Title: Characterizing risk for type 2 diabetes in First Nations people living in First Nations communities in Ontario, Canada using population-based survey data

AUTHORS

Laura C. Rosella, PhD[a,b], Kathy Kornas, MSc[a], Michael E. Green, MD MPH[c,d], Baiju R. Shah, MD PhD[b,e], Jennifer D. Walker, PhD[b,f], Eliot Frymire, MA[c,g], Carmen Jones [h]

AFFILIATIONS

a Dalla Lana School of Public Health, University of Toronto, Toronto, ON, Canada
b ICES, Toronto, ON, Canada
c ICES, Queens, Queens University
d Dept of Family Medicine Queen's University, Kingston, ON , Canada
e Sunnybrook Research Institute, Toronto, ON Canada
f Centre for Rural and Health Research, Laurentian University, Sudbury, ON, Canada
g Faculty of Health Sciences, Queen's University, Kingston, ON, K7L 3N6
h Chiefs of Ontario, Toronto, ON, Canada

CORRESPONDING AUTHOR
Dr. Laura Rosella
Dalla Lana School of Public Health, Health Sciences Building
6th floor, 155 College Street
Toronto, Ontario
M5T 3M7
Tel: 416-978-6064
Email: laura.rosella@utoronto.ca

Words: 2328

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Abstract

Background: This study characterized the distribution of type 2 diabetes risk factors in a representative sample of First Nations people living in First Nations communities in Ontario, Canada. The study also applied a validated population risk tool to predict 10-year diabetes burden and describe the factors that are contributing to diabetes risk in First Nations adults.

Methods: We measured the prevalence of type 2 diabetes risk factors in a cohort of 936 respondents (representing 50,703 First Nations adults living in First Nations communities) to the Ontario First Nations Regional Health Survey (RHS), Phase 3, 2013. Diabetes Population Risk Tool (DPoRT) equations were applied to risk factor information in the RHS to predict 10-year type 2 diabetes incidence and number of new diabetes cases in the First Nations population from 2013 and 2023.

Results: DPoRT estimated that between 2013 and 2023, the 10-year incidence risk for developing type 2 diabetes will be 9.6% (CI 8.3 to 10.8) in First Nations adults, corresponding to 3,501 (CI 2,653 to 4,348) new cases. New diabetes cases were predicted to disproportionately occur among First Nations adults experiencing food insecurity, low income, overweight, obesity, and physical inactivity. Reduced diabetes risk was predicted in those that reported connections to indigenous culture, such as eating traditional vegetative foods.

Interpretation: Socioeconomic conditions and known type 2 diabetes risk factors are important determinants of diabetes risk in First Nations people living in First Nations communities. Indigenous culture and traditions have an important role for diabetes prevention in First Nations communities.

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Introduction

Genetic susceptibility, socioeconomic determinants, and risk behaviours are among the factors that contribute to the development of type 2 diabetes [1]. Indigenous populations have unique experiences that impact their health and well-being, including intergenerational effects of colonization, loss of culture and language, and disproportionate experiences of low income, food insecurity, and risky behaviours compared to other populations in Canada [2, 3]. Understanding how the risk factors for type 2 diabetes are distributed in indigenous populations and how these factors contribute to the diabetes burden is critical for informing diabetes prevention strategies that address the health gaps, needs and challenges that are unique to indigenous communities [4].

Reliable data on risk factors and other health determinants relevant to First Nations people living in First Nations communities in Canada are collected in limited population health surveys. The First Nations Regional Health Survey (RHS) is the only First Nations governed Canadian national health survey for First Nations people in First Nations communities that is fully under First Nations ownership and control [5, 6]. Guided by a cultural framework that conceptualizes health from First Nations perspectives, the RHS collects information based on western and traditional understandings of health and wellbeing [7].

Diabetes prevention efforts can be informed by meaningful decision support tools that support the use of First Nations data for the benefit of First Nations people. The Diabetes Population Risk Tool (DPoRT) is a population based risk prediction algorithm that predicts type 2 diabetes risk by making use of risk factor information that is routinely collected in population surveys [8]. Importantly, DPoRT identifies segments of the population that are at elevated risk for diabetes, which is important for informing diabetes prevention strategies that are meaningful for First Nations communities.

The objective of this study was to apply DPoRT to risk factor data from the RHS to estimate the future diabetes burden and examine the social determinants and other factors that are driving diabetes risk in the First Nations population living in First Nations communities in Ontario.

