BMJ Open Temporal trends in cardiovascular disease risk factors among white, South Asian, Chinese and black groups in Ontario, Canada, 2001 to 2012: a population-based study

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ABSTRACT

Objectives: To determine ethnic-specific temporal trends in cardiovascular risk factors in Ontario between 2001 and 2012.

Design: A population-based repeated cross-sectional study.

Setting: Ontario, Canada.

Participants: 219 276 participants of the Canadian Community Health Survey (205 326 white, 5620 South Asian, 4368 Chinese and 3962 black) during the period 2001 to 2012.

Main outcome measures: Age-standardised ethnic-sex-specific prevalence of cardiovascular risk factors for three time periods: 2001–2004, 2005–2008 and 2009–2012 among Canada's four major ethnic groups: white, South Asian, Chinese and black.

Results: During the study period, the prevalence of diabetes increased 2.3-fold ($p=0.0001$) among South Asian males and 1.9-fold ($p=0.02$) among black females. The prevalence of obesity (body mass index ≥ 30 kg/m²) increased over time across all ethnic groups, with the largest relative increases observed among males of Chinese (2.1-fold increase, $p=0.04$) and black (1.7-fold increase, $p=0.06$) descent. The prevalence of hypertension increased the most among black females. Smoking prevalence decreased by more than 20% among South Asian, Chinese and white females. Overall, South Asian males and black males and females showed the greatest declines in cardiovascular health over the study period.

Conclusions: We observed important ethnic differences in the temporal trends in cardiovascular risk factor profiles in Ontario. Awareness of the direction and magnitude of these risk factor trends may be useful in informing targeted strategies for preventing cardiovascular diseases in multiethnic populations.

INTRODUCTION

Cardiovascular disease risk factors, such as tobacco use, high-blood pressure, obesity and

Strengths and limitations of this study

- This is the first study to examine temporal trends in the prevalence of cardiovascular risk factors across Canada's four major ethnic groups.
- Comprehensive cardiovascular risk factor data were available for a large representative population-based sample over a 12-year period.
- Limitations of the study are the use of self-reported data and the lack of information on lipids and details on diet.

physical inactivity are among the leading causes of morbidity and mortality worldwide.¹ Globally, the prevalence of most cardiovascular disease risk factors has been increasing in developing and developed regions of the world due in part to increasing urbanisation and the adoption of sedentary lifestyles.² Large increases in the global prevalence of diabetes and mean body mass index have been found in two recent meta-analyses of epidemiological data.^{3–4} Earlier studies have shown that the prevalence of key cardiovascular risk factors, such as obesity, hypertension and diabetes are on the rise in Canada,⁵ while smoking rates have declined.⁶ Similar trends have been documented in population-based studies in the USA⁷ and the UK.⁸

Migration between countries is becoming increasingly common, with Europe, Asia and North America receiving the highest numbers of international migrants in 2013.⁹ As international migration continues to increase, so too do projections for ethnic diversity in many countries such as Canada, the US and the UK.¹⁰ Canada is one of the most ethnically diverse nations in the world, with over 6 million (20.6%) foreign-born individuals living in Canada in 2011, the

highest proportion among the G8 countries.¹¹ Moreover, the three most populous ethnic minority populations in Canada, the Chinese, South Asian and black ethnic groups, also represent approximately 60% of the world's population. Despite Canada's ethnic diversity, there is little known about whether the prevalence of cardiovascular risk factors is changing differently over time across different ethnic groups. An understanding of ethnic disparities in temporal trends is important for predicting future burden of cardiovascular disease in Canada and other multiethnic nations; however, population-based risk factor data on individual ethnic groups especially over time have been limited, thus precluding previous analysis of trends by ethnicity.

