Growing social inequality in the prevalence of type 2 diabetes in Canada, 2004–2012

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ABSTRACT

OBJECTIVES: The prevalence of diabetes in Canada has nearly doubled since 2000. Trends in social inequalities in diabetes across Canada and its different regions have not been assessed. We estimated relative and absolute social inequalities in type 2 diabetes prevalence in Canada between 2004 and 2012.

METHODS: We used the relative (RII) and slope (SII) indices of inequality to measure relative and absolute education-based inequalities respectively in type 2 diabetes prevalence in a sample of 413,453 men and women surveyed as part of the Canadian Community Health Survey between 2004 and 2012.

RESULTS: Across regions and time periods, inequalities were more pronounced for women than for men, both on the absolute and relative scales. The difference in the prevalence of type 2 diabetes between individuals with the highest level of educational attainment compared to the lowest, as reflected by the SII, expanded from approximately 2.5% to 4.5% for women and 1.4% to 2.3% for men between 2004 and 2012.

CONCLUSIONS: Monitoring and tracking social inequalities in the burden of diabetes over time can help to assess whether Canadian diabetes strategies are effective at reaching marginalized populations and mitigating inequalities. Our results signal the need for interventions to address growing social inequalities in Canada with regard to type 2 diabetes, particularly among women.

KEY WORDS: Socio-economic factors; inequalities; diabetes mellitus, type 2; epidemiology; Canada

La traduction du résumé se trouve à la fin de l'article.

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The prevalence of diabetes in Canada has nearly doubled since 2000.[1] Diabetes is associated with substantial disability and is the leading cause of blindness, end stage renal disease (ESRD), and non-traumatic amputation among Canadian adults.[2–5] Type 2 diabetes mellitus (hereafter referred to as type 2 diabetes) accounts for roughly 90–95% of diabetes cases. It is among the top 10 leading causes of death in high income countries[6] and the 7th leading cause of death in Canada,[1] with approximately two thirds of deaths due to heart disease or stroke.[7] Recent estimates suggest that only 7 of 34 Organisation for Economic Co-operation and Development (OECD) countries had more years of life lost due to diabetes than Canada.[8] Furthermore, diabetes has an enormous impact on the Canadian economy, with total diabetes-related costs estimated at approximately $12 billion in 2010.[1]

There are pronounced social inequalities, typically measured by education and income, in diabetes incidence, survival, and prevalence in Canada. In terms of incidence, rates of diabetes incidence are higher among lower income individuals.[9,10] Few studies have examined the relation between socio-economic status (SES) and diabetes survival in Canada. A cohort study from Ontario showed that although diabetes mortality rates have been declining, they have been declining to a lesser extent for lower income relative to higher income groups.[11] Other research indicates that lower socio-economic groups have a higher prevalence of diabetes.[12,13] For example, in a cross-sectional analysis using data from the 2005 Canadian Community Health Survey, the prevalence of type 2 diabetes was over four times higher in the lowest income group compared to the highest.[12]

The relation between SES and diabetes may also vary by gender. One study showed that income-based socio-economic inequalities in diabetes incidence were wider among women.[10] Similarly, other work suggests that diabetes prevalence increases monotonically with decreasing income and education for women; by contrast, for men, prevalence was concentrated among those with lower education and income, but there was little difference between middle and higher SES groups.[14] Additionally, Tang et al. (2003) found evidence of socio-economic inequalities in diabetes prevalence for women, but not men, using data from the 1996–97 Canadian National Population Health Survey.[15] Taken together, this work suggests that the relation between SES and type 2 diabetes might be modified by gender.

From a population health perspective, it is important to monitor and track social inequalities in the burden of diabetes over time. Nonetheless, although there is some cross-sectional research, extant work has not utilized longitudinal data to

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summarize trends in social inequalities in type 2 diabetes across Canada and its different regions. In this study, we used data from the Canadian Community Health Survey (CCHS) to estimate relative and absolute social inequalities in type 2 diabetes prevalence in Canada during the period 2004–2012.

METHODS

Sample

We used data from the CCHS to measure trends in social inequalities in type 2 diabetes across Canada. The CCHS is a serial cross-sectional telephone survey administered by Statistics Canada for the purpose of measuring socio-demographic characteristics, preventive health practices, health care access, health risk behaviours, and health among the non-institutionalized general population of Canada over 12 years of age; individuals living on reserves or in prison facilities or health care facilities, and full-time members of the Canadian armed forces are excluded. The CCHS employs a multi-stage sampling procedure that, through the use of sample weights, provides population-representative health region-level estimates. Further information regarding the CCHS sampling methodology is available elsewhere.[16]

Our sampling frame included 427,746 adults over the age of 25 years from seven cycles of the CCHS fielded between 2004 and 2012. This included respondents to Cycle 3.1 (2004–2005), which is a two-year representative sample, as well as the six most recent annual cycles (2007–2012). For the purposes of these analyses, we excluded respondents with missing information on educational attainment or other covariates (14,293 or 3.3% of the total). This study was based on the secondary use of unidentifiable data and was approved by the Institutional Review Board of McGill University.

Measures

The CCHS asks respondents if they have diabetes. We utilized the Ng-Dasgupta-Johnson algorithm to identify cases of type 2 diabetes among those with a self-reported diagnosis. The algorithm utilizes the characteristics of each respondent, including their age, age at diagnosis, use of insulin, use of oral agents, and other variables, to distinguish between type 1, type 2, and gestational cases of diabetes in the CCHS.[17] Starting in 2009, Statistics Canada provided a derived variable for diabetes type based on the Ng-Dasgupta-Johnson algorithm. We applied the coding used to create this variable to prior cycles (Cycle 3.1, 2007 and 2008).