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Methods

Data source and study population

We used data from the adult Regional Health Survey (RHS), Phase 3 (2013), a cross-sectional survey of First Nations people living on-reserve and northern First Nations communities across Canada [5, 6]. Access to the RHS is governed by the First Nations Information Governance Centre, and its regional partners that serve as data stewards, including the Chiefs of Ontario. The adult survey included questions about diabetes, demographics, health and chronic conditions, food security, and other social determinants. The RHS Phase 3 had a response rate of 78.1%; methodological details about the RHS sampling frame are described elsewhere [6]. Access to RHS data for this study was approved by the data governance process at the Chiefs of Ontario.

The study sample was drawn from the 993 adult RHS Phase 3 respondents from the province of Ontario. We excluded individuals that were less than 20 years old at interview date, those who reported being diagnosed with type 1 or gestational diabetes, and women who reported being pregnant at interview. After exclusions, a total of 936 respondents were retained for the analysis, of which 708 reported no diabetes and 228 reported having a type 2 diabetes diagnosis at interview date.

Estimating type 2 diabetes risk

The Diabetes Population Risk Tool (DPoRT) was applied to risk factor information from the RHS to estimate 10-year type 2 diabetes incidence and future diabetes burden in the First Nations population living in First Nation communities. DPoRT is a validated population based risk prediction algorithm that estimates the future risk of type 2 diabetes using self-reported risk factor information from health surveys, including age, sex, body mass index, education, smoking status, heart disease and hypertension. Methodological details about the development and validation of DPoRT are described elsewhere [8]. Briefly, DPoRT was originally developed in a cohort of 19,861 individuals ≥ 20 years of age without diabetes, and validated in two external cohorts in the provinces of Ontario (n = 26,465) and Manitoba (n = 9,899) [8]. The algorithm was updated with more recent data, and demonstrated to have good discrimination and calibration (c-statistic = 0.77; HL X^2 < 20) [9]. The appropriateness of using DPoRT to estimate diabetes risk for First Nations populations was determined by applying the DPoRT algorithm to the RHS data and examining the model's performance according to self-reported type 2 diabetes across diabetes risk categories.

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Diabetes risk factors

We examined the distribution of type 2 diabetes risk across important risk factor variables that are known to contribute to diabetes risk [4]. Demographic and socioeconomic risk factors included sex, age group (20-44, 45-64, ≥65 years), household income category (≤24,999, 25,000-49,000, 50,000-69,999, 70,000-99,999, ≥100,000 dollars per year), and household food security (food secure, moderately/severely food insecure). Risk factors related to health included consumption of traditional vegetation (e.g., berries, wild vegetation, and wild rice) in the past 12 months (not at all, a few times/often), knowledge of a First Nations language (yes, no), self-reported diagnosis of hypertension, smoking status (current, former, never smoker), body mass index (BMI), and physical activity. BMI was calculated by dividing body weight by the square of body height (kg/m^2) and classified according to the international standard: normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), and obese (≥30 kg/m^2). Physical activity level was based on the total energy expenditure calculated from the frequency and duration of physical activities reported in the three months prior to interview date and metabolic equivalent (MET) value of each activity. Respondents were categorized as being inactive (0-1.4 kcal/kg/day), moderately inactive (1.5-2.9 kcal/kg/day), and active (≥3.0 kcal/kg/day).

Statistical Analysis

Means were calculated to describe the distribution of type 2 diabetes risk factors in the First Nations population by type 2 diabetes status. DPoRT diabetes risk estimates were restricted to individuals who did not report having type 2 diabetes at baseline and who had valid risk factor information required for the DPoRT algorithm (n = 670). In the DPoRT algorithm, income is included as a binary variable (highest income, quintile 5 versus lowest income, quintiles 1-4). For the purposes of estimating diabetes risk with DPoRT, individuals who reported having a household income of ≥$70,000 were assigned to the highest income quintile (quintile 5), which corresponds to the income distribution for the Ontario general population. Individuals that had missing values on income were assigned to the bottom income quintile groups (quintiles 1-4), which corresponded to the most frequently reported income groups for this population.

Diabetes risk estimates were averaged across all respondents to determine the 10-year population risk of diabetes between 2013 and 2023. DPoRT risk estimates were reported by important sub-groups defined by diabetes risk factors. The number of new cases of type 2 diabetes was estimated by multiplying the average risk by the population size. Estimates were weighted and confidence intervals were calculated using the SPSS Complex Samples Module, which produces estimated based on weights and specifications of the RHS' complex sampling

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design. Sampling weights were provided by the First Nations Information Governance Centre, and were based on 2014 registry counts from Indigenous and Northern Affairs Canada. All analyses were conducted at the Chiefs of Ontario office in Toronto, Canada, using SPSS, Version 23.