Ethnic differences in the overall prevalence of all major cardiovascular risk factors are well documented in the literature; including previous work published by our group, which found significant differences in the prevalence of cardiovascular risk factors across white, South Asian, Chinese and black ethnic groups in Ontario.¹² Evidence suggests that South Asians generally have a higher prevalence of diabetes and hypertension^{12–14} and white populations have a higher prevalence of smoking and obesity^{15 16} compared to other ethnic groups. Ethnic differences in the temporal trends in the prevalence of cardiovascular risk factors have been reported among South Asian and Chinese individuals living in the UK^{8 17} and among white and black groups living in the USA.^{18 19} What is not known is whether cardiovascular risk factor prevalence is changing differently over time across the major ethnic groups living in Canada.

The objective of this study was to examine temporal trends in the prevalence of key cardiovascular risk factors from 2001 to 2012 across Ontario's four major ethnic groups: white, South Asian, Chinese and black.

METHODS

Data sources and study population

The study population included Ontario residents who responded to Statistics Canada's Canadian Community Health Survey (CCHS) cycles 1.1 (2001), 2.1 (2003), 3.1 (2005), 2007, 2008, 2009, 2010, 2011, 2012. Data from multiple cross-sectional CCHS cycles with independent samples were combined so that temporal trends could be examined across three time periods: 2001–2004, 2005–2008 and 2009–2012 with adequate sample sizes in each of the four ethnic groups. The CCHS used a consistent multistage stratified cluster sampling strategy to collect self-reported data on sociodemographic characteristics and health-related information from a representative sample of persons aged 12 years or older living in private dwellings. The individual response rates for the surveys ranged from 75.1% to 94.4%. The surveys were conducted by highly-skilled interviewers in over 25 languages. Further details about the CCHS methodology are described elsewhere.²⁰

In this study, we analysed Ontario residents who identified their racial-cultural group as white, Chinese, South Asian (ie, those of Indian, Pakistani, Bangladeshi or Sri Lankan origin) or black (ie, those of African or Caribbean origin).

Study variables

Sociodemographic characteristics included age, sex, marital status, highest level of education attained in the household and by the individual, household income in Canadian dollars, immigrant status and urban or rural dwelling.

We analysed a total of eight cardiovascular risk factors, including four major risk factors (ie, diabetes, obesity ($\text{BMI} \geq 30 \text{ kg/m}^2$), current smoking and hypertension); and four other risk factors (ie, inadequate leisure physical activity, inadequate fruit and vegetable consumption, psychosocial stress and non-regular alcohol consumption). Inadequate leisure physical activity was defined as participating in ≤ 15 min of daily leisure physical activity (eg, walking for exercise, jogging, swimming, bicycling, etc); inadequate fruit and vegetable intake was defined as eating fruits or vegetables fewer than three times a day;²¹ psychosocial stress was defined as an individual feeling 'extremely' or 'quite a bit' versus 'not at all', 'not very' or 'a bit' stressed on most days. Non-regular alcohol consumption was defined as consuming fewer than three drinks per week.²² Diabetes and hypertension were self-reported physician-diagnosed and included both treated and untreated conditions. We also assessed trends in the mean BMI (kg/m^2) and the prevalence of overweight/obesity ($\text{BMI} \geq 25 \text{ kg/m}^2$) by ethnic group.

Statistical analyses

We calculated the age-standardised and sex-standardised prevalence of sociodemographic characteristics and the age-standardised sex-specific prevalence of cardiovascular risk factors for each of the three time periods across the four ethnic groups. We used direct standardisation with 5-year age bands and the 2001 Ontario census as the standard population. All analyses were weighted by Statistics Canada's sample weights to account for the complex survey sampling design and to improve generalisability of the estimates. Per cent changes in the prevalence of risk factors between the 2009–2012 and 2001–2004 periods were calculated; 95% CIs and p values were estimated using bootstrap methods.^{23 24} All tests were two-sided and $p < 0.05$ was considered statistically significant. Invalid responses for each risk factor (which made up $< 5\%$ of respondents) were considered missing data and were excluded from calculations for the specific risk factor.

