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Early onset of diabetes mellitus among visible minority and immigrant populations in Canada

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Abstract

Type 2 is a chronic condition that affects nearly over three million Canadians, including immigrants. The timing of the first onset of diabetes has been linked to several other severe ailments such as acute retinopathy, end-renal diseases and micro and macro vascular complications. Yet, there is a dearth of empirical studies that examine the timing of the first onset of diabetes among Canadians, in general, and among immigrants and ethnic minority populations within Canada, in particular. Applying event history techniques (Cox proportional hazards model) to the most recent Canadian Community and Health Survey (CCHS 2013), this study addresses this research void by examining factors that contribute to the first onset of diabetes among immigrant and visible minority populations in Canada (N=8905). Given the gendered patterns in the epidemiology of diseases, and the differences in risk factors for men and women, gender-specific models were estimated. These results showed that South Asian, Black and Filipino women developed diabetes earlier, compared to women from the UK. Similarly, South Asian, Chinese, Filipino, Black, South East Asian and Arab men developed diabetes earlier than men from the UK. A significant and important finding of this analysis was that the risks of developing diabetes earlier in life vanished completely for Black and Filipino women, after accounting for lifestyle factors. This finding implies by modifying behaviors that predispose them to developing this condition, the timing of the onset of diabetes among these ethnic groups could be significantly postponed. Similarly, for South Asian women, there was significant attenuation in their risks after accounting for lifestyle factors. However, the findings were strikingly different for immigrant men. Specifically, their risks of developing diabetes earlier increased after accounting for lifestyle factors. These results suggest the development of gender-specific interventions, targeted at specific immigrant groups with increased risks of developing diabetes earlier in the life course.

Keywords: Diabetes Mellitus; Visible minorities; Immigrants; Timing; Gender; Cox model.

INTRODUCTION

Type 2 diabetes arises mainly as a result of the inability of the pancreas to produce enough insulin due to insulin resistance, and is often considered a chronic ailment common in both developing and developed societies. Global estimates indicate that about 387 million people (constituting 8.3% of the World's population) live with Type 2 diabetes, and that approximately 4.9 million people died of this ailment in 2014 (International Diabetes Federation 2014). These grim global statistics are also reflected within the Canadian population. For instance, a recent document by the Public Health Agency of Canada (PHAC 2011) indicates that about 2.4 million Canadians (6.8% of the population) are living with diabetes and this is projected to reach 3.7 million in 2018/19. However, there are regional/provincial, gender and age disparities worth noting. For instance, Newfoundland and Labrador, Nova Scotia and Ontario have the highest prevalence of diabetes; men have a higher incidence than women; and Canadians within the working age group (25-64 years) are diagnosed with diabetes than other age groups (PHAC 2011).

The increasing prevalence of diabetes, if not checked, may have dire socio-economic and health consequences. By way of illustration, it was reported that adults aged 20-49 years with diabetes made frequent visits to family doctors and had been hospitalized more often than those without diabetes (PHAC 2011). It was also estimated that Canada spent approximately $12.2 billion on the management and treatment of diabetes in 2010 (Canadian Diabetes Association 2009).

It should not be too surprising that in the past few decades health researchers have invested considerable time and energy attempting to understand the epidemiology of diabetes in Canada. Previous studies have focused exclusively on risk factors by examining who is more likely to live with this medical condition or not (Shah 2013; Lipscombe & Hux 2007; Tan & MacLean 1995; Liu et al. 2010). Missing from this research effort is how the timing, or onset of the disease, varies amongst the various cultural, socio-economic and demographic groupings within Canada. This gap in the literature is problematic in that the timing of the onset of diabetes has several medical/clinical implications; is considered crucial for the management and survival of patients living with this condition; and has consequences for healthcare delivery and planning. For instance, several studies have demonstrated that early onset of type 2 diabetes is strongly associated with co-morbidities such as increased retinopathy risks (see Wong et al. 2008; Henricsson et al. 1996); microvascular and macrovascular complications (see Wilmot and Idris 2014; Allison et al. 2014; Song and Hardisty 2009); end-stage renal diseases (Freedman et al. 2002; Evans and Forsyth 2004; Pavkov et al. 2006; Jiang et al. 2014); and other cardiovascular ailments (see Hillier and Pedula 2003; Pavkov et al. 2006; Song and Hardisty 2009). Furthermore, the implications of earlier onset of type 2 diabetes on health delivery and planning are ably highlighted by several authors. Wilmot and Idris (2014) point to the need for multidisciplinary specialist clinics with access to psychological, dietary and bariatric support for individuals with early onset of diabetes.

Although the evidence demonstrates that delaying the development of the disease may be a better financial investment given the concomitant implications, studies that examine the timing of the onset of diabetes among Canadians and in particular, the ethnic and immigrant populations are surprisingly missing in the literature. Using the most recent version of the Canadian

Community and Health Survey (CCHS), this paper fills an important research gap by examining the timing and onset of Type 2 diabetes among visible minorities and immigrant populations within Canada.

Background & Context

There is evidence that the ethnic and immigrant composition of Canada is changing. A release from the 2011 National Household Survey indicates that immigrants constitute 21% (6.8 million) of the Canadian population, while visible minorities make up 19% (Fong 2014). The increasing presence of visible minority populations in Canada reflects shifts in immigrant source countries, especially in the post-World War II era. Now the majority of immigrants, most of whom also identify as visible minorities, come from Asia, the Middle East, Africa, the Caribbean, and Central and South America (Fong 2014). Consequently, source regions for immigration to Canada have changed from developed countries located in Europe to transitional and developing countries. Given the increasing prevalence of chronic diseases in source countries, and the commitment of host countries to ensure healthy and productive populations, discussions have often ensued around the health of immigrants and ethnic minorities.