Results

The weighted distribution of baseline characteristics of the cohort are summarized in **Table 1**. At interview, First Nations adults with diabetes were older, more likely to be classified with obesity, and more likely to report hypertension compared to First Nations adults without diabetes. Overall, First Nations adults were observed to experience a high prevalence of low household income and food insecurity. The most prevalent risk factors in both those with and without diabetes were physical inactivity, overweight, obesity, and current smoking. However, the majority of First Nations adults reported consuming different types of traditional vegetation in the year prior to the survey and had knowledge of a First Nations language.

In the Ontario RHS (phase 3), 228 respondents ≥ 20 years old (representing 11,209 First Nations adults after applying survey sampling weights) reported being diagnosed with type 2 diabetes, of which DPoRT correctly classified 30.0% as high risk (≥20% diabetes risk) and 60.2% as moderate risk (5%-20% diabetes risk), while 9.8% were classified as low risk (<5% diabetes risk), demonstrating that risk corresponded with diabetes status at baseline. In comparison, in the general Ontario population, DPoRT was observed to classify individuals with type 2 diabetes with a similar distribution of risk: 45.4% classified as high diabetes risk, 49.4% classified as moderate diabetes risk, and 5.1% classified as low diabetes risk (estimated using the Canadian Community Health Survey, cycle 2013/14).

After applying DPoRT, we estimated that the 10-year incidence for developing type 2 diabetes in First Nations adults living in First Nations communities was 9.6% (CI 8.3 to 10.8), corresponding to 3,501 new type 2 diabetes cases between 2013 and 2023. The 10-year diabetes risk and number of new cases by important subgroups is reported in **Table 2**. About one third of new diabetes cases were predicted to occur in First Nations adults aged 20 to 44 (1,658 new cases), and about half of the total cases were predicted among those aged 45 to 64 (1,237 new cases).

Socioeconomic factors are important to the diabetes burden among First Nations people in First Nations communities. The two lowest income groups (≤$24,999 and $25,000-$49,999) were predicted to account for 48.5% (1,699 new cases) of the diabetes burden between 2013 and 2023. Furthermore, almost half of the total new diabetes cases (1,595) were predicted to occur among First Nations adults who reported experiencing food insecurity.

Other risk factors were observed to contribute to the type 2 diabetes burden in First Nations adults. The 10-year risk for developing diabetes was predicted to be 15.8% (CI 14.8 to 16.9) in

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those with obesity and 10.7% (CI 9.3 to 11.9) in those that were physically inactive, compared to 2.7% (CI 2.0 to 3.5) in those with normal weight and 7.5% (CI 5.7 to 9.2) in physically active individuals. Diabetes risk was found to be lower among First Nations adults who reported eating traditional vegetation a few times or often in the past year compared to those who reported not at all (9.5%, CI 8.1 to 10.9 and 10.4%, CI 7.8 to 12.9, respectively). Of the total new diabetes cases, about two thirds were predicted to occur among those with obesity (2,270 cases), about half among physically inactive individuals (1,960), and about one fifth in those who were classified in the overweight category (929 cases). Although diabetes risk was elevated in those with hypertension (21.1%, CI 18.8 to 23.4), a larger proportion of new diabetes cases were predicted to occur among First Nations adults with no hypertension (2,382 cases) compared to those with hypertension (1,118 cases) reflecting the distribution of hypertension in the community.

Interpretation

The burden of diabetes in the First Nations population in First Nations communities is a function of the level of risk associated with the factors that contribute to type 2 diabetes and the prevalence of those risk factors in the population. We have shown that key socioeconomic and additional risk factors that contribute to type 2 diabetes are highly prevalent in First Nations adults living in First Nations communities in Ontario. Furthermore, using a validated population risk tool, DPoRT, and risk factor information from the RHS, we predicted that between 2013 and 2023, there will be about 3,500 new cases of type 2 diabetes in this population. We demonstrated that a large burden of new diabetes cases will occur among First Nations adults experiencing socioeconomic disadvantage relating to low income and food insecurity, as well as for well established diabetes risk factors including overweight, obesity, and physical inactivity. We also found important reductions in diabetes risk among First Nations adults that reported connections to Indigenous culture, specifically, eating traditional vegetative foods and knowledge of a First Nations language.

The results offer support to ongoing calls to improve socioeconomic conditions and access to societal resources in these communities and highlight the potential benefits for diabetes prevention among First Nations people in First Nations communities. Given that the diabetes burden was projected to disproportionately affect those experiencing socioeconomic disadvantage, initiatives to address the factors that contribute to household income and food insecurity in First Nations people must be considered in any strategy that is focused on meaningfully reducing the diabetes burden. Previous research has documented large income inequalities among Indigenous people in Canada, with one study estimating that the median income for Indigenous people was 30% lower than the income for the rest of Canadians in 2006 [10]. Remote northern First Nations communities in particular experience unique food security challenges in accessing healthy, inexpensive, and traditional foods [5, 11].