The two traditional socio-economic indicators available in the CCHS are household income and education. We selected education as our indicator of SES because it is a characteristic of the individual rather than household; moreover, income may be affected by type 2 diabetes and education avoids this problem of endogeneity. The highest level of education attained was measured using a 10-category ordered variable, ranging from grade 8 or lower to greater than a bachelor's degree. Additionally, respondents were asked about other demographic variables, including age and gender. Additional information regarding the design of the CCHS can be found elsewhere.[18]

Statistical analyses

Our objective was to measure trends in social inequalities in the prevalence of type 2 diabetes for Canada and separately for Western Canada (British Columbia, Alberta, Saskatchewan, Manitoba), Atlantic Canada (New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador), Ontario and Quebec; consistent with prior research using the CCHS, we did not produce regional estimates for Northern Canada due to small sample sizes.[19] We measured social inequalities in type 2 diabetes using the relative and slope indices of inequality (RII and SII respectively). The RII and SII are regression-based indices that measure inequality across the entire socio-economic distribution and are recommended for analyses comparing the magnitude of inequality across areas and/or time periods.[20–23]

The RII is defined as the ratio between the estimated prevalence of diabetes among those with the highest level of educational attainment relative to those with the lowest. For men and women in each cycle and region, as well as for Canada as a whole, we ordered individuals by their educational attainment from lowest to highest. We then assigned individuals a ranking based on their position in the cumulative distribution of education. For example, if men in the lowest (grade 8 or lower) and second lowest (grade 9–10) categories of education composed 8% and 10% of the total population, they received ranks of 0.04 (0.08/2) and 0.13 [0.08 + (0.10/2)] respectively. Next, we estimated the age-adjusted association between education and type 2 diabetes on the prevalence ratio (PR) scale by fitting a logistic model regressing type 2 diabetes on education, including a continuous indicator and quadratic for age; post-estimation procedures were used to predict diabetes prevalence at various levels of education and to calculate the RII. The RII takes a value of 1 if the prevalence of type 2 diabetes is equal across educational levels, whereas values less than 1 indicate that type 2 diabetes is more prevalent among those with lower levels of educational attainment.

In contrast to the RII, the SII is an absolute measure of social inequality. The SII is defined as the difference in the prevalence of type 2 diabetes between those with the highest level of educational attainment and those with the lowest. This prevalence difference (PD) was estimated by fitting a logistic model regressing type 2 diabetes on education and age, including continuous and quadratic indicators for age, and then taking the difference in the estimated predicted prevalence of type 2 diabetes between those with an educational rank of 1 and those with an educational rank of zero. As such, an SII value of zero indicates that the prevalence of type 2 diabetes is equal across educational levels, whereas negative values indicate that type 2 diabetes is more prevalent among those with lower levels of educational attainment.

We followed the guidelines issued by Statistics Canada[24] and utilized the Balanced Repeated Repetition (BRR) method to derive 95% confidence intervals. The BRR method utilizes repeated half-samples of the original sample (in this case, the "bootstrap weights" provided with each CCHS master file), calculates the estimate for each half-sample, and then constructs variances based on the average squared differences between the half-samples and the full sample. All models included

respondent-level sample weights. We used SAS version 9.3 for data management and SUDAAN 11.0.1 for statistical analysis.

To assess whether there were time trends in our measures of social inequality, we regressed the SII and the natural log of the RII on time (7 time points corresponding to each survey cycle) using random effects meta-regression analyses; these models, run using the Metafor package in R,[25] were weighted by the inverse of the standard error of the gender-specific inequality measure for each cycle. The coefficients from these models represent the absolute and relative changes in the SII and RII respectively for each additional year, 2004–2012. A slope coefficient of zero suggests that there is no trend in the particular measure of social inequality, whereas negative values indicate that type 2 diabetes has become more prevalent among those with lower compared to those with higher educational attainment over time.

RESULTS

Descriptive analyses

From 2004 to 2012, the prevalence of type 2 diabetes among men and women in Canada increased from 5.5% to 7.4%. The prevalence of type 2 diabetes for men and women followed a similar increasing trajectory over time. From 2004 to 2012, the prevalence of type 2 diabetes for men increased from 6.13% to 7.97% while the prevalence for women increased from 4.92% to 6.92% (Table 1).

Absolute inequalities in type 2 diabetes

In the total Canadian population, women had consistently higher absolute inequalities in type 2 diabetes prevalence over time (Table 2). The most recent data from the 2012 cycle of the CCHS indicated that the absolute inequality in type 2 diabetes prevalence, as measured by the SII, was –0.045 [95% confidence interval (CI) = –0.06, –0.029] for women; this suggests that the prevalence of type 2 diabetes was nearly 5 percentage points higher among women with the lowest level of educational attainment compared to those with the highest. By comparison, the inequality in type 2 diabetes was –0.023 (95% CI = –0.037, –0.01) for men. In the majority of regions and time periods, absolute social inequalities in type 2 diabetes were more pronounced for women than for men. Compared to the Canadian average, women in Atlantic Canada experienced consistently higher absolute social inequalities in type 2 diabetes across the cycles, whereas women in Western Canada appeared to fare better. Atlantic Canada also exhibited some of the largest differences between women and men in terms of their absolute social inequalities in type 2 diabetes across cycles. Figure 1 shows SII estimates for Canada and its regions over time.