Ethics committee approval

The analysis of the Ontario components of the CCHS data for this study was approved by the Research Ethics Board at Sunnybrook Health Sciences Centre. Statistics

Canada obtained informed consent from all survey participants at the time of the original surveys.

RESULTS

Study population

We analysed a total of 219 276 survey participants (205 326 white, 5620 South Asian, 4368 Chinese and 3962 black) over the 12-year study period from 2001 to 2012.

Sociodemographic characteristics

There was an apparent consistent improvement in the household-level and individual-level educational status in all four ethnic groups (table 1). The mean household income also increased significantly in all four ethnic groups. Between 2009 and 2012, the non-white ethnic groups reported on average \$10 866–\$27 959 lower household income than the white group.

Prevalence of cardiovascular risk factors

Figure 1 displays the temporal trends in the prevalence of major cardiovascular risk factors by ethnicity. Between the periods of 2001–2004 and 2009–2012, the prevalence of diabetes increased from 6.7% (95% CI 4.4 to 9.2) to 15.2% (95% CI 11.7 to 18.0) among South Asian males and from 6.3% (95% CI 3.8 to 9.5) to 12.2% (95% CI 8.0 to 15.8) among black females—representing 2.3-fold ($p=0.0001$) and 1.9-fold ($p=0.02$) increases, respectively (see online supplementary table S1). The prevalence of obesity increased in all ethnic and sex groups during the study period; with the largest relative increases observed among males of Chinese (2.1-fold increase, $p=0.04$) and black (1.7-fold, $p=0.06$) descent. By the end of the study period, the prevalence of overweight/obesity exceeded 50% for white and black males, and was 46% for South Asian males (figure 2). Smoking prevalence declined by more than 20% among South Asian, Chinese and white females. Among white males and females, the prevalence of diabetes, hypertension, overweight/obesity increased, while smoking prevalence improved (see online supplementary tables 1 and 2).

Daily leisure physical activity improved modestly in the white and South Asian groups and remained relatively unchanged in the Chinese and black groups (figure 3). A large increase was observed in the proportion of South Asian males who reported eating fruits and vegetables fewer than three times per day (20.9% in 2001–2004 vs 27.5% in 2009–2012, $p=0.02$; see online supplementary table S2), however, the prevalence in South Asian females remained relatively unchanged over the study period. The prevalence of psychosocial stress declined among males in all ethnic groups, with the largest declines observed among South Asian and Black males (figure 3). A decline in non-regular alcohol consumption was observed in the white group, particularly white females (−9.1%, $p<0.0001$) and an increase was observed in black males (7.7%, $p=0.09$), while temporal trends in other ethnic and sex groups were relatively stable.

Figure 4 summarises the trends in the major cardiovascular disease risk factors among males and females of the different ethnic groups. Trends for which the per cent change was more than 20% are shown—overall, the prevalence of cardiovascular disease risk factors appeared to be worsening the most in South Asian males (ie, large increases in diabetes, hypertension and overweight/obesity prevalence), black males (ie, large increases in diabetes and obesity prevalence) and black females (ie, large increases in diabetes and hypertension prevalence). Black females also showed the greatest increase in the prevalence of hypertension.

INTERPRETATION

We found striking ethnic differences in the trends in cardiovascular risk factors over time in a Canadian population. Overall, South Asian males showed the greatest worsening of cardiovascular risk factor profiles over time, followed by black males and females. South Asian, Chinese and black populations represent the majority of the world's population and make up a significant proportion of many western countries, including Canada. Findings from this large, population-based study of ethnic-specific temporal trends in several cardiovascular risk factors therefore provides important and comprehensive information for many multiethnic western nations.