The theoretical pathways to explaining relationships between ethnicity, immigration and health outcomes, including the risks of living with diabetes are rather very complex. Creatore et al. (2013) argue that ethnicity affects the risks of living with diabetes through genetics in a manner that is not completely understood. Additionally, several studies in Canada and elsewhere highlighted the increased risks of diabetes among people of South Asian and African ancestry, compared to their Caucasian counterparts (see Shah 2013; Mitra and Janjua 2010; Gujral et al. 2013; Sohani et al. 2014; Lyssenko and Laakso 2013). Furthermore, Mitra and Janjua (2010) have emphasized that South Asians in particular are highly susceptible to diabetes because of their tendency to develop metabolically-active, abdominal fat, even at low body mass indices. While past research identified some ethnic minority groups as susceptible to the risks of living with diabetes, these works remained silent on the timing of onset among these groups. It cannot be assumed, however, that higher risks will necessarily translate into earlier timing of diabetes among the visible and ethnic minority groups within Canada.

There is strong consensus among researchers that genetic susceptibility combines with socio-cultural and environmental factors to determine the risks of living with diabetes. Given these research findings, it has been argued that immigrants and ethnic minorities are more vulnerable to developing diabetes because of changes in diet, physical activity levels and stress levels when they transition from their country of origin to new host societies (Creatore et al. 2013; Oldroyd et al. 2010; Hayes et al. 2002; Sohal et al. 2015). Moreover, past research shows that physical activity levels are extremely low among all visible and ethnic minority groups in Canada, and their diets also rich in fat, meat, processed food and salt (Liu et al. 2010; Creatore et al. 2013; Kobayashi et al. 2008). Meanwhile, the extant research associates lack of physical activity, poor diet and dietary habits, alcohol use, smoking, etc. to Type 2 diabetes in Canada and elsewhere (Sohal et al. 2015; Hayes et al. 2002; Chiu et al. 2015; Hu 2013).

Intricately linked to these lifestyle and modifiable risk factors is the socio-economic status of immigrants and ethnic minorities in the host societies. Although the majority of ethnic and visible minorities may belong to high socio-economic strata in countries of origin, it is often the case that they drop in socioeconomic status in comparison with the Caucasian population in the host society. Several studies show that in spite of their higher levels of education/human capital, visible minorities, in particular, Blacks and South Asians, have incomes lower than their education and occupational backgrounds would merit (Hou & Balakrishnan 1996; Tastsoglou & Preston 2005; Shields et al. 2006). It is argued that the economic disadvantage experienced by visible minority groups may translate into health disadvantages. This, in turn, may increase their disease burden, including those related to diabetes. While relevant, the effects of modifiable risk factors such as diet, physical activity, smoking, alcohol use, etc. and the socio-economic characteristics of ethnic minority populations have only been explored in the context of the risks of living with diabetes, with less emphasis on timing of the onset of diabetes.

This paper contributes to the existing literature by examining the timing of the onset of diabetes among the visible minority and immigrant populations in Canada. Also, the paper's focus on comparing immigrant ethnic minorities to immigrant Caucasian populations is a departure from previous work that always compared ethnic minorities to the Canadian-born population (Ali et al. 2004; Ng 2011; Islam 2013). Gender-specific models are considered given that previous studies have highlighted gendered patterns in the epidemiology of diseases and differences in risk factors for men and women (Vlassoff 2007; Piccinelli & Wilkinson 2000; Barrett-Connor 1997; Matheson et al. 2014). Furthermore, because the proportion of recent immigrant women entering Canada as visible minorities is high, and is projected to increase in the future, it becomes increasingly relevant to highlight the timing of the onset of diabetes for this important demographic group different from their male counterparts.

DATA & METHODS

Data for this study was accessed from the 2013 Canadian Community and Health Survey (CCHS) housed in Statistics Canada's Research Data Centre (RDC). The CCHS is a cross-sectional survey of 65,000 respondents from 110 health regions that annually monitors disease and health conditions, lifestyle and social conditions, health care utilization, and other health determinants of the Canadian population (Statistics Canada 2014). The CCHS collects information from Canadians aged 12 years across the ten provinces and three territories. Approximately 3% of the Canadian population were excluded from the target sample of the CCHS, including Aboriginal persons living on the reserve and those located in other settlements in the other provinces, members of the Canadian Forces, etc. (Statistics Canada 2014). Survey respondents were selected from households, an aerial frame and a Random Digit Dialing (RDD) sampling frame. Computer-Assisted Telephone Interviewing (CATI) techniques were used to select survey respondents. The sample for this study was restricted all immigrants in Canada which corresponded to about 8,905 respondents (Male = 4,208, Females = 4,697).

Measures

The dependent variable used for this study was the respondent's self-reported age at which they were first diagnosed with diabetes. This was after respondents had been asked if they had been diagnosed with this condition in the last 12 months. For analytical purposes, this study focused on respondents whose diabetic condition developed in Canada and not outside of it. This means respondents who had diabetes before immigrating to Canada (constituting about 5% of the sample) were dropped from the analysis. Female respondents whose diabetic condition developed mainly due to pregnancy (also known as gestational diabetes) constituted a negligible proportion of the sample (less than 1%) and were dropped from the analysis.

