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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 temporal trends in cardiovascular risk factors by ethnic group in Ontario between 2001 and 2012.

Design: This was a population-based 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-standardized ethnic-sex-specific prevalence of cardiovascular risk factors for three time periods: 2001 to 2004, 2005 to 2008 and 2009 to 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 among South Asian males (P=0.0001) and 94.2% (p=0.02) among black females. The prevalence of obesity (body-mass index ≥30 kg/m^2) increased over time across all ethnic groups, with the largest relative increases observed among males of Chinese and black descent. The prevalence of hypertension increased the most among black females. Significant and steady declines in smoking prevalence were observed in the white group. Overall, South Asian and Chinese males and black females showed the greatest declines in cardiovascular health over the study period.

Conclusions: We observed important ethnic differences in the temporal trends of 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 multi-ethnic populations.

Article Summary

Article Focus

- To examine temporal trends in the prevalence of cardiovascular risk factors across white, South Asian, Chinese and black ethnic groups living in Ontario, Canada (2001-2012)

Key Messages

- The prevalence rates of cardiovascular risk factors are changing differently over time for different ethnic groups.
- The prevalence of diabetes more than doubled in the past decade among South Asian males
- The prevalence of hypertension increased the most among black females
- Smoking declined significantly among white males and females
- The prevalence of obesity increased in all ethnic and sex groups, with the largest relative increase observed among Chinese males

Strengths and limitations of the study

- This is the first study to examine temporal trends in the prevalence of cardiovascular risk factors across Canada's four major ethnic groups
- Cardiovascular risk factor data were available for a large representative population-based sample over an 11-year period
- Limitations of the study are the use of self-reported data and the lack of information on lipids and details on diet

INTRODUCTION

Cardiovascular disease risk factors, such as tobacco use, high blood pressure, obesity, and physical inactivity are among the leading causes of morbidity and mortality worldwide.[1] Globally, the prevalence of cardiovascular disease risk factors has been increasing in both developing and developed regions of the world due in part to increasing urbanization and the adoption of sedentary lifestyles.[2] Large increases in the global prevalence of diabetes and mean BMI 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 United States [7] and the United Kingdom.[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 the Canada, the United States, and the United Kingdom.[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] 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 internationally; 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 among white, South Asian, Chinese, and black Ontario residents.[12] Evidence suggests that South Asians generally have a higher prevalence of diabetes and hypertension [12,13] [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 Asians and Chinese individuals living in the UK[8,17] and among white and black groups living in the US.[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 for Ontario's four major ethnic groups: white, South Asian, Chinese, and black.

METHODS

Data sources & 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 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 analyzed Ontario residents who identified their racial-cultural group as white, Chinese, South Asian (i.e. those of Indian, Pakistani, Bangladeshi, or Sri-Lankan origin), or black (i.e. 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 analyzed a total of 8 cardiovascular risk factors, including 4 major risk factors (i.e., current smoking, diabetes, hypertension, and weight-related risk factor (i.e., mean body-mass index (BMI), overweight (BMI≥25 kg/m^2) and obesity (BMI≥30 kg/m^2)); and 4 other risk factors (i.e., inadequate physical activity, inadequate fruit and vegetable consumption, non-regular alcohol consumption, and psychosocial stress). Inadequate physical activity was defined as participating in ≤15 minutes of daily physical activity (e.g. walking for exercise, jogging, swimming, bicycling, etc.); inadequate fruit and vegetable intake was defined as eating fruits or vegetables fewer than 3 times a day[21]; psychosocial stress was defined as an individual feeling "extremely" or "quite a bit" vs. "not at all", "not very" or "a bit" stressed in most days. Non-regular alcohol consumption was defined as consuming fewer than 3 drinks per week.[22]

Diabetes and hypertension were self-reported physician-diagnosed and included both treated and untreated conditions.

Statistical Analyses

We calculated the age- and sex-standardized prevalence of sociodemographic characteristics and the age-standardized sex-specific prevalence of cardiovascular risk factors for each of the three time periods across the four ethnic groups. We used direct standardization 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 generalizability of the estimates. Percent changes in the prevalence of risk factors between the 2009-2012 and 2001-2004 periods were calculated and bootstrap methods were used for variance estimation.[23],[24] All tests were two-sided and $P<0.05$ was considered statistically significant. Invalid responses for each risk factor (<5% of respondents) were considered missing data and were excluded from calculations for the specific risk factor.

To summarize our findings, we calculated a summary score that was the difference between the number of risk factors for which there was a significant improvement in prevalence between the 2009-2012 and 2001-2004 periods and the number of risk factors for which there was a significant worsening in prevalence.

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 analyzed a total of 219,276 survey participants (205,326 white, 5620 South Asian, 4368 Chinese, and 3962 black) over the 11-year study period from 2001-2012.