Relative inequalities in type 2 diabetes

Relative inequalities in type 2 diabetes prevalence were consistently larger for women than for men (Table 2). For the 2012 cycle, the RII was 0.303 (95% CI = 0.209, 0.439) for women and 0.569 (95% CI = 0.414, 0.783) for men. This suggests that the prevalence of type 2 diabetes was approximately 70% and 43% lower among women and men respectively for those with the highest vs. those with the lowest level of educational attainment. Subregional patterns (Figure 2) were similar, with

Table 1. Distributions of type 2 diabetes, age and education by gender; respondents to the Canadian Community Health Survey, 2004–2012 (n = 413,453)

Men	2004–2005, % (95% CI)	2007, % (95% CI)	2008, % (95% CI)	2009, % (95% CI)	2010, % (95% CI)	2011, % (95% CI)	2012, % (95% CI)
Type 2 diabetes	6.13 (5.81, 6.44)	7.31 (6.86, 7.77)	7.4 (6.81, 7.99)	7.8 (7.27, 8.34)	8.77 (8.13, 9.41)	7.72 (7.19, 8.26)	7.97 (7.38, 8.55)
Age	48.66 (48.55, 48.77)	48.77 (48.61, 48.94)	49.1 (48.94, 49.26)	49.41 (49.23, 49.59)	49.74 (49.56, 49.93)	49.46 (49.28, 49.64)	50.05 (49.83, 50.26)
Education							
Grade 8 or lower	6.86 (6.5, 7.23)	6.85 (6.39, 7.31)	6.07 (5.54, 6.6)	5.82 (5.38, 6.26)	5.65 (5.13, 6.17)	5.09 (4.69, 5.5)	5.26 (4.84, 5.68)
Grade 9–10	6.43 (6.14, 6.71)	6.44 (5.97, 6.9)	6.24 (5.78, 6.69)	5.99 (5.54, 6.45)	5.82 (5.33, 6.3)	5.7 (5.25, 6.14)	6.17 (5.52, 6.82)
Grade 11–13	3.67 (3.43, 3.91)	3.19 (2.9, 3.48)	3.39 (3.05, 3.73)	3.38 (3.03, 3.73)	2.99 (2.63, 3.36)	3.01 (2.66, 3.37)	2.89 (2.51, 3.26)
Secondary school grad	14.29 (13.81, 14.77)	15.09 (14.37, 15.81)	14.53 (13.82, 15.23)	15.07 (14.28, 15.85)	15.21 (14.38, 16.04)	14.89 (14.07, 15.71)	16.89 (15.87, 17.91)
Some post-secondary	6.76 (6.4, 7.13)	6.56 (6.06, 7.06)	6.37 (5.86, 6.89)	5.97 (5.45, 6.5)	6.05 (5.48, 6.63)	4.98 (4.41, 5.55)	4.31 (3.76, 4.85)
Trades certificate/diploma	18.23 (17.75, 18.72)	17.19 (16.5, 17.88)	17.4 (16.65, 18.15)	17.46 (16.67, 18.25)	18.13 (17.21, 19.05)	17.03 (16.21, 17.86)	16.49 (15.65, 17.32)
College/CEGEP diploma	16.43 (15.92, 16.95)	17.58 (16.81, 18.36)	17.44 (16.59, 18.28)	17.44 (16.56, 18.31)	17.26 (16.33, 18.19)	18.85 (17.87, 19.83)	18.69 (17.64, 19.73)
Univ. Certificate below BA	2.96 (2.73, 3.18)	3.32 (2.95, 3.68)	3.13 (2.77, 3.5)	3.31 (2.83, 3.78)	3.39 (2.92, 3.85)	4.23 (3.69, 4.77)	4.04 (3.46, 4.63)
Bachelor's degree	15.33 (14.78, 15.89)	15.73 (14.93, 16.52)	15.63 (14.77, 16.5)	15.79 (14.95, 16.63)	15.98 (15.05, 16.92)	16.59 (15.64, 17.53)	16.13 (15.16, 17.1)
Above bachelor's degree	9.03 (8.57, 9.49)	8.06 (7.45, 8.67)	9.8 (9.06, 10.54)	9.76 (9.08, 10.44)	9.52 (8.73, 10.3)	9.63 (8.82, 10.44)	9.14 (8.31, 9.97)
Women	**2004–2005, % (95% CI)**	**2007, % (95% CI)**	**2008, % (95% CI)**	**2009, % (95% CI)**	**2010, % (95% CI)**	**2011, % (95% CI)**	**2012, % (95% CI)**
Type 2 diabetes	4.92 (4.69, 5.16)	5.6 (5.2, 6)	6.05 (5.62, 6.48)	5.82 (5.41, 6.23)	5.96 (5.49, 6.44)	6.07 (5.59, 6.55)	6.92 (6.37, 7.47)
Age	49.7 (49.6, 49.81)	49.83 (49.67, 49.98)	50.07 (49.9, 50.24)	50.24 (50.07, 50.4)	50.53 (50.36, 50.7)	50.81 (50.63, 50.99)	51 (50.82, 51.18)
Education							
Grade 8 or lower	7.98 (7.6, 8.36)	8.02 (7.51, 8.53)	7.39 (6.88, 7.9)	7.06 (6.63, 7.5)	6.23 (5.82, 6.64)	6.19 (5.72, 6.67)	6.31 (5.79, 6.83)
Grade 9–10	6.46 (6.16, 6.75)	6.38 (5.99, 6.77)	5.86 (5.46, 6.26)	5.84 (5.43, 6.25)	5.3 (4.9, 5.71)	5.1 (4.73, 5.47)	5.15 (4.77, 5.54)
Grade 11–13	3.44 (3.21, 3.67)	3.07 (2.79, 3.35)	2.86 (2.6, 3.12)	3.24 (2.9, 3.59)	3.14 (2.76, 3.51)	2.65 (2.4, 2.91)	2.91 (2.6, 3.23)
Secondary school grad	16.17 (15.69, 16.66)	16.63 (15.98, 17.29)	16.59 (15.86, 17.31)	16.13 (15.43, 16.83)	17.03 (16.17, 17.9)	16.43 (15.65, 17.21)	16.93 (16.06, 17.8)
Some post-secondary	6.36 (6.07, 6.66)	6.36 (5.85, 6.87)	6.39 (5.87, 6.92)	6.28 (5.73, 6.84)	5.88 (5.33, 6.42)	4.5 (4.05, 4.95)	4.46 (3.95, 4.98)
Trades certificate/diploma	10.74 (10.38, 11.09)	9.11 (8.64, 9.59)	9.12 (8.58, 9.65)	8.44 (7.88, 9)	8.8 (8.26, 9.35)	8.82 (8.21, 9.42)	8.35 (7.72, 8.99)
College/CEGEP diploma	23.54 (22.96, 24.13)	24.38 (23.6, 25.17)	24.64 (23.84, 25.43)	24.56 (23.7, 25.43)	24.82 (23.84, 25.8)	25.62 (24.6, 26.65)	26.52 (25.55, 27.5)
Univ. Certificate below BA	3.79 (3.54, 4.03)	3.7 (3.34, 4.05)	4.1 (3.62, 4.58)	3.39 (3.03, 3.74)	4.01 (3.57, 4.44)	4.47 (4.01, 4.94)	4.02 (3.59, 4.44)
Bachelor's degree	15.39 (14.85, 15.92)	15.94 (15.27, 16.61)	16.24 (15.41, 17.06)	18.01 (17.14, 18.89)	17.43 (16.6, 18.26)	18.09 (17.22, 18.96)	17.48 (16.55, 18.41)
Above bachelor's degree	6.13 (5.77, 6.49)	6.4 (5.93, 6.87)	6.82 (6.29, 7.35)	7.03 (6.51, 7.55)	7.36 (6.73, 7.99)	8.12 (7.44, 8.8)	7.86 (7.22, 8.49)