The focal independent variable, ethnicity, is a polytomous variable that asked respondents to self-identify when they immigrated to Canada and belonged to a visible/ethnic minority group. Further information regarding which specific visible minority groups (such as

Africans, Caribbean, Chinese, Japanese, Koreans, Arabs, etc.) respondents belonged were also available, which allowed for analyses of within group differences. Explanatory variables employed for analysis are grouped into three main blocks; *socio-economic predictors* (educational background of respondents, employment status and total household income), *lifestyle/modifiable risk factors* (total amount of fruits and vegetables consumed daily, physical activity index, type of smoker, type of drinker and the Body Mass Index of the respondent) and variables that measure if respondents live with other *co-morbidities* (diagnosed with blood pressure, diagnosed with a heart disease and if they had experienced some side effects of stroke) that render them highly susceptible to the risks of developing diabetes. The analyses controlled for demographic variables including the province of residence of respondents, marital status and time since immigration to Canada.

Analytical strategy

The Cox proportional hazards model was used to estimate the hazards (risks) of first diagnosis with diabetes, considering other theoretically relevant covariates. Cox regression is one of the numerous techniques in survival/event history analysis used to model time until an event, while simultaneously adjusting for influential covariates and accounting for problems such as attrition, delayed entry and temporal biases. The Cox model, also referred to as the proportional hazards model, was proposed by Cox (1972) and is very useful for examining the influence of some covariates/explanatory variables without additional assumption about time dependency. Thus, unlike other parametric models, the duration dependency is introduced in the Cox model as the baseline hazard rate $\lambda_0(t)$, which is not further specified and is considered a nuisance function. The covariates are included in a log-linear form in the model $(x'\beta)$. The baseline function and the log-linear covariate vector are then multiplicatively related as follows: $\lambda(t/x) = \lambda_0(t)\exp(x'\beta)$. The hazard function $\lambda_0(t)$ describes the concept of the risk of an outcome (e.g., death, failure, diagnosis with diabetes) in an interval after time t. The hazard rate is then defined as the probability that an individual is diagnosed with diabetes somewhere between t and (t+Δ), divided by the probability that an individual survived diagnosis beyond time t (Smith et al., 2003).

The model makes certain assumptions whose violation can have detrimental effects on the validity and efficiency of inferences. It assumes that at any specific point only one individual will be experiencing the event, thus most individuals are not expected to experience the event at the same time. There is also the proportionality assumption, which states that the ratio of the hazard functions for two members of the population should be constant throughout the entire observation period. This means, if two individuals are characterized by time invariant covariate vectors x_i and x_j the ratio of the hazard functions

$$\frac{\lambda(t/x_i)}{\lambda(t/x_j)} = \frac{\lambda_0(t)\exp(x_i'\beta)}{\lambda_0(t)\exp(x_j'\beta)} = \exp[\beta'(x_i - x_j)] \text{------------------------------(1)}$$

would be independent of time (Blossfeld & Gozt 2002). Thus, diagnostics were performed to ensure that model assumptions were met.

The Cox model has been chosen for analysis for three major reasons. First, like other event history techniques, it recognizes the fact that the event of interest (age at first diagnosis with diabetes) is rarely observed in all subjects so that those who were not diabetic at the time of the interview were right censored. As such, it stands an advantage over other less dynamic and static models where those cases cannot be censored. Second, it uses the partial likelihood estimation procedure which in combination with Breslow's method[2] is efficient in handling the problem of ties in the data. This assures of the robustness of the parameter estimates, especially as the age at first diagnosis of diabetes was reported in complete and not exact years. Third, as a semi-parametric model, it is very flexible as it does not require that one know the functional form or distribution of the data as is the case for parametric techniques. This means any functional misspecification of individual covariates may not have an impact on inferences made.

Descriptive and multivariate statistics were employed to describe the data. Four multivariate models were run each for both males and females. The first model included ethnicity and control variables; the second model added socio-economic predictors; the third model included if respondents lived with co-morbidities and the final model added variables capturing modifiable risk factors. Results obtained are interpreted as hazard ratios. A hazard ratio greater than 1 implies earlier timing to the onset of diabetic, while that less than 1 implies later or slower timing to the first onset of diabetes.

RESULTS

Descriptive results

Descriptive results are shown in Table 1. Of the visible minority groups, South Asians were the largest, followed by Chinese, Blacks and Filipinos. The majority of immigrants were married, had lived in Canada for 20 years or more and reside in Ontario. Regarding their socio-economic characteristics, most immigrants had less than a bachelor's education; fell within the lower income category, albeit income was higher for females; and worked fulltime. The majority

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[2] Breslow (1975) assumed that event times are continuous with the hazard of the event constant in the interval (t_i, t_{i+1}). Breslow suggested adding covariate-related components for all subjects experiencing the event at given time point t_i and the results raised to a power equal to the number of events tied at t_i (see also Borucka 2014).

of immigrants, both males and females were physically inactive and consumed fruits and vegetables less than 5 times per day. Compared to females, a higher proportion of male immigrants were regular drinkers, smoked daily and were overweight.

Table 2 shows bivariate and unadjusted hazard ratios for both men and women. The results demonstrated that ethnicity, the focal independent variable, was significantly associated with the risks of developing diabetes. South Asian, Filipino and black women had higher hazards/risks of developing diabetes earlier compared to immigrants from the UK (used as the reference category due to size of group). For men however, it was determined that South Asians, Blacks, Filipinos, Arabs and South East Asians had increased risks of developing diabetes earlier compared to immigrant men from the UK. It was clear that some socio-economic and lifestyle factors were significantly associated with the timing of the first onset of diabetes, but these are just the unadjusted hazard ratios. The adjusted hazard ratios are presented in the multivariate tables.