Sociodemographic characteristics

Household-level and individual-level educational status, as well as household income improved significantly through the years for all four ethnic groups (Table 1). All other sociodemographic characteristics appeared stable during the study period.

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

	White			South Asian			Chinese			Black		
	2001-2004	2009-2012	Percent change†	2001-2004	2009-2012	Percent change†	2001-2004	2009-2012	Percent change†	2001-2004	2009-2012	Percent change†
N	69416	66876		1394	2299		1405	1449		1098	1425	
Age, mean (years)	42.3	42.4	n/a	42.3	42.3	n/a	42.3	42.4	n/a	41.8	42.2	n/a
Male sex	49.1	49.1	n/a	49.1	49.1	n/a	49.1	49.1	n/a	48.7	49.1	n/a
Marital status												
Divorced	4.0	4.4	10.3‡	1.7	1.7	3.3	2.3	2.3	0.4	4.5	6.6	47.2
Separated	2.3	2.8	18.3§	1.8	1.2	-33.4	0.9	0.6	-36.5	6.6	5.7	-13.7
Widowed	5.3	4.5	-15.1§	7.5	3.8	-49.4§	5.4	5.1	-5.4	3.8	3.1	-17.3
Single, never married	29.6	31.1	4.9§	24.6	26.6	8.2‡	32.0	32.0	-0.2	37.1	44.3	19.3§
Common law	5.9	8.1	37.2§	0.8	0.8	-1.9	1.2	1.3	11.2	4.4	4.2	-5.6
Married	52.8	49.1	-7.0§	63.5	65.8	3.6	58.2	58.7	0.9	43.1	36.1	-16.3‡
Married or common law	58.7	57.2	-2.5§	64.3	66.6	3.5	59.4	60.1	1.1	47.5	40.2	-15.3‡
Highest educational attainment (household)												
<High school graduate	8.7	5.5	-36.7§	5.1	2.8	-45.8‡	5.7	3.0	-46.4‡	9.5	5.8	-38.6‡
High school graduate	14.3	10.9	-23.9§	13.0	9.0	-31.1‡	12.7	10.9	-14.1	11.9	13.9	17.0
Some post-secondary	6.7	4.5	-32.9§	5.1	3.6	-30.3	6.5	3.2	-50.3‡	7.6	4.2	-44.4‡
College/university degree	70.4	79.2	12.5§	76.8	84.7	10.3‡	75.1	82.8	10.2‡	70.6	76.1	7.7

Table 1 (Cont'd) Age- and sex-standardized prevalence of sociodemographic characteristics, by ethnicity and survey period, Ontario, Canada (2001-2012)

	White			South Asian			Chinese			Black		
	2001-2004	2009-2012	Percent change†	2001-2004	2009-2012	Percent change†	2001-2004	2009-2012	Percent change†	2001-2004	2009-2012	Percent change†
Highest educational attainment (individual)												
<High school graduate	25.8	19.5	-24.5§	27.3	20.7	-24.1‡	23.9	20.6	-13.6‡	24.7	19.1	-22.4‡
High school graduate	20.4	17.3	-15.4§	18.1	14.7	-18.9	21.2	15.0	-29.0‡	20.2	17.4	-14.0
Some post-secondary	7.5	7.3	-3.2	5.9	6.0	1.4	6.7	4.5	-32.0	8.9	5.8	-35.5‡
College/university degree	46.3	56.0	21.0§	48.7	58.6	20.3§	48.3	59.8	23.9§	45.7	57.7	26.2§
Urban dwelling	83.1	81.2	-2.3§	97.3	98.4	1.1	98.3	98.4	0.1	96.1	97.7	1.6
Household income (mean, Canadian $)	73858	90337	22.3§	62600	74414	18.9§	60339	79471	31.7§	49515	62378	26.0§
Immigrant	17.7	16.1	-9.0§	88.4	87.9	-0.6	84.5	82.7	-2.1	78.7	77.0	-2.2
Number of years in Canada (among immigrants)	24.5	24.6	0.4	13.0	15.8	21.5§	14.2	16.5	16.2§	18.6	19.6	5.4

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- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Definitions--n/a: not applicable.

†Percent change for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004.