The increasing trends we report in diabetes prevalence among South Asian, black and white populations are consistent with trends observed in other multiethnic jurisdictions. In the UK, Bhopal *et al*¹⁷ conducted an analysis of the Health Survey for England (1999–2004) and showed a significant increase in the prevalence of diabetes among Indian males and females. In the USA, analysis of the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2002 found that the prevalence of diagnosed diabetes in the black population increased rapidly from 8.4% in 1988–1994 to 11% in 1999–2002.²⁵ Consistent with our study findings, a meta-analysis of international epidemiological studies and health examination surveys found large increases in diabetes prevalence and fasting plasma glucose levels among males from South Asian countries.³ In our study, the rapidly increasing prevalence of diabetes found in South Asian males may be in part due to changes in diet and weight gain over time, as evidenced by the increased prevalence of inadequate fruit and vegetable consumption and overweight/obesity in this group.

We found an increasing trend in the prevalence of obesity across all ethnic groups, but the largest relative increase was among Chinese males. We reported significant increases in mean BMI among Chinese and South Asian males; both groups showing an absolute 0.8 kg/m² increase over the past decade. Similarly, a meta-analysis of studies examining trends in BMI from 1980 to 2008 found an increase per decade of 0.4–0.5 kg/m² among East Asians and an increase of 0.4 kg/m² among South

Table 1 Age-standardised and sex-standardised prevalence of sociodemographic characteristics, by ethnicity and survey period, Ontario, Canada (2001–2012)

	White		South Asian		Chinese		Black	
	2001–2004	2009–2012	2001–2004	2009–2012	2001–2004	2009–2012	2001–2004	2009–2012
N	69 416	66 876	1394	2299	1405	1449	1098	1425
Age, mean (years)	42.3	42.4	42.3	42.3	42.3	42.4	41.8	42.2
Male sex	49.1	49.1	49.1	49.1	49.1	49.1	48.7	49.1
Marital status								
Divorced	4.0	4.4	1.7	1.7	2.3	2.3	4.5	6.6
Separated	2.3	2.8	1.8	1.2	0.9	0.6	6.6	5.7
Widowed	5.3	4.5	7.5	3.8	5.4	5.1	3.8	3.1
Single, never married	29.6	31.1	24.6	26.6	32.0	32.0	37.1	44.3
Common law	5.9	8.1	0.8	0.8	1.2	1.3	4.4	4.2
Married	52.8	49.1	63.5	65.8	58.2	58.7	43.1	36.1
Highest educational attainment (household)								
<High school graduate	8.7	5.5	5.1	2.8	5.7	3.0	9.5	5.8
High school graduate	14.3	10.9	13.0	9.0	12.7	10.9	11.9	13.9
Some post-secondary	6.7	4.5	5.1	3.6	6.5	3.2	7.6	4.2
College/university degree	70.4	79.2	76.8	84.7	75.1	82.8	70.6	76.1
Highest educational attainment (individual)								
<High school graduate	25.8	19.5	27.3	20.7	23.9	20.6	24.7	19.1
High school graduate	20.4	17.3	18.1	14.7	21.2	15.0	20.2	17.4
Some post-secondary	7.5	7.3	5.9	6.0	6.7	4.5	8.9	5.8
College/university degree	46.3	56.0	48.7	58.6	48.3	59.8	45.7	57.7
Urban dwelling	83.1	81.2	97.3	98.4	98.3	98.4	96.1	97.7
Household income (mean, Canadian \$)	73 858	90 337	62 600	74 414	60 339	79 471	49 515	62 378
Immigrant	17.7	16.1	88.4	87.9	84.5	82.7	78.7	77.0
Number of years in Canada (among immigrants)	24.5	24.6	13.0	15.8	14.2	16.5	18.6	19.6

Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys.

All values are percentages unless otherwise specified. Estimates were age-standardised and sex-standardised to the 2001 Ontario Census population and weighted by the survey sample weight. The age and sex distributions appear almost identical due to age-standardisation and sex-standardisation.

Figure 1 Temporal trends in the prevalence (%) of major cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardised to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. $[(\text{estimate for 2009-2012} - \text{estimate for 2001-2004}) / (\text{estimate for 2001-2004})] \times 100$. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004. Definition: Obesity, body-mass index $\geq 30 \text{ kg/m}^2$. * $p < 0.05$.