Multivariate results

Table 3 presents results from the multivariate models. Results showed significant relationships between ethnicity and the risks of developing diabetes net of other theoretically relevant variables. The results also showed differential risks and patterns of developing diabetes for visible minority and immigrant men and women. For instance, visible minority men such as South Asians, Chinese, Blacks, Filipinos, Arabs and South East Asians had higher hazards/risks of developing diabetes earlier, compared to immigrants from the UK (see model 1). Yet, for women, it was only South Asians, Filipinos and Blacks who had higher risks of developing diabetes earlier compared to immigrants from the UK. It is evident from the results that these risks were statistically robust even after variables capturing the socio-economic characteristics of respondents and comorbidity were added (see models 2 and 3 of Table 5). However, different patterns in results were observed after adding lifestyle/modifiable risk factors. For females, it was found that significant attenuation occurred in the risks of South Asians developing diabetes earlier and a complete mediation of the risks of blacks and Filipinos (see model 4 for females in Table 5). On the other hand, the results for men differed significantly from women. Specifically, for men, the risks of all visible minority groups magnified after adding lifestyle/modifiable risk factors (see model 4 for males in Table 5). Also, the risks of developing diabetes for French Canadians became significant, which is discussed in detail in subsequent sections of the paper.

In addition, variables measuring the socio-economic characteristics, comorbidity and lifestyle of respondents were all significantly associated with the risks of developing diabetes, albeit they affected males and females differently. For instance, compared to those without bachelor's education, immigrant women with bachelor's education had lower hazards of developing diabetes earlier. Interestingly, men who did not state their educational background had higher hazards/risks of developing diabetes compared to those without bachelor's education. Both immigrant men and women working fulltime had higher hazards/risks of developing diabetes earlier compared with the unemployed. Surprisingly, income made a difference to the risks of developing diabetes for men, but not for women. Immigrant men in middle and high income groups had lower hazards/risks of developing diabetes earlier compared to those in low income groups. Both immigrant men and women diagnosed of hypertension had higher hazards of developing diabetes earlier compared to those not living with hypertension.

Lifestyle factors were significantly associated with the risks of developing diabetes for both men and women. By way of illustration, physically inactive women had higher hazards/risks of developing diabetes earlier, compared to physically active women. Similar results were observed for men and women who ate fruits and vegetables '5 to 10 times per day' and 'more than 10 times per day' respectively. Immigrant men who drank alcohol either regularly or occasionally had increased hazards of developing diabetes earlier, compared to those who did not drink alcohol in the last 12 months. Surprisingly, women who drank regularly had lower hazards of developing diabetes earlier. Also, men who identified as occasional smokers had lower risks of developing diabetes earlier compared to those who did not smoke at all. Body Mass Index (BMI) was an important predictor of developing diabetes for both immigrant men and women. Obese and overweight men and women had higher hazards of developing diabetes earlier, compared to their counterparts with normal weight.

DISCUSSIONS

Type 2 diabetes, also known as diabetes mellitus is a chronic condition affecting over 300 million people globally (WHO 2015). In Canada, more than 3 million people live with this medical condition and about 50% of these cases are among the working age population (PHAC 2011; Canadian Diabetes Association 2013). The health impact of type 2 diabetes on Canadians and immigrants is immense. For instance, individuals with diabetes are not only more likely to develop other cardiovascular diseases such as hypertension, stroke, heart diseases etc., but also end-stage renal diseases (Henricsson et al. 1996; Allison et al. 2014; Song and Hardisty 2009). It is estimated that more than one in ten deaths in Canada can be prevented if diabetes-related mortality are reduced to zero (PHAC 2011). This probably provides partial explanation to the sudden proliferation of cardiovascular research, including diabetes research in Canada. Previous studies on diabetes in Canada focused mainly on identifying epidemiological risk factors (Dasgupta et al. 2010; Lipscombe & Hux 2007; Tan & MacLean 199) and estimating the direct and indirect costs related to treatment and management of this condition (see Dawson et al. 2002; Grima et al. 2007; O'Brien et al. 2001; Simpson et al. 2003; Yu & Raphael 2004). To date, very few studies (see Creatore 2013), have examined the timing of the first onset of diabetes mellitus in Canada, although a plethora of evidence show that age at first onset of diabetes is strongly associated with the development of other severe medical complications (see Henricsson et al. 1996; Pavkov et al. 2006; Song and Hardisty 2009). We make an important contribution by filling this gap in the literature. The focus on immigrant populations in this paper is equally unique as previous studies had always compared immigrants to non-immigrants on various scores of health outcomes (Ali et al. 2004; Kingston et al. 2011; Ng 2011; Islam 2013). The present study provides evidence as to how immigrants fare amongst each other regarding diabetes—an important health outcome, and contributes to the ethnicity, immigration and health literature in Canada. Furthermore, building gender-specific models was insightful as the results point to important gender nuances within the sample.

The results indicate that some immigrants, mostly those in the visible minority groups developed diabetes earlier compared to their Caucasian counterparts, specifically those from the United Kingdom. For women, it was South Asians, Blacks and Filipinos who developed diabetes earlier than females from the UK. For men however, Blacks, South Asians, Chinese, Filipinos, Arabs and South East Asians experienced earlier timing to diabetes.

While interesting the results are not particularly surprising as the current literature demonstrated increased diabetes prevalence among some members of the visible minority groups, mostly South Asians and those with African ancestry (Gujral et al. 2013; Sohani et al. 2014; Lyssenko and Laakso 2013; Shah 2013). In particular, Creatore (2013) reported young ages at diabetes onset for South Asian, African and individuals of Middle-Eastern descent in

Ontario. Several theoretical explanations have been postulated for the increased risks and earlier timing of diabetes among visible minority populations. Specifically, genetic and family history reasons have been provided as important factors that facilitate susceptibility to developing this condition earlier in the life course (see Wilmot and Idris 2014). For instance, it is documented that unlike Europeans, there is a single nucleotide polymorphism in the gene of South Asians that affects fat mass and obesity considered important risk factors for diabetes (Yajnik et al. 2009; Becerra & Becerra 2015). It is similarly documented that compared to Caucasians, Filipinos have lower levels of a protein called adiponectin that regulates blood sugar (Araneta et al. 2007; Becerra & Becerra 2015) increasing their chances of developing diabetes earlier in the life course.