‡ indicates significant at $p<0.05$. § indicates significant at $p<0.001$

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 2.3-fold (P=0.0001) among South Asian males, however, no significant change was observed among South Asian females (Supplementary Table 1). During the same period, the prevalence of overweight increased significantly among South Asian males (20.6% relative increase, P=0.01) but not among females. The most dramatic increases in the prevalence of obesity were 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 exceeded 50% for white and black males, and was 46% for South Asian males (Figure 2). Among white males and females, the prevalence of diabetes, hypertension, overweight and obesity increased significantly, while smoking and leisure physical activity prevalence improved significantly. (Supplementary Table 1 and 2)

The percentage of people reporting at most 15 minutes of daily leisure physical activity declined in the white and South Asian groups and remained unchanged in the Chinese and black groups (Figure 3). A significant increase was observed in the prevalence of South Asian males who reported eating fruits and vegetables fewer than 3 times per day (20.9% in 2001-2003 vs. 27.5% in 2009-2012, p=0.02) (Supplementary Table 2), however, the prevalence in South Asian females remained relatively unchanged over the study period. The prevalence of psychosocial stress declined significantly among white and South Asian males (p=0.0004; p=0.02). A significant decline in non-regular alcohol consumption was observed in the white group,

particularly white females, however, no significant changes were observed in the non-white ethnic groups.

According to the summary scores in Figure 4, South Asian males (score= -2) fared the worst, followed by Chinese males (score= -1) and black females (score= -1). In general, South Asian males showed an increasing prevalence of diabetes, overweight and inadequate fruit and vegetable consumption, but an improving trend in psychosocial stress (Figures 1 and 3). Chinese males and black females showed the worst trends in obesity and diabetes, respectively (Figure 1). Although the white group had a larger sample size, resulting in a greater number of significant changes being observed, the summary scores reflected this higher propensity for finding significant trends in both upward and downward directions (i.e. summary score:+1 among white males, 0 among white females).

INTERPRETATION

Between the periods of 2001-2004 and 2009-2012, the prevalence of diabetes increased 2.3-fold in South Asian males and 94.2% among black females. South Asian males also showed significant increases in the prevalence of overweight and inadequate fruit and vegetable consumption. The prevalence of obesity increased across all ethnic and gender groups, with the largest relative increases observed among males of Chinese and black descent. Significant and steady declines in smoking prevalence were observed in white males and females and large but non-significant declines were observed in South Asian males and females as well as Chinese females. Overall, South Asian males showed the greatest worsening of cardiovascular risk factor profiles over time, followed by Chinese males and black females.

The increasing trends we report in diabetes among South Asian, black and white populations are consistent with trends observed in other multi-ethnic jurisdictions. In the UK, Bhopal et al. 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.[17] In the US, 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 11.0% 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]

We found an increasing trend in the prevalence of obesity across all ethnic groups, but the largest relative increase was in Chinese males. We reported significant increases in mean BMI among Chinese and South Asian males; both groups showing an absolute 0.8 kg/m^2 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 to 0.5 kg/m^2 among East Asians and an increase of 0.4 kg/m^2 among South Asian females.[4] An analysis of NHANES data from 1988 to 2004 [19] 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 this trend is occurring in some ethnic-sex groups but not all. Consistent with our findings, previous studies in the UK have shown significant declines in smoking

prevalence among Indian and Irish white populations.[17] Smoking rates among Chinese and South Asian people living in Canada are generally lower than rates found in men in China (52.9%) [27] and men in India (33.7%).[28] However, it is disconcerting that smoking rates appear to be increasing, albeit non-significantly, among Chinese males in Ontario. Further analysis is needed to understand these trends, particularly among Chinese youth 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.[29]

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 increasing trends in diastolic blood pressure among Pakistani and Indian women.[17] Increasing 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 cost and greater availability in Canada.[31] Similarly, Chinese populations have been found to decrease their consumption of traditional foods and increase consumption of fats, sweets and meats upon immigration.[32]

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 the CCHS; 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 countries, such as the United States.[33] Studies in the US 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. [19,34] 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 of cardiovascular risk factors by ethnicity.[17]

The results of this study raise several important issues of which clinicians and policy makers 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 Chinese 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.[35] When we consider that the metabolic impact of excess weight is particularly pronounced for Chinese and South Asian groups, [36,37] 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 result in misclassification. Also, body-mass index 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 body-mass index, irrespective of ethnicity.[36] 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 analyze other risk factors for cardiovascular diseases (e.g. 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 acculturation (the tendency for immigrants' cardiovascular health to decline with longer duration of residence in western cultures). [38] Future studies with larger sample sizes in each ethnic group are needed to understand the age, period and cohort effects of 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 ethnically diverse populations.

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Author Contributions: M.C. was the Principal Investigator, conceived the study, performed the analyses, and wrote the paper. L.C.M. assisted with the writing of the paper. M.C., L.C.M., B.R.S., and J.V.T. interpreted the data, critically revised the manuscript for important intellectual content, and approved the final version of the manuscript. J.V.T. obtained funding for the study. Administrative, technical, and logistic support was provided by all authors.

Conflicts of Interest Disclosure:

The authors have no conflicts of interest to disclose.