Asian females.⁴ An analysis of NHANES data from 1988 to 2004¹⁹ found that the prevalence of obesity increased in all ethnic groups during the study period. The largest increase was noted in the US black population that showed a 32.5% relative increase in the prevalence of

obesity, an estimate very comparable to the 31.3% relative increase we observed in the black population in Ontario.

Recent studies have shown that smoking rates have been declining globally,²⁶ however our study shows that

Figure 2 Temporal trends in age- and sex-standardised prevalence of overweight/obesity, by ethnicity and sex. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardised to the 2001 Ontario Census population using 5-year age categories, and weighted by the survey sample weight. Definitions: Overweight/obesity, body-mass index ≥ 25 kg/m²; Obesity, body-mass index ≥ 30 kg/m².

this trend is occurring in some ethnic-sex groups but not all. Previous studies in the UK have shown significant declines in smoking prevalence among Indian and Irish white populations,¹⁷ which is consistent with our findings. In our study, modest increases in smoking prevalence were observed among Chinese males and black females. Further analysis is needed to understand these trends, particularly among Chinese individuals given that smoking prevalence among young people in China has been increasing and the average age at smoking initiation has been decreasing in recent years.²⁷

We found significant increasing trends in hypertension prevalence among white males and females and non-significant but increasing trends among South Asian and

black groups. Similarly, reports from the UK show worsening trends in diastolic blood pressure among Pakistani and Indian women.¹⁷ Rising prevalence of hypertension was also noted in US white and black populations.¹⁹

Ethnic variations in temporal trends observed in our study may be associated with differential changes in health behaviours and cultural practices and the adoption of western lifestyles and diet subsequent to immigration and with increasing time since immigration. South Asian individuals have been shown to be particularly sensitive to dietary changes associated with acculturation to Western lifestyles, such as the tendency to consume more high-fat and 'convenience foods' due to their low

Figure 3 Temporal trends in the prevalence (%) of other cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardised to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. $[(\text{estimate for 2009-2012} - \text{estimate for 2001-2004}) / (\text{estimate for 2001-2004})] \times 100$. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004. Definitions: Psychosocial stress ("extremely" or "quite a bit" stressed on most days); inadequate fruit and vegetable intake (< three times per day); inadequate leisure physical activity (≤ 15 min/day); nonregular alcohol consumption (< three drinks per week).

cost and greater availability in Canada.²⁸ Similarly, Chinese populations have been found to decrease their consumption of traditional foods and increase

consumption of fats, sweets and meats on immigration.²⁹ In this study, we also found significantly lower mean household income among non-white ethnic groups

Figure 4 Summary of trends in major cardiovascular risk factors among males and females by ethnicity, Ontario, Canada. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Arrows $\uparrow\downarrow$ indicate $\geq 20\%$ increases or decreases in major cardiovascular risk factor prevalences comparing the estimates for 2009-2012 to estimates for 2001-2004. * $P < 0.05$.

Males	White	South Asian	Chinese	Black
Diabetes	$\uparrow^*$	$\uparrow^*$		$\uparrow$
Obesity		$\uparrow$	$\uparrow^*$	$\uparrow$
Current smoking				
Hypertension		$\uparrow$		

Females	White	South Asian	Chinese	Black
Diabetes	$\uparrow^*$			$\uparrow^*$
Obesity	$\uparrow^*$	$\uparrow$		
Current smoking	$\downarrow^*$	$\downarrow$	$\downarrow$	
Hypertension				$\uparrow$

compared to the white group; further investigation of the effects of socioeconomic factors on ethnic-specific temporal trends in cardiovascular risk is warranted.

