	0.4	
Positive family history of diabetes			
No relatives with DM	282	19.1	
Secondary relative has DM (sibling or other)	448	30.3	0
Primary relative has DM (mother, father, or child)	620	41.9	
No confirmed cases, but suspected cases[a]	129	8.7	
Education			
Some high school or less	686	46.4	
High school diploma	279	18.9	0
Some college or university	371	25.1	
College or university degree	143	9.7	
History of macrosomia (% of female)	**228**	**26.9**	**0**

Abbreviations: BMI, body mass index; DM, diabetes mellitus; m, metre; WC, waist circumference.
Note: Total N = 1479.
[a] No relatives marked as yes, but some relatives marked as "unsure."

Among participants aged 40 years and over, using the CANRISK score of 33 as a cut-off point for high risk of dysglycemia, we found similar sensitivity and specificity to that reported in the original CANRISK validation paper:[17] sensitivity of 68% versus 66%; specificity of 63% versus 70%, respectively. Using the same threshold scores for younger adults yielded lower sensitivity (27%) and higher specificity (87%). However, using a lower CANRISK score threshold of 21 points for younger adults, a sensitivity of 77% and specificity of 44% was achieved. In other words, in order to achieve comparable predictive ability, a lower CANRISK score threshold of 21 points is needed for First Nation and Métis Canadians adults below the age of 40 years.

TABLE 2
Blood test results for prediabetes and diabetes

	Proportion (%)	Sample
Prediabetes		
A) FPG only (6.1 to < 7.0 mmol/L)	2.7	40
B) 2hPG only (7.8–11.0 mmol/L)	5.3	78
C) Both FPG and 2hPG	1.6	24
D) Total prediabetes (A+B+C)	9.6	142
Diabetes		
E) FPG only (≥ 7.0 mmol/L)	1.7	25
F) 2hPG only (> 11.0 mmol/L)	1.4	21
G) Both FPG and 2hPG	2.0	30
H) Total diabetes (E+F+G)	5.1	76
Total prediabetes and diabetes	**14.7**	**218**

Abbreviations: 2hPG, plasma glucose after 2-hour glucose challenge; FPG, fasting plasma glucose.
Note: Total N = 1479.

The need for a lower score threshold for younger participants is logical. Age is a key unmodifiable variable in the CANRISK score with 0 points attributed to ages 40 to 44 years up to 15 points attributed to those 65 to 74 years old, out of the highest possible score of 93 points. The maximum CANRISK score is therefore lower for participants under 40 years of age than for participants over 40 years of age. To compensate, in practice, this would mean using a threshold of 21 points for younger First Nations and Métis people (age 18 to 39) and 33 points for participants 40 and older. This does, however, have implications for the positive predictive value (PPV) of the test and its accuracy. For those under 40, given the relatively low prevalence of dysglycemia at younger ages, the PPV is only 13% at a cut-off of 33 and 18% at a cut-off of 21, whereas for those 40 and over, the PPV is 29% and 38%, at cut-offs of 33 and 21 points, respectively. The higher PPV at both cut-offs among the older age group reflects the higher underlying prevalence of dysglycemia with increasing age. For those under the age of 40, while accuracy was reduced from 81%, at the 33-point cut-off, to 47%, at the 21-point cut-off, the sensitivity was sufficiently increased to a more ideal level, compensating for the decrease in accuracy. The increase in sensitivity ensures that potentially affected young individuals do move on to clinical diabetes testing, which is more important than having the highest accuracy. Using cut-off points that balance sensitivity and specificity in both age groups ensures that potentially affected individuals from either age group do move on to clinical diabetes testing, while reducing the need for expensive and cumbersome screening of low-risk participants.