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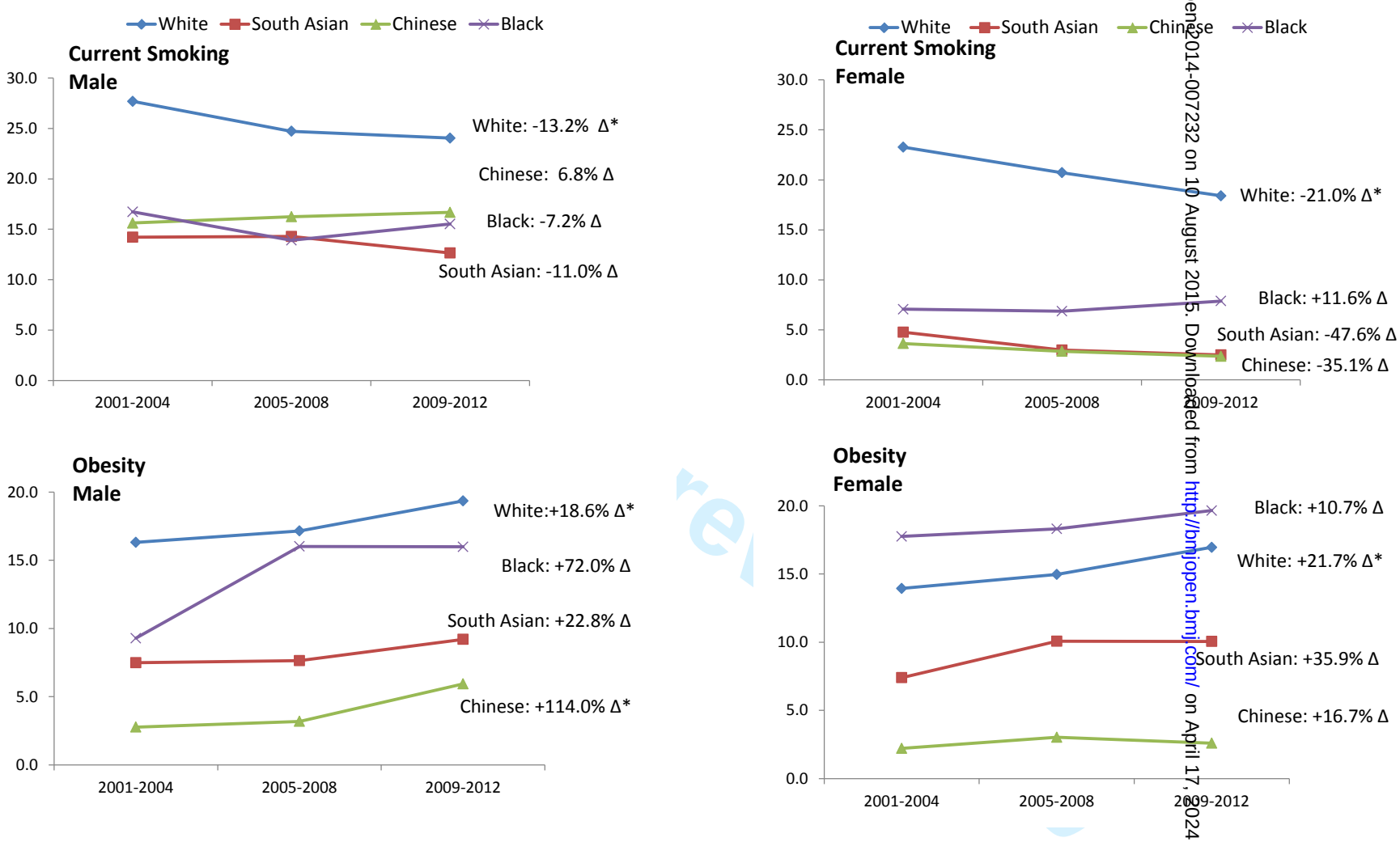
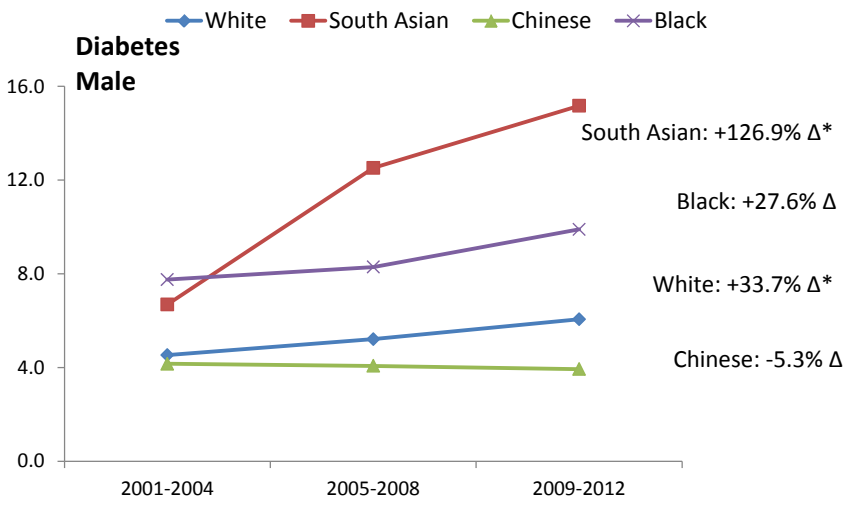
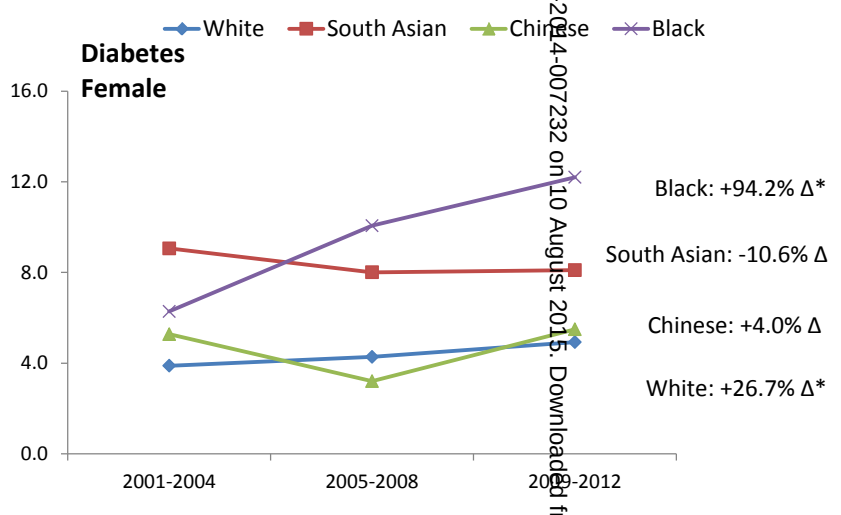
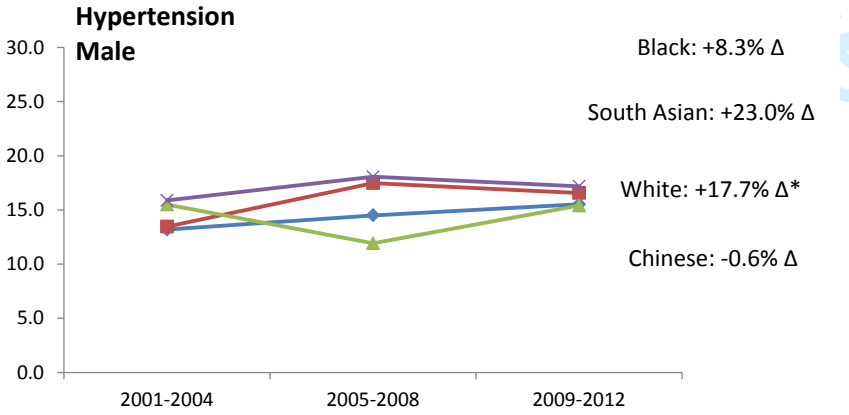