It is widely understood that genetic susceptibility combines with socio-economic, lifestyle, cultural and environmental factors in a complex manner to determine the risks of developing diabetes. For immigrants and some visible minority populations, in particular, whose educational credentials are overlooked on the Canadian job market (Hou & Balakrishnan 1996; Li 2008; Grant 2005) and make low incomes as a result, it is possible that their economic vulnerabilities may translate into health disadvantages. Given this concern, the current study accounted for the socio-economic characteristics of respondents, expecting these to confound the relationship between ethnicity and the risks of developing diabetes. The introduction of socio-economic variables did not change the hazards/risks of the ethnic groups substantially. Notwithstanding the lack of substantial impact, it is important to note that immigrant men with higher income and immigrant women with bachelor’s education experienced delays in their timing to the onset of diabetes.

These findings are consistent with theoretical expectations and corroborate the extant literature (Dasgupta et al. 2010; Tang et al. 2003; Hwang & Shon 2014). While higher educational attainment may increase respondents' knowledge of diseases and how they can be avoided, higher income in turn facilitates access to resources that are crucial for adopting health preventive behaviors (Borrell et al. 2006; Roche & Wang 2014; Barker et al. 2011). The finding that immigrant men and women working fulltime experienced earlier timing to diabetes was intriguing, but not too surprising. Previous literature shows higher unemployment and underemployment rates among immigrants in Canada (Yssaad 2012; Zeitsma 2010; Galarneau & Morissette 2008). The latter has meant that some immigrants, mostly those in the visible minority categories, work in jobs not commensurate with their skills and training, and sometimes under precarious conditions (Zeitsma 2010). Thus, although immigrants may be employed fulltime, they may be working under such conditions that may be detrimental to their health outcomes. Chaufan et al. (2011) argued that type and conditions of work was yet another important barrier to healthy eating, which, in turn, may have implications for early onset of diabetes. Employment under precarious conditions rarely provides breaks, even for meal times, making it difficult to develop healthy eating habits.

It is thus not surprising that a plethora of research has identified lifestyle and other behavioral risk factors as important determinants of diabetes risks in Canada and elsewhere (Chiu et al. 2015; Hu 2013; Mozaffarian et al. 2008; Johnson et al. 2001; Kriska et al. 2003). Our results largely corroborate research that find that physical activity, smoking, drinking, vegetable and fruit consumption, and Body Mass Indices (BMI) are significant predictors of type 2 diabetes. Most important in this study, however, is that these modifiable risk factors worked differently for men and women and for immigrants with different ethnicities regarding the timing of the onset of diabetes. For instance, for Black and Filipino women, their risks of developing diabetes earlier in the life course completely vanished after accounting for lifestyle factors. This suggests that the timing of the onset of diabetes among these ethnic groups could be significantly postponed by modifying behaviors that predispose them to developing this medical condition. For South Asian women, there were significant attenuation in the effects of the risks of developing diabetes earlier after lifestyle/modifiable risk factors were controlled. This suggests that to a very large extent engaging in healthy behaviors may delay the onset of diabetes for this group, but other extraneous and unobservable factors, probably genetic factors, may enhance their risks of developing diabetes earlier.

For immigrant men, the results are strikingly different—their risks of developing diabetes earlier in the life course increased and accentuated after lifestyle factors were considered. While these findings are intriguing, they may largely be explained by recent and emerging trends of high risk and unhealthy behaviors such as smoking and drinking among some immigrant male groups (Sanou et al. 2014; Beiser 2005; McDonald 2006). For instance, although not discussed, the analysis in this paper identified higher rates of drinking among French immigrants than any other immigrant group. After controlling for this variable, their risks of developing diabetes became apparent. Similarly, Arabs had the highest smoking rates than all immigrant groups. As the effects of this variable were controlled for, their risks became more precisely defined. It is evident then that some visible minority male groups may be experiencing early onset to diabetes because of living unhealthy lifestyles, even more than their Caucasian UK male counterparts who were used as the reference here.

Several of other findings are worth highlighting, especially given that they are consistent with and support the existing research findings. For instance, some other studies find increased risks and earlier timing of diabetes in persons with hypertension, compared to those without (Weycker et al. 2009; Bays et al. 2007). Cheung and Li (2012) report substantial overlap in etiology and disease mechanisms for the two cardiovascular diseases. Also, the finding that immigrant men were more likely to develop diabetes after living in Canada for more than 10 years corroborates others who argue that acculturation and changes in lifestyle in host country may elevate the risks and hasten the timing to onset of diabetes for this group (see Creatore et al. 2013).

Policy implications and limitations

Several policy questions emerge from this study. First, it is important to increase education around diabetes among immigrant populations in Canada. More importantly, gender-specific interventions should be targeted at specific immigrant groups, that otherwise have increased risks of developing diabetes earlier in the life course. As unhealthy lifestyles increase the risks of developing diabetes earlier, it is a cost-effective investment to develop culturally sensitive programs that educate specific immigrant groups. These programs can emphasize the importance of healthy eating and living healthier lifestyles, such as engaging in physical activities regularly. This is particularly important given the substantial benefits that such disease preventive behaviors yield for these groups. It is equally important to deal with the high levels of poverty among immigrant groups in Canada as this can be a barrier to healthy eating and engaging in health preventive behaviors.