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The findings reinforce the epidemiology of known risk factors for type 2 diabetes among First Nations people living in First Nations communities, including obesity, and physical inactivity. Moreover, our results highlighted the importance of having access to traditional vegetative foods, such as berries, wild vegetation and wild rice. Previous research has linked deviations from traditional diets and lifestyle to obesity in First Nations communities, and have documented persistent challenges to maintaining a traditional diet, including high food prices in remote communities and the impact of environmental contaminants [12]. First Nations communities have a critical role in designing polices and community-based programs to prevent risk factors for diabetes in ways that are culturally appropriate and sensitive to the needs of First Nations people.

The results emphasize that connections to Indigenous culture are important determinants of diabetes risk in First Nations people in First Nations communities. It is widely recognized that the process of colonization has impacted the health and well-being of Indigenous people through dislocation from traditional lands and lifestyles, cultural suppression, forced assimilation, among other effects [13, 14]. Despite these challenges, our study demonstrated the protective effects of traditional foods and language on diabetes risk among First Nations people. The findings underscore the importance of a holistic approach and incorporation of First Nations understandings of health to diabetes prevention efforts for First Nations people.

The findings of this study should be interpreted in context with several considerations. It is important to recognise that the DPoRT algorithm was originally developed and validated in a cohort of individuals from the Ontario general population, which included First Nations individuals living off-reserve [8]. Although DPoRT was determined to have appropriate predictive accuracy for the First Nations population in that most First Nations people with self-reported diabetes were correctly classified as high-risk, a small proportion were shown to be misclassified as low-risk. Further, DPoRT was validated against physician-diagnosed diabetes as captured in the Ontario Diabetes Database which does not capture individuals with diabetes not recognized by themselves or their doctor. Given these considerations, it is possible that the DPoRT estimates may be under-estimating the true diabetes burden in First Nations people. Finally, with the use of self-reported data there is potential for reporting biases, such as recall, social desirability, and over-reporting of healthier behaviours. Nonetheless, the results from these survey data represent one of the largest and comprehensive source of risk factor information among First Nations people in Ontario living on First Nations reserve.

Conclusions

We found that low income and food insecurity, along with overweight, obesity, and physical inactivity are associated with a large proportion of the predicted diabetes burden in First Nations people living in First Nations communities. We also demonstrated important protective effects of Indigenous cultural connections on diabetes risk in this population. Our findings underscore that policies, programming and services that address socioeconomic disadvantage and known type 2 diabetes risk factors, as well as incorporate traditional and cultural

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approaches, can have tangible impacts on preventing type 2 diabetes in First Nations communities.

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Table 1. Weighted distribution of baseline characteristics according to type 2 diabetes status in First Nations adults aged ≥20 living in First Nations communities in Ontario, RHS Phase 3 (2013).

Characteristic	Without Diabetes % (95% CI) N= 708 Weighted = 39,494 [a]	With type 2 Diabetes % (95% CI) N = 228 Weighted = 11,209 [a]
Sex (% Males)	51.5 (48.7, 54.3)	44.7 (41.1, 48.4)
Age at interview		
20-44	61.4 (54.5, 67.9)	25.9 (16.3, 38.6)
45-64	28.5 (22.8, 35.0)	44.9 (34.7, 55.7)
≥65	10.0 (7.7, 13.1)	29.2 (24.1, 34.8)
Household Income (CAD $)		
≤ 24,999	22.2 (18.1, 26.9)	26.9 (20.4, 34.6)
25,000 – 49,999	22.9 (17.5, 29.4)	19.1 (13.1, 26.9)
50,000 – 69,999	4.1 (2.6, 6.4)	12.2 (8.5, 17.3)
70,000 – 99,999	5.1 (3.4, 7.5)	6.6 (4.7, 9.0)
≥ 100,000	3.1 (1.4, 6.7)	7.7 (4.1, 14.0)
missing	42.6 (34.3, 51.3)	27.5 (21.8, 34.1)
Food Security		
Food Secure	52.0 (47.0, 56.9)	57.3 (50.2, 64.1)
Food Insecure	44.8 (39.9, 49.8)	41.3 (34.5, 48.4)
Body mass Index (kg/m^2)		
Normal weight	23.0 (16.0, 31.9)	8.4 (4.7, 14.5)
Overweight	36.0 (31.4, 40.9)	33.8 (27.7, 40.3)
Obese	38.8 (31.6, 46.5)	53.0 (46.0, 59.8)
Physical Activity		
Active	29.0 (23.9, 34.5)	22.9 (17.6, 29.1)
Moderately active	13.9 (10.6, 18.0)	12.6 (7.8, 19.5)
Inactive	50.5 (45.3, 55.5)	58.4 (51.6, 64.8)
Smoking		
Never smoker	24.9 (18.1, 33.0)	21.1 (15.5, 28.0)
Former smoker	21.3 (16.8, 26.6)	35.8 (28.6, 43.7)
Current smoker	51.1 (42.6, 59.5)	41.5 (32.6, 50.9)
Hypertension		
Yes	14.0 (11.6, 16.9)	53.6 (43.7, 63.3)
No	83.2 (80.3, 85.6)	45.4 (35.7, 55.3)
Traditional Vegetation Consumption		
A few times/often in past 12 months	84.0 (77.5, 88.6)	90.8 (84.8, 94.5)
Not at all in past 12 months	12.6 (8.0, 19.0)	7.3 (4.1, 12.7)
Knowledge of a First Nations language		
Yes	89.8 (84.9, 93.2)	92.1 (88.8, 94.5)