Figure 1: Temporal trends in the prevalence (%) of major cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004. Definition: Obesity, body-mass index ≥ 30 kg/m2. * p <0.05







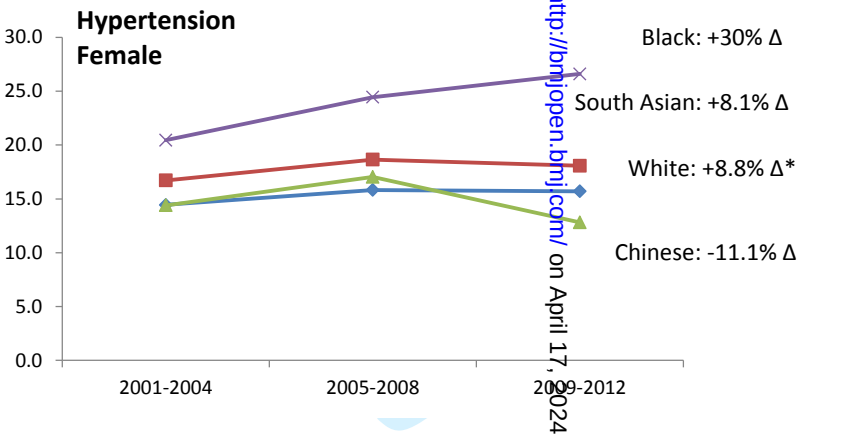


Figure 1 cont'd: Temporal trends in the prevalence (%) of major cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004. Definition: Obesity, body-mass index ≥ 30 kg/m2. * p <0.05