Table 2. Absolute and relative social inequalities in type 2 diabetes prevalence by gender, Canadian subregion and year; respondents to the Canadian Community Health Survey, 2004–2012 (*n* = 413,453)

	Canada		Western Canada		Atlantic Canada		Quebec		Ontario	
Women	**RII***	**SII**	**RII***	**SII**	**RII***	**SII**	**RII***	**SII**	**RII***	**SII**
2004–2005	0.409 (0.33, 0.508)	−0.025 (−0.031, −0.018)	0.616 (0.425, 0.893)	−0.012 (−0.021, −0.003)	0.428 (0.288, 0.635)	−0.036 (−0.052, −0.019)	0.346 (0.199, 0.604)	−0.031 (−0.049, −0.014)	0.352 (0.243, 0.511)	−0.028 (−0.038, −0.017)
2007	0.346 (0.254, 0.471)	−0.034 (−0.045, −0.024)	0.578 (0.339, 0.985)	−0.015 (−0.028, −0.001)	0.245 (0.144, 0.417)	−0.057 (−0.083, −0.031)	0.226 (0.103, 0.499)	−0.049 (−0.074, −0.024)	0.323 (0.193, 0.541)	−0.039 (−0.059, −0.018)
2008	0.303 (0.228, 0.402)	−0.044 (−0.057, −0.031)	0.197 (0.107, 0.363)	−0.052 (−0.078, −0.027)	0.365 (0.209, 0.637)	−0.065 (−0.101, −0.029)	0.448 (0.209, 0.963)	−0.027 (−0.053, −0.001)	0.299 (0.182, 0.491)	−0.044 (−0.069, −0.019)
2009	0.364 (0.263, 0.504)	−0.032 (−0.044, −0.021)	0.507 (0.291, 0.886)	−0.019 (−0.035, −0.003)	0.354 (0.205, 0.61)	−0.053 (−0.081, −0.025)	0.252 (0.125, 0.505)	−0.042 (−0.066, −0.019)	0.344 (0.18, 0.656)	−0.034 (−0.055, −0.013)
2010	0.253 (0.175, 0.365)	−0.048 (−0.063, −0.034)	0.244 (0.116, 0.513)	−0.044 (−0.069, −0.02)	0.319 (0.165, 0.618)	−0.055 (−0.087, −0.024)	0.309 (0.106, 0.903)	−0.03 (−0.057, −0.002)	0.204 (0.104, 0.401)	−0.065 (−0.094, −0.036)
2011	0.375 (0.269, 0.521)	−0.038 (−0.051, −0.025)	0.373 (0.192, 0.727)	−0.032 (−0.054, −0.01)	0.32 (0.177, 0.578)	−0.08 (−0.128, −0.033)	0.281 (0.142, 0.557)	−0.034 (−0.055, −0.014)	0.458 (0.242, 0.868)	−0.034 (−0.06, −0.009)
2012	0.303 (0.209, 0.439)	−0.045 (−0.06, −0.029)	0.563 (0.289, 1.097)	−0.021 (−0.043, 0.002)	0.268 (0.154, 0.467)	−0.064 (−0.104, −0.024)	0.092 (0.025, 0.344)	−0.085 (−0.139, −0.032)	0.346 (0.209, 0.572)	−0.039 (−0.061, −0.018)
	Canada		**Western Canada**		**Atlantic Canada**		**Quebec**		**Ontario**	
Men	**RII**	**SII**	**RII**	**SII**	**RII**	**SII**	**RII**	**SII**	**RII**	**SII**
2004–2005	0.616 (0.508, 0.746)	−0.014 (−0.019, −0.008)	0.707 (0.517, 0.968)	−0.01 (−0.018, −0.001)	0.522 (0.348, 0.782)	−0.021 (−0.035, −0.007)	0.657 (0.451, 0.959)	−0.012 (−0.023, −0.001)	0.574 (0.407, 0.811)	−0.016 (−0.026, −0.006)
2007	0.535 (0.402, 0.712)	−0.023 (−0.034, −0.012)	0.47 (0.293, 0.752)	−0.024 (−0.041, −0.007)	0.432 (0.247, 0.758)	−0.052 (−0.087, −0.018)	0.449 (0.212, 0.954)	−0.027 (−0.049, −0.004)	0.685 (0.418, 1.123)	−0.014 (−0.036, 0.008)
2008	0.619 (0.429, 0.891)	−0.019 (−0.032, −0.006)	0.583 (0.366, 0.927)	−0.015 (−0.028, −0.002)	0.449 (0.252, 0.799)	−0.037 (−0.063, −0.01)	0.669 (0.351, 1.275)	−0.016 (−0.04, 0.007)	0.631 (0.27, 1.475)	−0.021 (−0.052, 0.009)
2009	0.637 (0.487, 0.833)	−0.017 (−0.028, −0.007)	0.753 (0.498, 1.138)	−0.01 (−0.024, 0.004)	0.515 (0.248, 1.067)	−0.029 (−0.067, 0.009)	0.972 (0.572, 1.652)	−0.001 (−0.018, 0.016)	0.446 (0.274, 0.727)	−0.035 (−0.056, −0.013)
2010	0.549 (0.417, 0.722)	−0.032 (−0.046, −0.017)	0.404 (0.268, 0.609)	−0.034 (−0.051, −0.017)	0.779 (0.485, 1.253)	−0.017 (−0.048, 0.014)	0.497 (0.269, 0.916)	−0.024 (−0.046, −0.002)	0.587 (0.366, 0.943)	−0.038 (−0.07, −0.006)
2011	0.411 (0.313, 0.539)	−0.034 (−0.046, −0.022)	0.78 (0.515, 1.18)	−0.007 (−0.019, 0.004)	0.395 (0.194, 0.801)	−0.047 (−0.083, −0.01)	0.31 (0.172, 0.558)	−0.039 (−0.059, −0.018)	0.326 (0.198, 0.536)	−0.053 (−0.082, −0.024)
2012	0.569 (0.414, 0.783)	−0.023 (−0.037, −0.01)	0.322 (0.165, 0.631)	−0.052 (−0.088, −0.017)	1.046 (0.601, 1.821)	0.002 (−0.025, 0.03)	0.844 (0.466, 1.526)	−0.004 (−0.019, 0.01)	0.637 (0.347, 1.168)	−0.019 (−0.043, 0.005)