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No	10.2 (6.8, 15.1)	7.9 (5.5, 11.2)

ª Represented population estimated using RHS sampling weights. Column percentages do not total 100% where missing values are not reported.

Table 2. DPoRT estimated 10-year (2013 – 2023) diabetes risk and new diabetes cases expected among adult First Nations people living in First Nations communities in Ontario, Canada.

Characteristic	10-year diabetes riskª (%) Estimated	Number of new diabetes cases[b] Estimated
Overall	9.6 (8.3, 10.8)	3,501 (2,653, 4,348)
Sex		
Males	11.3 (9.3, 13.4)	2,013 (1,507, 2,518)
Females	7.9 (7.1, 8.8)	1,488 (1,106, 1,870)
Age at interview		
20-44	5.6 (4.6, 6.6)	1,237 (893, 1,582)
45-64	15.8 (14.0, 17.6)	1,658 (1,176, 2,141)
≥65	15.7 (13.7, 17.8)	605 (372, 839)
Household Income (CAD $)		
≤ 24,999	10.3 (8.4, 12.3)	863 (597, 1,129)
25,000 – 49,999	10.4 (8.7, 12.1)	836 (607, 1,167)
50,000 – 69,999	12.6 (9.7, 15.5)	204 (89, 319)
70,000 – 99,999	8.9 (5.9, 11.7)	177 (94, 261)
≥ 100,000	8.0 (5.4, 10.5)	93 (15, 171)
missing	8.7 (6.4, 10.9)	1,326 (799, 1,854)
Food Security		
Food Secure	9.5 (8.0, 11.1)	1,869 (1,336, 2,402)
Food Insecure	9.6 (8.2, 11.1)	1,595 (1,213, 1,976)
Body mass Index (kg/m^2)		
Normal weight	2.7 (2.0, 3.5)	244 (182, 308)
Overweight	7.4 (6.4, 8.4)	929 (734, 1,125)
Obese	15.8 (14.8, 16.9)	2,270 (1,527, 3,013)
Physical Activity		
Active	7.5 (5.7, 9.2)	845 (536, 2,339)
Moderately active	10.6 (7.4, 13.8)	565 (300, 830)
Inactive	10.6 (9.3, 11.9)	1,960 (1,581, 2,339)
Smoking		
Never smoker	10.5 (9.3, 11.8)	1,024 (595, 1,451)
Former smoker	11.2 (9.8, 12.7)	907 (663, 1,151)
Current smoker	8.4 (6.5, 10.4)	1,569 (1,177, 1,961)
Hypertension		

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Yes	21.1 (18.8, 23.4)	1,118 (792, 1,445)
No	7.6 (6.3, 8.9)	2,382 (1,754, 3,010)
Traditional Vegetation Consumption		
A few times/often in past 12 months	9.5 (8.1, 10.9)	3,007 (2,230, 3,783)
Not at all in past 12 months	10.4 (7.8, 12.9)	367 (251, 668)
Knowledge of a First Nations Language		
Yes	9.8 (8.7, 10.9)	3,093 (2,308, 3,877)
No	10.1 (7.7, 12.5)	369 (183, 555)

[a]Diabetes risk estimated among respondents that reported not having a diabetes diagnosis at baseline, n = 708, represented population = 39,494.

[b] Column totals for number of new diabetes cases do not add to 3,501 due to rounding and where estimated new cases for those with missing information is not reported.

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