In spite of the strong policy implications, some limitations are observed. Firstly, the CCHS is a cross-sectional data set, implying that it may be difficult to draw ‘causal’ connections between dependent and independent variables. Secondly, the data used are self-reported and are subject to report and recall bias. This is especially the case when respondents have been asked to report their ages at first onset of diabetes. Thirdly, this paper focused on immigrants who developed diabetes in Canada, but it is possible that pre-migration factors may have contributed to the development of this medical condition in Canada. However, we were not able to control for pre-migration factors due to lack of such data in the CCHS. Despite these limitations, the study is relevant given that it is one of the few that uses nationally representative data to examine the timing of diabetes among immigrant populations in Canada with important implications for policy makers.

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Table 1a: Percentage distribution of selected independent variables by Gender

Ethnicity/cultural background	**Male (N=4208)**	**Female (N=4697)**
British/Welsh/Scottish/Irish	8.1	9.0
Canadian/French	2.6	2.3
Ukrainian/Polish	4.0	4.2
Portuguese/Italian	6.1	5.3
Netherlands/German	5.3	6.1
South Asia	15.5	12.8
Chinese	12.7	14.3
Black	7.5	8.4
Filipino	5.2	8.2
Latin America	6.4	5.2
Arab	4.1	2.9
South East Asia	3.1	4.3
West Asia/Korea/Japanese	4.1	3.9
Other	15.3	13.1
Control variables		
Time spent in Canada		
Less than 10 years	28.8	30.4
10 to 19 years	24.6	21.5
20 years and More	46.6	48.1
Marital Status		
Single	25.1	18.1
Married	63.2	60.5
Common Law	4.1	4.7
Widowed/Separated/Divorced	7.7	16.8
Province of residence		
Atlantic Canada	1.4	1.2
Quebec	14.1	13.7
Ontario	52.9	51.9

Table 1a Continued

Modifiable risk factors	**Male (N=4208)**	**Female (N=4697)**
Physical Activity		
Active	26.8	20.7
Moderately Active	23.4	22.1
Inactive	47.2	54.0
Not stated	2.6	3.2
Total amount of Fruits/Veges consumed		
Less than 5 per day	59.4	52.8
5 to 10 times per day	32.7	36.4
More than 10 times per day	2.0	3.7
Not stated	6.0	7.1
Type of drinker		
No drink in the last 12 months	25.8	46.1
Regular drinker	59.3	35.0
Occasional drinker	14.9	18.9
Type of smoker		
Not at all	82.0	92.8
Daily	11.7	5.1
Occasional	6.2	2.1
Body Mass Index (BMI)		
Normal weight	38.1	48.2
Underweight	1.8	5.6
Overweight	39.0	24.5
Obese	13.0	10.4
Not Applicable	8.2	11.3
Co-morbid factors		
Diagnosed with blood pressure		
No	79.5	80.4
Yes	20.5	19.6

Manitoba	2.4	2.5
Saskatchewan	1.5	1.2
Alberta	10.5	11.1
British Columbia	17.0	18.3
Northern Territories	0.1	0.1
Socio-economic variables		
Level of Education		
Less than Bachelor's	45.1	47.2
Bachelor's	29.0	25.8
More than Bachelor's	20.2	22.4
Not Stated	5.7	4.6
Total Household Income		
Low income (Less than $5000 to $59999)	44.0	54.5
Middle Income ($60,000 to $89999)	21.9	19.9
High Income ($90,000 to $150,000 or more)	34.1	25.6
Employment		
Unemployed	35.9	46.5
Part-time	6.7	12.1
Fulltime	57.4	41.4

Note: All results are weighted

Diagnosed with heart disease		
No	94.6	96.6
Yes	5.4	3.4
Side effects of Stroke		
No	99.0	99.0
Yes	1.0	1.0

Note: All results are weighted

Table 2a: Unadjusted hazard ratios of selected independent variables by gender		
	HR Male	**HR Female**
Ethnicity/cultural background	**(N=4208)**	**(N=4697)**
British/Welsh/Scottish/Irish	1.00	1.00
Canadian/French	2.61 (.795)***	1.17 (.546)
Ukrainian/Polish	.716 (.323)	.680 (.294)
Portuguese/Italian	1.42 (.347)	1.53 (.384)
Netherlands/German	.993 (.271)	.919 (.254)
South Asia	2.33 (.529)***	3.08 (.743)***
Chinese	1.56 (.378)	1.31 (.330)
Black	4.03 (.962)***	2.73 (.722)***
Filipino	2.62 (.808)***	2.70 (.691)***
Latin America	1.62 (.602)	1.27 (.536)
Arab	3.35 (1.18)***	2.08 (1.04)
South East Asia	6.04 (1.68)***	.465 (.315)
West Asia/Korea/Japanese	.195 (.212)	.512 (.374)
Other	1.11 (.252)	1.21 (.301)
Control variables		
Time spent in Canada		
Less than 10 years	1.00	1.00
10 to 19 years	1.36 (.358)	.921 (.275)
20 years and More	1.58 (.354)**	.938 (.224)
Marital Status		
Single	1.00	1.00
Married	.582 (.126)***	.637 (.150)**
Common Law	1.02 (.319)	.605 (.271)
Widowed/Separated/Divorced	.740 (.184)	.484 (.122)***
Province of residence		
Atlantic Canada	1.00	1.00
Quebec	2.59 (1.46)	2.15 (1.48)
Ontario	1.27 (.712)	1.69 (1.13)