Strengths and limitations

In this paper we investigated the effectiveness of the CANRISK tool in screening for dysglycemia risk in a relatively large sample size of First Nations and Métis people from across Canada. We also investigated whether alternative BMI and WC cut-off points improved the predictive ability of the CANRISK model for dysglycemia in this population. To our knowledge, this is the first paper to examine the impact of using alternative BMI and WC categorizations in

TABLE 3
Logistic regression model comparison predicting dysglycemia status

Variable	Model A with CANRISK cut-off points			Model B with alternative WC cut-off points			Model C with alternative BMI cut-off points			Model D with alternative WC and BMI		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
Age (years)												
18–29	0.44	0.25	0.77	0.43	0.24	0.77	0.46	0.26	0.81	0.45	0.25	0.80
30–39	0.61	0.36	1.05	0.61	0.35	1.04	0.62	0.36	1.06	0.61	0.36	1.05
40–44	Ref			Ref			Ref			Ref		
45–54	1.18	0.66	2.12	1.16	0.65	2.08	1.14	0.64	2.04	1.12	0.62	2.00
55–64	2.24	1.15	4.36	2.21	1.13	4.32	2.16	1.11	4.20	2.12	1.09	4.13
65+	3.28	1.24	8.71	3.31	1.24	8.83	2.91	1.10	7.67	2.92	1.10	7.77
BMI (kg/m²) – CANRISK cut-off points												
Normal/ underweight (< 25)	Ref			Ref								
Overweight (25–29.9)	1.21	0.69	2.12	1.12	0.62	2.01						
Obese, non-morbid (30–34.9)	1.57	0.84	2.94	1.38	0.73	2.63						
Obese, morbid (≥ 35)	3.08	1.64	5.79	2.71	1.42	5.16						
BMI (kg/m²) – Alternative cut-off points												
Normal/ underweight (< 23)							Ref			Ref		
Overweight (23 to < 27.5)							1.07	0.57	2.00	1.01	0.52	1.95
Obese (≥ 27.5)							1.78	0.94	3.36	1.54	0.78	3.04
WC – CANRISK cut-off points												
Male < 94, Female < 80	Ref						Ref					
Male 94–102, Female 80–88	0.94	0.46	1.92				0.91	0.45	1.87			
Male > 102, Female > 88	1.34	0.68	2.63				1.42	0.72	2.80			
WC – Alternative cut-off points												
Male < 90, Female < 80				Ref						Ref		
Male 90–100, Female 80–90				0.66	0.31	1.40				0.65	0.31	1.40
Male > 100, Female > 90				1.36	0.66	2.83				1.46	0.68	3.10
Daily brisk physical activity												
Yes	Ref			Ref			Ref			Ref		
No	1.50	1.06	2.14	1.51	1.06	2.15	1.56	1.10	2.21	1.56	1.10	2.21
Daily consumption of fruit/vegetable												
Yes	Ref			Ref			Ref			Ref		
No	1.06	0.76	1.47	1.05	0.76	1.45	1.04	0.75	1.44	1.03	0.75	1.43

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TABLE 3 (continued)
Logistic regression model comparison predicting dysglycemia status

Variable	Model A with CANRISK cut-off points			Model B with alternative WC cut-off points			Model C with alternative BMI cut-off points			Model D with alternative WC and BMI		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
High blood pressure												
Yes	1.13	0.76	1.68	1.10	0.74	1.64	1.18	0.79	1.75	1.15	0.77	1.70
No	Ref			Ref			Ref			Ref		
High blood sugar												
Yes	2.73	1.78	4.21	2.75	1.79	4.23	2.72	1.78	4.18	2.75	1.79	4.22
No	Ref			Ref			Ref			Ref		
Positive family history of diabetes												
None	Ref			Ref			Ref			Ref		
Primary relative	1.26	1.06	1.51	1.26	1.06	1.50	1.28	1.07	1.52	1.27	1.07	1.51
Gender												
Female	Ref			Ref			Ref			Ref		
Male	1.77	1.21	2.59	1.79	1.24	2.60	1.69	1.16	2.47	1.71	1.18	2.48
Education												
Some high school or less	1.18	0.81	1.72	1.17	0.81	1.71	1.19	0.82	1.73	1.18	0.81	1.71
High school diploma	1.27	0.80	2.02	1.28	0.80	2.04	1.30	0.82	2.06	1.31	0.82	2.07
Some/graduated college or university	Ref			Ref			Ref			Ref		
History of macrosomia												
No/NA	Ref			Ref			Ref			Ref		
Yes	0.93	0.57	1.51	0.92	0.57	1.50	0.92	0.57	1.49	0.92	0.57	1.48
AUC	0.7412			0.7448			0.7296			0.7332		
Hosmer Lemeshow goodness of fit	p = 0.6602 (DF = 8)			p = 0.6148 (DF = 8)			p = 0.3453 (DF = 8)			p = 0.7490 (DF = 8)		

Abbreviations: AUC, area under the curve; BMI, body mass index; CI, confidence interval; DF, degrees of freedom; kg, kilogram; m, metre; NA, not available; OR, odds ratio; Ref, reference group; WC, waist circumference.