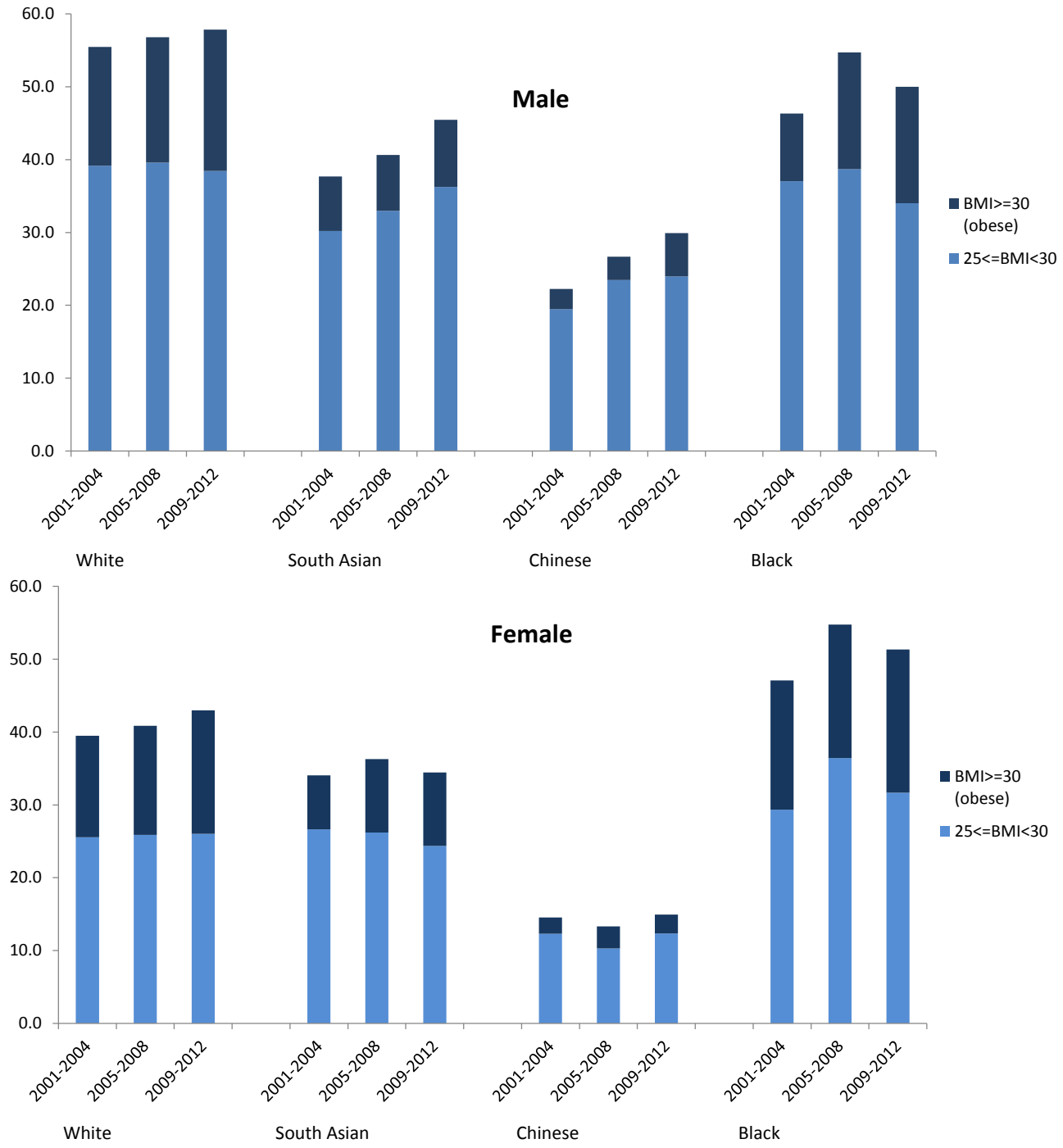


Figure 2: Temporal trends in age- and sex-standardized prevalence of overweight and obesity, by ethnicity and sex. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population using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