Table 2b Continued	Male(N=4208)	Female(N=4697)
Modifiable risk factors	**HR**	**HR**
Physical Activity		
Active	1.00	1.00
Moderately Active	1.09 (.173)	1.23 (.293)
Inactive	1.19 (.162)	2.20 (.431)***
Not stated	.824 (.217)	1.92 (.539)**
Total amount of Fruits/Veges consumed		
Less than 5 per day	1.00	1.00
5 to 10 times per day	.634(.080)***	.829 (.112)
More than 10 times per day	.875 (.415)	.178 (.130)***
Not stated	.653 (.127)**	.876 (.174)
Type of drinker		
No drink in the last 12 months	1.00	1.00
Regular drinker	1.11 (.155)	.448 (.068)***
Occasional drinker	1.85(.317)***	.781 (.127)
Type of smoker		
Not at all	1.00	1.00
Daily	.955 (.174)	1.05 (.302)
Occasional	.073 (.083)**	1.02 (.648)
Body Mass Index (BMI)		
Normal weight	1.00	1.00
Underweight	.548 (.373)	.233 (.215)
Overweight	1.05 (.135)	1.74 (.279)***
Obese	1.72(.263)***	3.62 (.581)***
Not Applicable	.796 (.198)	1.25 (.294)
Co-morbid factors		
Diagnosed with blood pressure		
No	1.00	1.00
Yes	2.24(.252)***	2.16 (.278)***

Manitoba	2.21 (1.40)	2.50 (1.87)
Saskatchewan	2.79 (1.86)	3.05 (2.51)
Alberta	1.47 (.851)	1.24 (.879)
British Columbia	1.27 (.723)	1.24 (.856)
Northern Territories	1.25 (2.36)	3.14 (5.80)
Socio-economic variables		
Level of Education		
Less than Bachelor's	1.00	1.00
Bachelor's	.864 (.132)	.885 (.142)
More than Bachelor's	.994 (.151)	.501 (.107)***
Not Stated	2.43 (.418)***	.743 (.224)
Total Household Income		
Low income (Less than $5000 to $59999)	1.00	1.00
Middle Income ($60,000 to $89999)	.642 (.098)***	.976 (.166)
High Income ($90,000 to $150,000 or more)	.771 (.099)**	.840 (.140)
Employment		
Unemployed	1.00	1.00
Part-time	.871 (.239)	.757 (.218)
Fulltime	1.25 (.159)	1.40 (.216)**

Note: ** p<0.05; *** p<0.01; standard errors in brackets; all results are weighted

Diagnosed with heart disease		
No	1.00	1.00
Yes	.955 (.158)	1.24 (.244)
Side effects of Stroke		
No	1.00	1.00
Yes	1.02 (.377)	1.34 (.423)

Note: ** p<0.05; *** p<0.01; standard errors in brackets

Table 3: Adjusted hazard ratios for timing of first onset of diabetes among immigrant and visible minority populations in Canada, 2013

Independent variables	**Male**				**Female**			
Ethnicity/cultural background	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 1**	**Model 2**	**Model 3**	**Model 4**
British/Welsh/Scottish/Irish	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Canadian/French	1.79 (.582)	1.62 (.532)	1.64 (.538)	2.05 (.675)**	.984 (.470)	1.03 (.492)	1.01 (.484)	.984 (.475)
Ukrainian/Polish	.756 (.343)	.773 (.351)	.676 (.307)	.810 (.371)	.641 (.279)	.608 (.265)	.617 (.269)	.511 (.224)
Portuguese/Italian	1.28 (.323)	1.20 (.304)	1.07 (.272)	1.07 (.277)	1.48 (.377)	1.31 (.335)	1.34 (.343)	1.03 (.268)
Netherlands/German	.956 (.262)	.929 (.255)	.946 (.261)	.988 (.274)	.929 (.258)	.887 (.247)	.919 (.256)	.854 (.239)
South Asia	2.77(.645)***	2.59(.609)***	2.81(.665)***	3.93(.983)***	3.16(.786)***	3.28(.829)***	3.09(.785)***	2.12(.573)***
Chinese	1.97(.495)***	1.94(.488)***	1.85 (.471)**	2.27(.606)***	1.43 (.368)	1.53 (.395)	1.49 (.386)	1.46 (.406)
Black	3.61(.898)***	3.28(.828)***	2.88(.735)***	3.31(.875)***	2.58(.706)***	2.38(.658)***	2.09(.581)***	1.40 (.404)
Filipino	3.46(1.09)***	3.79(1.23)***	3.28(1.09)***	4.01(1.36)***	2.65(.686)***	2.38(.630)***	2.14(.579)***	1.64 (.470)
Latin America	1.39 (.524)	1.42 (.537)	1.58 (.604)	1.87 (.734)	1.27 (.542)	1.05 (.452)	.973 (.419)	.767 (.335)
Arab	3.46(1.25)***	3.09(1.14)***	3.02(1.12)***	5.05(1.94)***	1.97 (1.02)	2.18 (1.13)	2.02 (1.05)	1.54 (.814)
South East Asia	5.40(1.54)***	5.21(1.49)***	5.43(1.57)***	6.12(1.82)***	.457 (.311)	.459 (.313)	.424 (.290)	.399 (.276)
West Asia/Korea/Japanese	.223 (.243)	.194 (.212)	.197 (.216)	.243 (.267)	.598 (.441)	.628 (.464)	.685 (.505)	.513 (.383)
Other	1.05 (.244)	1.01 (.234)	.964 (.225)	1.14 (.270)	1.18 (.297)	1.17 (.295)	1.13 (.286)	.862 (.222)
Control variables								
Time spent in Canada								
Less than 10 years	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10 to 19 years	1.41 (.374)	1.47 (.394)	1.51 (.406)	1.70 (.461)**	1.01 (.305)	.816 (.252)	.853 (.263)	.827 (.256)
20 years and More	1.87(.434)***	1.94(.451)***	1.83(.430)***	1.81(.424)***	1.18 (.297)	.961 (.250)	.864 (.225)	.888 (.231)
Marital Status								
Single	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Married	.622 (.137)**	.722 (.161)	.694 (.156)	.583 (.132)**	.718 (.174)	.810 (.196)	.791 (.196)	.659 (.167)
Common Law	1.20 (.380)	1.34 (.436)	1.27 (.415)	1.16 (.379)	.825 (.373)	.960 (.438)	1.03 (.470)	1.05 (.483)
Widowed/Separated/Divorced	.767 (.192)	.799 (.201)	.770 (.196)	.615 (.158)	.549(.140)***	.580 (.149)**	.560 (.145)**	.507(.135)***
Province of residence								
Atlantic Canada	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Quebec	2.01 (1.14)	1.94 (1.11)	2.03 (1.16)	1.85 (1.06)	1.71 (1.19)	1.72 (1.19)	1.84 (1.28)	2.15 (1.50)
Ontario	1.13 (.635)	1.10 (.618)	1.11 (.623)	1.03 (.579)	1.33 (.901)	1.27 (.863)	1.34 (.911)	1.52 (1.04)
Manitoba	2.12 (1.35)	1.90 (1.21)	1.80 (1.16)	1.50 (.965)	2.25 (1.69)	2.03 (1.53)	2.08 (1.57)	2.01 (1.53)