*RII: Defined as the ratio between the estimated prevalence of diabetes among those with the highest level of educational attainment relative to those with the lowest; it takes a value of 1 if the prevalence of type 2 diabetes is equal across educational levels, whereas values less than 1 indicate that type 2 diabetes is more prevalent among those with lower levels of educational attainment.

SII: Defined as the difference in the prevalence of type 2 diabetes between those with the highest level of educational attainment compared to those with the lowest; a SII value of zero indicates that the prevalence of type 2 diabetes is equal across educational levels, whereas negative values indicate that type 2 diabetes is more prevalent among those with lower levels of educational attainment.

women consistently having higher relative inequalities in type 2 diabetes prevalence than men.

Trends over time

In general, absolute inequality in type 2 diabetes has increased over time (Figure 1). Further, the inequalities have increased more for women than for men over the study period: between 2004 and 2012, the absolute inequality in type 2 diabetes prevalence increased by approximately 2 percentage points for women, from –0.025 to –0.045, compared to about 1 percentage point for men, from –0.014 to –0.023. Meta-regression analyses (Figure 3) suggest that the absolute inequality in type 2 diabetes prevalence has grown by 0.27 (95% CI = 0.12, 0.42) and 0.20 (95% CI = 0.07, 0.34) percentage points per year for women and men respectively.

Relative inequality in type 2 diabetes did not change markedly over the study period in the total Canadian population or subregions (Figure 2). Meta-regressions of the natural log of the RII estimates on time indicated that the relative social inequality in type 2 diabetes has not increased substantially for women and men over time (Figure 3).

DISCUSSION

In this study, we examined inequalities in the prevalence of type 2 diabetes in Canada and specific sub-areas, including Western Canada, Atlantic Canada, Quebec and Ontario, since 2004. We estimated absolute and relative education-based inequalities in type 2 diabetes. Our findings corroborate a growing body of work, both in Canada[12,13] and in other OECD countries,[26–30] demonstrating social inequalities in type 2 diabetes prevalence. Consistent with prior work from Canada,[12] Spain[31] and Korea,[30] we found that these inequalities were more pronounced for women than for men, both on the absolute and relative scales. Additionally, we found that absolute inequalities in type 2 diabetes were greater than the Canadian average among residents of Atlantic Canada. Absolute social inequality in the prevalence of type 2 diabetes has expanded in Canada since 2004.

Social inequalities in diabetes prevalence likely reflect increased incidence rather than improved diagnosis and survival among socially disadvantaged groups. Extant research demonstrates social gradients in diabetes risk in Canada[9,10] and other countries.[26] Furthermore, a recent meta-analysis suggested that lower SES is consistently associated with risk of type 2 diabetes in high-income contexts.[32] Social gradients in incidence of type 2 diabetes, like the pattern we observed for prevalence, appear to be stronger for women than for men.[26,32] By comparison, there is little evidence to suggest that the increased burden of type 2 diabetes among lower SES groups is due to their improved access to health services or survival.