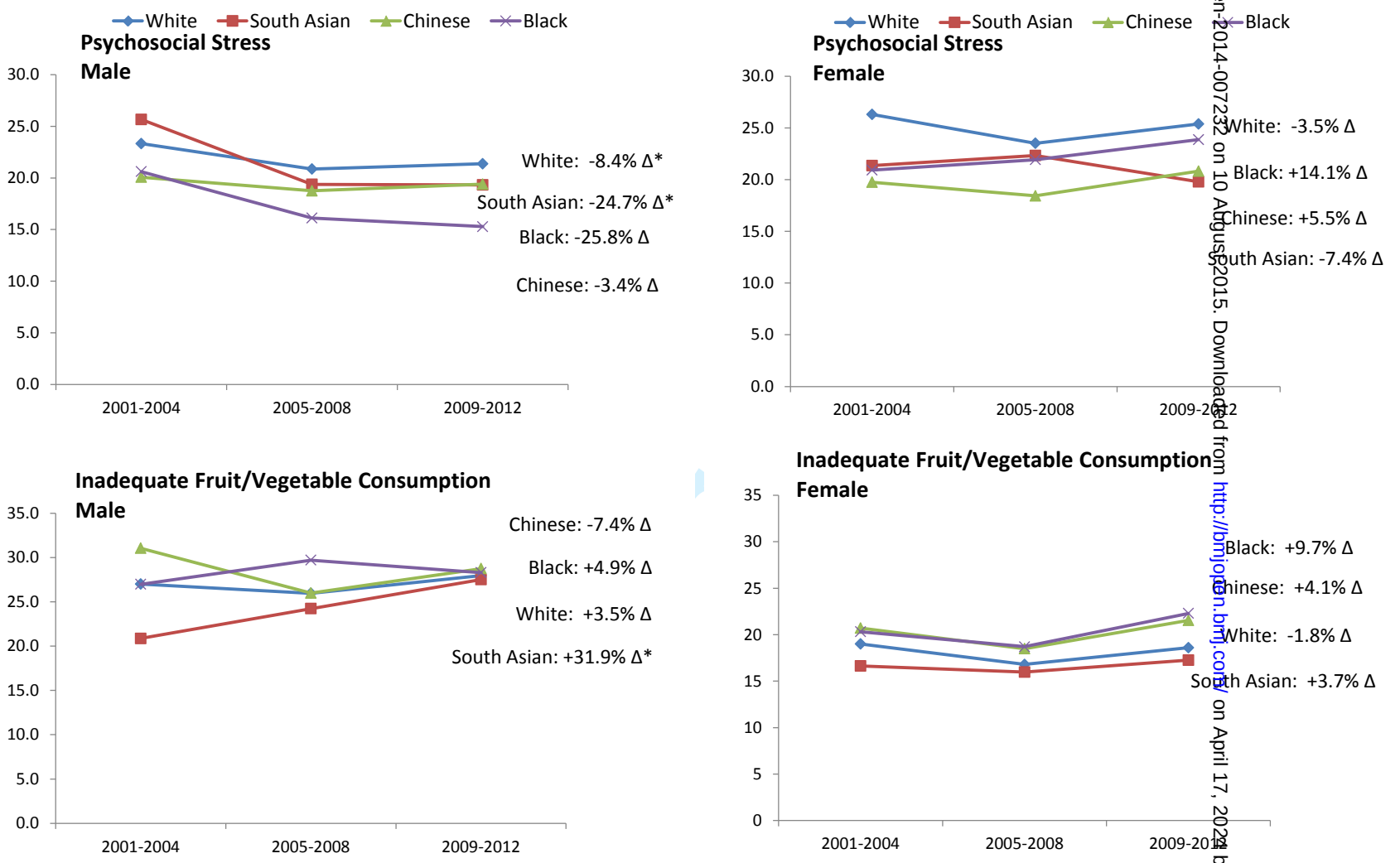
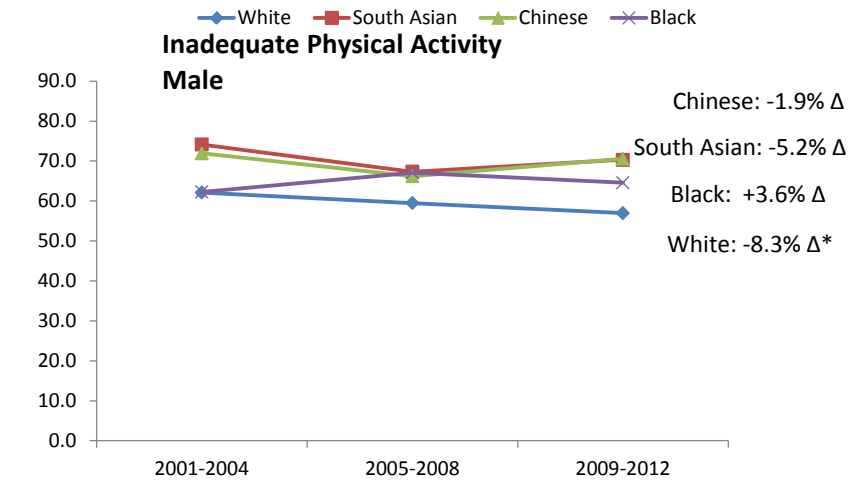
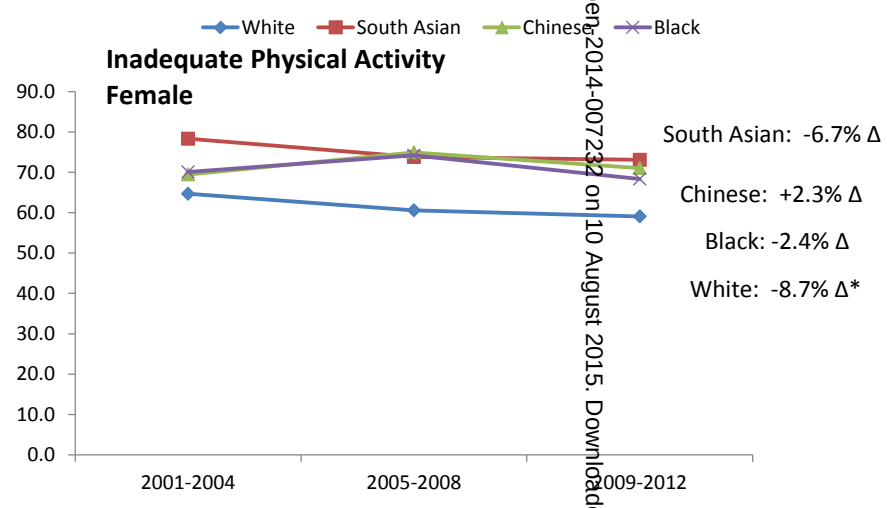
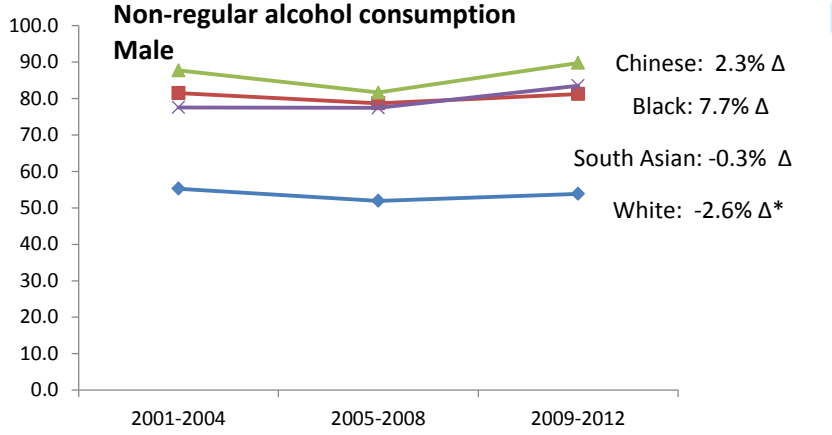