Saskatchewan	2.85 (1.91)	2.84 (1.90)	3.09 (2.07)	2.66 (1.79)	2.76 (2.29)	2.65 (2.20)	3.03 (2.51)	3.47 (2.88)
Alberta	1.29 (.811)	1.47 (.860)	1.58 (.928)	1.53 (.901)	1.14 (.811)	1.03 (.733)	1.07 (.759)	1.30 (.926)
British Columbia	1.24 (.711)	1.19 (.688)	1.18 (.685)	1.07 (.619)	1.03 (.710)	.927 (.643)	.982 (.680)	1.08 (.751)
Northern Territories	1.07 (2.03)	1.15 (2.18)	1.19 (2.26)	1.04 (1.97)	2.25 (4.15)	1.92 (3.54)	2.03 (3.75)	1.84 (3.41)
Socio-economic variables								
Level of Education								
Less than Bachelor's		1.00	1.00	1.00		1.00	1.00	1.00
Bachelor's		.797 (.130)	.742 (.123)	.736 (.124)		.773 (.132)	.819 (.139)	.813 (.140)
More than Bachelor's		1.07 (.177)	1.01 (.168)	1.02 (.172)		.418(.097)***	.462(.108)***	.553(.134)***
Not Stated		2.15(.382)***	1.96(.356)***	1.94(.355)***		.695 (.211)	.706 (.215)	.699 (.220)
Total Household Income								
Low income (Less than $5000 to $59999)		1.00	1.00	1.00		1.00	1.00	1.00
Middle Income ($60,000 to $89999)		.621(.099)***	.645(.104)***	.640(.104)***		.924 (.169)	.877 (.161)	.982 (.187)
High Income ($90,000 to $150,000 or more)		.771 (.112)	.730 (.107)**	.664(.100)***		.958 (.178)	.960 (.177)	1.07 (.204)
Employment								
Unemployed		1.00	1.00	1.00		1.00	1.00	1.00
Part-time		1.01 (.279)	1.02 (.287)	.952 (.267)		.734 (.213)	.881 (.257)	.963 (.285)
Fulltime		1.43(.202)***	1.65(.233)***	1.62(.238)***		1.29 (.220)	1.53 (.266)**	1.50 (.270**
Modifiable risk factors								
Co-morbid factors								
Diagnosed with blood pressure								
No			1.00	1.00			1.00	1.00
Yes			2.42(.287)***	2.33(.282)***			2.15(.293)***	1.78(.248)***
Diagnosed with heart disease								
No			1.00	1.00			1.00	1.00
Yes			.883 (.152)	.958 (.167)			1.03 (.232)	.871 (.199)
Side effects of Stroke								
No			1.00	1.00			1.00	1.00
Yes			.738 (.281)	.671 (.263)			1.01 (.363)	.906 (.3350
Physical Activity								
Active				1.00				1.00

Moderately Active	.923 (.155)	1.16 (.284)
Inactive	.814 (.121)	1.49 (.310)**
Not stated	1.20 (1.15)	5.71(3.43)***
Total amount of Fruits/Veges consumed		
Less than 5 per day	1.00	1.00
5 to 10 times per day	.697(.094)***	.991 (.144)
More than 10 times per day	.537 (.265)	.230 (.170)**
Not stated	.694 (.203)	.741 (.249)
Type of drinker		
No drink in the last 12 months	1.00	1.00
Regular drinker	1.43 (.225)**	.557(.093)***
Occasional drinker	1.55 (.288)**	.897 (.155)
Type of smoker		
Not at all	1.00	1.00
Daily	1.07 (.206)	1.11 (.341)
Occasional	.056(.064)***	1.24 (.798)
Body Mass Index (BMI)		
Normal weight	1.00	1.00
Underweight	.755 (.521)	.205 (.190)
Overweight	1.07 (.149)	1.43 (.245)**
Obese	2.01(.344)***	2.81(.507)***
Not Applicable	.872 (.779)	.467 (.214)

Note: ** p<0.05; *** p<0.01; standard errors in brackets; all results are weighted