Few studies have examined trends in social inequalities in type 2 diabetes. Our findings suggest that absolute inequalities in type 2 diabetes have been expanding for Canadian women and (to a lesser extent) men. These findings are consistent with those from other high-income contexts. For example, Imkampe et al. (2011) found that absolute social inequalities in type 2 diagnoses widened for women, but not men, in England between 1994 and 2006.[28] Similar trends were observed in Spain.[31] We did not observe substantial changes in relative social inequalities over

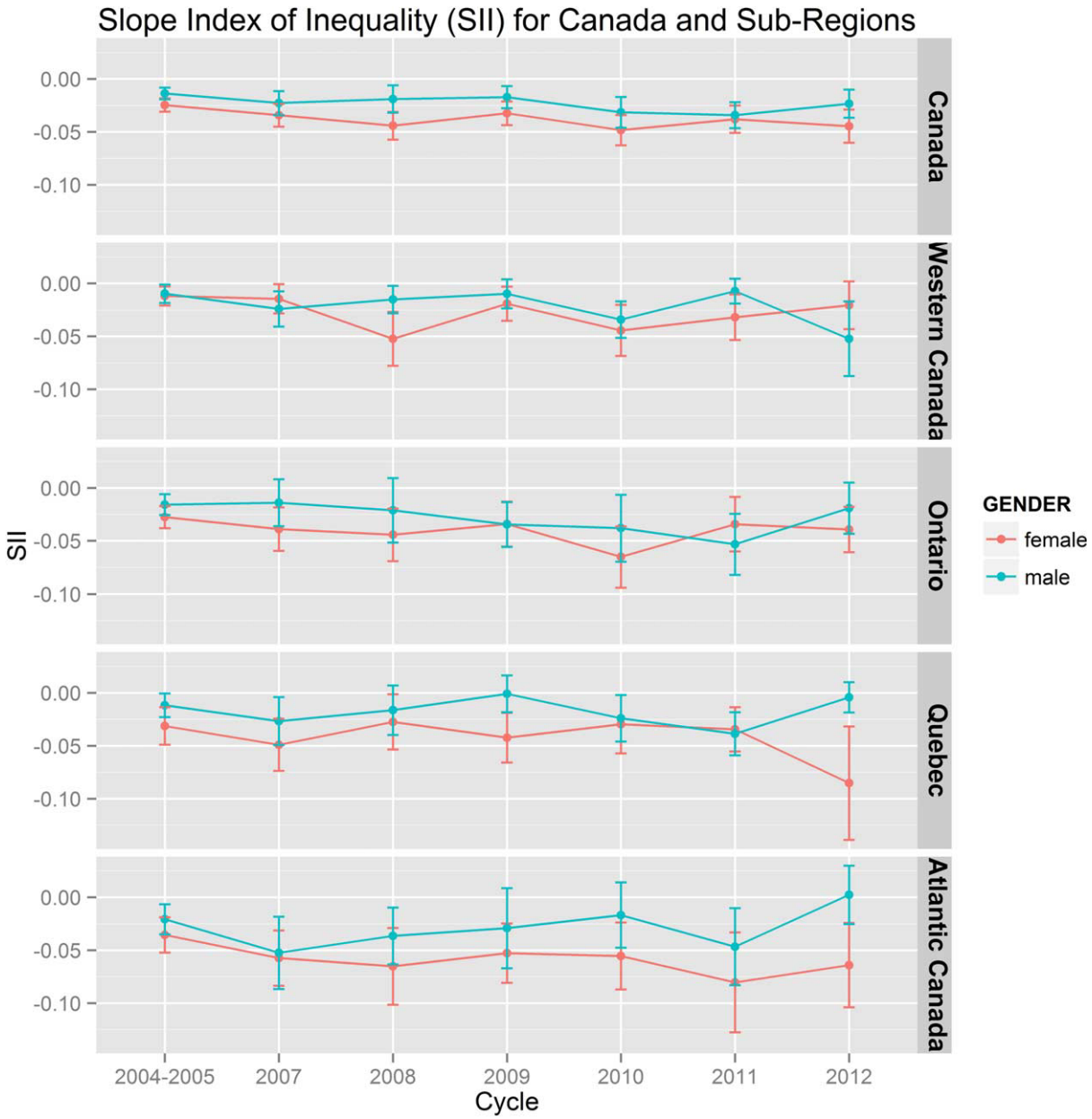

Figure 1. Trends in absolute social inequalities in type 2 diabetes prevalence for the total Canadian population and selected subregions*† SII: Defined as the difference in the prevalence of type 2 diabetes between those with the highest level of educational attainment compared to those with the lowest; a SII value of zero indicates that the prevalence of type 2 diabetes is equal across educational levels, whereas negative values indicate that type 2 diabetes is more prevalent among those with lower levels of educational attainment.

time, likely due to the rising prevalence of type 2 diabetes over the study period. Conclusions about whether social inequalities in type 2 diabetes prevalence have expanded over time are therefore dependent on how inequalities are measured.

The increased burden of type 2 diabetes among socially disadvantaged groups, at least in absolute terms, may be partly attributable to the concentration of unhealthy behaviours, including smoking and physical inactivity, among these groups. Research suggests that social inequalities in diabetes risk are partly explained by gradients in unhealthy behaviours. For example, a recent mediation analysis suggested that unhealthy behaviours explained nearly one half of the social gradient in the risk of type 2 diabetes among London civil servants.[33] A stronger social gradient in risk factors for type 2 diabetes, including smoking, poor diet, and physical inactivity, for women compared to men could explain the larger social inequalities in type 2 diabetes prevalence observed for them compared to men; however, this has not been empirically verified.