Note: Total N = 1373.

the Canadian First Nations and Métis population in predicting dysglycemia risk.

Additionally, this study supports the use of the CANRISK tool among young adults of First Nations and Métis in Canada to identify dysglycemia risk, provided that a lower CANRISK score threshold of 21 points is used. Though specificity at this threshold was low, the improved sensitivity is a sensible compromise when implementing CANRISK among those aged under 40 years as it is more important to identify high-risk individuals in this population. This is important as diabetes rates are high in the First Nations and Métis population with a greater incidence rate among younger individuals.[2,10] Using the CANRISK tool will facilitate diabetes screening among young First Nations and Métis people, providing initial convenient screening without having to offer expensive clinical screening to young low-risk First Nations and Métis individuals. Until future research can determine the optimal model for young First Nations and Métis individuals, our results show acceptable predictive ability for this population using the "Slightly Elevated Risk" original CANRISK cut-off point. In the future, it may also be useful to create separate risk algorithms for men and women.

Considering this study relied on a convenience sample of English or French speaking volunteers who self-identified as either First Nations or Métis by their parents' ethnic background, it was not possible to fully investigate dysglycemia risk in a fully representative sample of the general First Nations and Métis population in

TABLE 4
Predictive ability of CANRISK by age group

Age group	All ages	Under 40 years	40 years or over
n	1479	1015	464
Minimum CANRISK Score	3.0	3.0	3.0
Maximum CANRISK Score	65.0	56.0	65.0
Median CANRISK Score	25.0	22.0	31.0
Mean CANRISK Score	25.7	23.1	31.3
CANRISK (%) – Using a cut-off point of 33 (high risk as specified in original CANRISK instructions)			
Sensitivity	49.1	26.7	68.4
Specificity	80.2	86.8	62.8
Positive predictive value	30.0	18.2	38.3
Negative predictive value	90.1	91.5	85.5
Accuracy	75.6	80.8	64.2
CANRISK (%) – Using a cut-off point of 21 (slightly elevated risk as specified in original CANRISK instructions)			
Sensitivity	86.2	77.2	94.0
Specificity	37.7	43.8	21.6
Positive predictive value	19.3	13.2	28.8
Negative predictive value	94.1	94.6	91.5
Accuracy	44.8	47.1	39.9

Canada. It is possible that our two separate recruitment strategies resulted in some group differences in the participating individuals between Phases 1 and 2. In addition, the fact that those with a pre-existing diabetes diagnosis were excluded from the current analysis makes it impossible to compare rates of diabetes and its risk factors between the current study and the general First Nations and Métis population.

Conclusion

The CANRISK tool functions well in a sample of Canadian First Nations and Métis as the primary step of diabetes screening for not only those aged 40 years or over but also for those under 40, with an adjustment of CANRISK score cut-off point. Our study found that alternative First Nations and Métis specific BMI and WC cut-off points did not improve the predictive ability of a logistic regression model using the CANRISK variables. Using CANRISK in the First Nations and Métis population can effectively support the early detection of type 2 diabetes and help promote awareness of its risk factors.

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Conflict of interest

Dr. Gina Agarwal was contracted to lead this project by the Science Integration Division of the Public Health Agency of Canada. Research ethics board approval was obtained from each of the regions in which data were collected and from the Health Canada/Public Health Agency of Canada Research Ethics Board.

The authors declare no conflict of interest.

Authors' contributions and statement

G.A., Y.J., H.M. and Y.M. contributed substantially to the study design and drafted the paper. H.O. provided methodological advice for data analysis. S.R.V.K. and C.L. analysed the data. B.H., K.D., and L.L. developed site collection protocols and completed data acquisition. Y.J., C.L., and H.O. reviewed and revised the paper. All authors read and gave final approval of this version to be published and agreed to be guarantors of the work.

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