This study has many strengths worth noting. To our knowledge, it is the first Canadian examination of ethnic-specific temporal trends in cardiovascular risk factors over the most recent decade. Few data sources are available with consistently collected data on cardiovascular disease risk factors in ethnic minority populations. In Canada, such an analysis has not previously been possible due to the limited sample size of ethnic minority groups in population health surveys; the combining of multiple cycles of the CCHS in this study allowed us to investigate temporal trends over the past decade by ethnicity. The ethnic groups examined in this study represent the four largest ethnic groups in Canada and are large and growing populations in other countries worldwide.³⁰ Studies in the USA have only recently had adequate sample sizes to examine ethnic cardiovascular risk factor trends over time since the US NHANES started oversampling ethnic minority groups in 1988.^{19 31} In the UK, the Health Survey of England focused on major ethnic minority groups for the 1999 and 2004 cycles by oversampling these groups, however a planned oversampling in the 2009–2010 cycle was cancelled, thus precluding ongoing analysis of trends in cardiovascular risk factors by ethnicity.¹⁷

The results of this study raise several important issues of which clinicians and policymakers should be mindful. As countries continue to become more ethnically diverse, an understanding of risk factor trends in different ethnic groups can aid in predicting the future burden of cardiovascular disease. For example, the worsening of cardiovascular risk factor profiles for South Asian and black males and females portends an increasing risk for cardiovascular disease in these populations in the future. Therefore, risk reduction strategies for these ethnic groups are urgently needed, including

perhaps culturally-specific approaches. Obesity is increasing in all ethnic and gender groups, but the largest relative increase was in Chinese males, a population in which obesity has traditionally been relatively rare.³² When we consider that the metabolic impact of excess weight is particularly pronounced for Chinese, black and South Asian groups,^{33 34} ethnic-specific screening and management strategies for diabetes and other metabolic consequences of obesity may be needed. Owing largely to public health messaging and policies, cigarette smoking has declined in the overall population. However, our results suggest that existing public health measures may not be equally effective in all ethnic-sex groups.

Limitations

Our study has some limitations to consider. First, the data were self-reported which may have resulted in misclassification. Also, BMI was calculated from self-reported height and weight and may be influenced by ethnic differences in reporting. However, a previous analysis of self-reported and measured weight and height collected on a representative sample of participants of the CCHS cycle 3.1 found very high concordance between self-reported and measured BMI, irrespective of ethnicity.³³ Second, our results are from a series of cross-sectional surveys with independent samples rather than a cohort study following up the same people. Third, we were unable to analyse other risk factors for cardiovascular diseases (eg, lipids, waist-to-hip ratio and detailed dietary information) that are not collected in the CCHS. Fourth, it is difficult to disentangle the temporal trends that we observed from immigration and acculturation (ie, the tendency for immigrants' cardiovascular health to decline with longer duration of residence in western cultures).³⁵ Finally, the sample sizes of the ethnic-sex groups ranged widely and thus we had variable statistical power to detect changes in the prevalence of risk factors

over time. Future studies with larger sample sizes in each ethnic group are needed to understand the age, period and cohort effects on trends in cardiovascular risk factor profiles in ethnic groups.

CONCLUSION

In conclusion, we found significant ethnic differences in the temporal trends in cardiovascular risk factor profiles between 2001 and 2012. Knowledge of risk factors and their trends across ethnicities is an important step in understanding the relative distribution of the burden of cardiovascular disease and to anticipate future incidence within ethnically diverse populations. A combination of a population-wide strategy to combat obesity and diabetes and ethnically-tailored strategies to combat other risk factors might be optimal for reducing the significant burden of cardiovascular diseases in multiethnic populations.

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Contributors MC was the Principal Investigator, conceived the study, performed the analyses and wrote the first draft of the paper. MC, LCM, BRS and JVT. interpreted the data, critically revised the manuscript for important intellectual content and approved the final version of the manuscript. JVT obtained funding for the study. Administrative, technical and logistic support was provided by all authors.

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Competing interests None declared.

Patient consent Not obtained.

Ethics approval Research Ethics Board at Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada.

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