There were caveats to our study. First, we utilized an established methodology, the Ng-Dasgupta-Johnson algorithm,[17,34] to distinguish between diabetes types and identify individuals with type 2 diabetes within the CCHS. Although the algorithm has not been validated, it yields prevalence estimates similar to those in the total Canadian population, suggesting it is reasonably

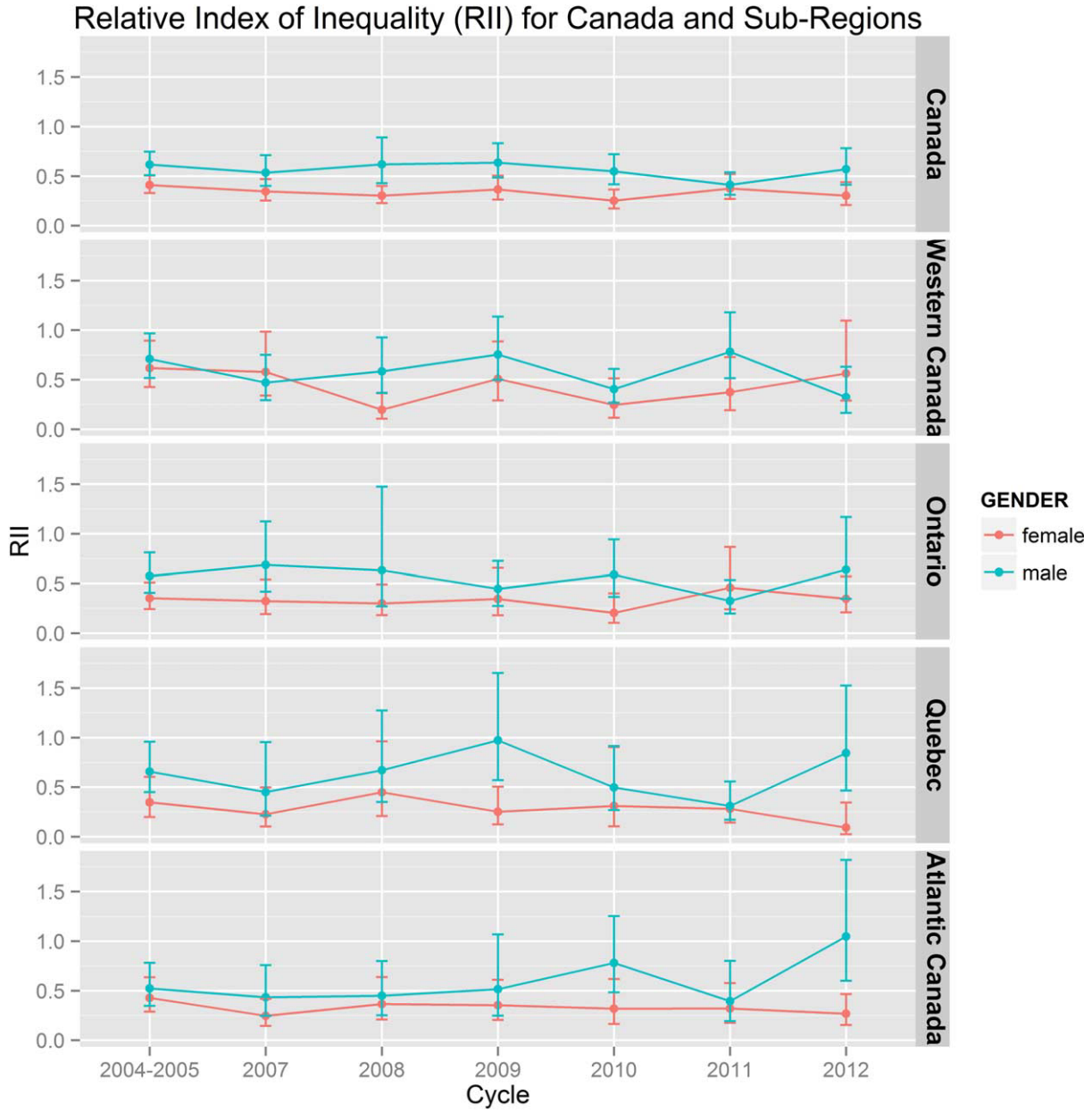

Figure 2. Trends in relative social inequalities in type 2 diabetes prevalence for the total Canadian population and selected subregions*†
RII: Defined as the ratio between the estimated prevalence of diabetes among those with the highest level of educational attainment relative to those with the lowest; it takes a value of 1 if the prevalence of type 2 diabetes is equal across educational levels, whereas values less than 1 indicate that type 2 diabetes is more prevalent among those with lower levels of educational attainment.

accurate.[12] Second, the true prevalence of diabetes in our sample is likely underestimated because many individuals with diabetes have not been diagnosed; this would only bias our estimates of social inequality if the concentration of undiagnosed cases varied by SES. For example, if undiagnosed cases were more common among respondents with lower educational attainment, then our estimates of social inequalities in diabetes prevalence may have been underestimated. Third, the serial cross-sectional nature of the CCHS might affect the comparability of estimates across survey waves. Statistics Canada suggests that differences between cycles may result from sampling variability or changes in the questionnaire and coverage, as well as the collection mode.[35] Fourth, other determinants, including early-life circumstances might contribute to education-based inequalities in diabetes prevalence. Decomposing social inequalities in diabetes to identify these determinants would be a fruitful area for future work.

CONCLUSION

The rapidly rising prevalence of type 2 diabetes in Canada is a cause for concern. Caveats considered, our estimates suggest that, in addition to rising prevalence, we should be wary of growing absolute social inequalities in diabetes, particularly for women and residents of Atlantic Canada. Monitoring social inequalities

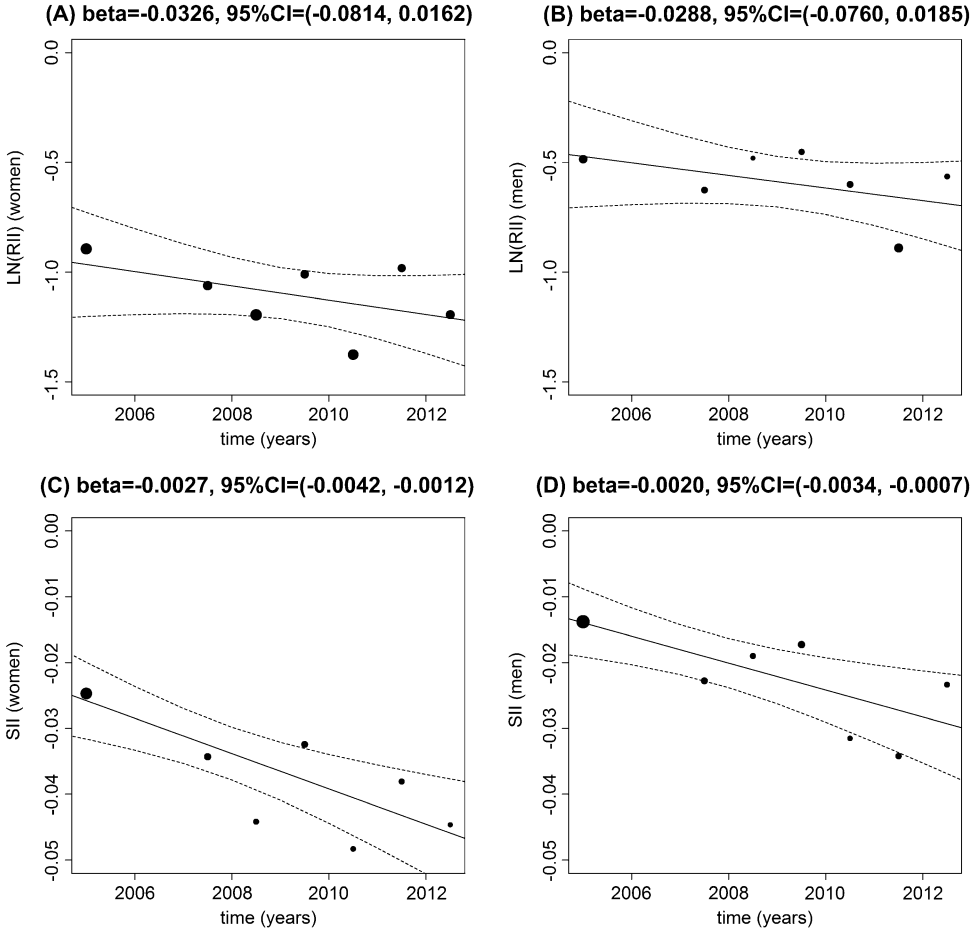

Figure 3. Associations between time (years) and relative (top) and absolute (bottom) social inequalities in type 2 diabetes prevalence for women (left) and men (right); respondents to the Canadian Community Health Survey, 2004–2012 (n = 413,453)*†‡
*Results are from bivariate random-effects meta-regressions of each inequality on time (years), weighted by the inverse of the standard error for each inequality measure.
†Dashed lines show 95% confidence intervals.
‡Beta coefficients represent the relative and absolute change in the RII and SII respectively for each additional year, 2004–2012.

in type 2 diabetes is an important first step. However, a concerted Canadian Diabetes Strategy is needed to identify policies and programs to mitigate social inequalities in diabetes and related complications.

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RÉSUMÉ

OBJECTIFS : La prévalence du diabète au Canada a presque doublé depuis 2000. On n'a pas évalué les tendances des inégalités sociales pour le diabète au Canada et dans les différentes régions du pays. Nous avons estimé les inégalités sociales relatives et absolues liées à la prévalence du diabète de type 2 au Canada entre 2004 et 2012.

MÉTHODE : Nous avons utilisé un indice d'inégalité relative (RII) et un indice d'inégalité absolue (SII) pour mesurer les inégalités relatives et absolues de la prévalence du diabète de type 2 fondées sur l'instruction dans un échantillon de 413 453 hommes et femmes ayant répondu à l'Enquête sur la santé dans les collectivités canadiennes entre 2004 et 2012.

RÉSULTATS : Dans l'ensemble des régions et des intervalles, les inégalités étaient plus prononcées chez les femmes que chez les hommes, à l'échelle absolue et relative. La différence dans la prévalence du diabète de type 2 entre les sujets les plus et les moins instruits, selon le SII, est passée d'environ 2,5 % à 4,5 % pour les femmes et de 1,4 % à 2,3 % pour les hommes entre 2004 et 2012.

CONCLUSIONS : Surveiller et localiser les inégalités sociales dans la charge du diabète au fil du temps peut aider à évaluer si les stratégies canadiennes de lutte contre le diabète sont efficaces lorsqu'il s'agit d'atteindre les populations marginalisées et d'atténuer les inégalités. Nos résultats montrent qu'il faudrait des interventions pour contrer la croissance des inégalités sociales au Canada en ce qui a trait au diabète de type 2, surtout chez les femmes.

MOTS CLÉS : facteurs socioéconomiques; inégalités; diabète sucré, type 2; épidémiologie; Canada