Figure 3: Temporal trends in the prevalence (%) of other cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*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).







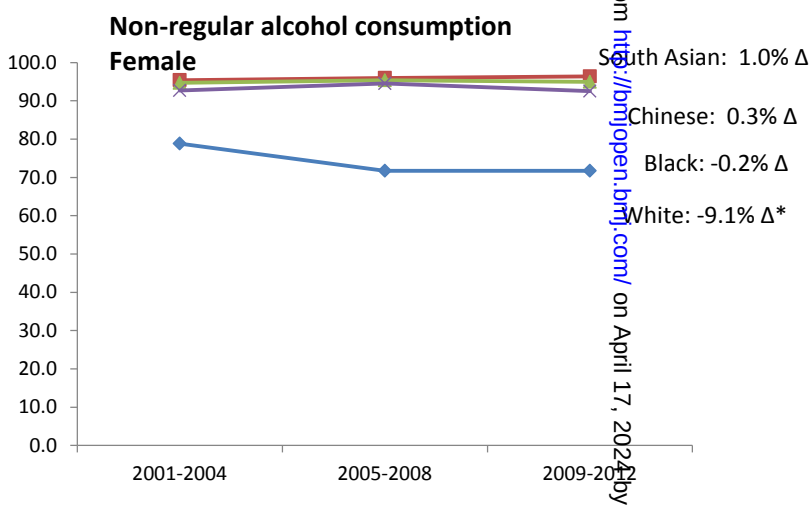


Figure 3 cont'd: Temporal trends in the prevalence (%) of other cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)] *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).

Males	White	South Asian	Chinese	Black
Current smoking	+1			
Diabetes	-1	-1		
Hypertension	-1			
Weight-related risk factor	-1	-1	-1	
Inadequate physical activity	+1			
Inadequate fruit and vegetable consumption		-1		
Non-moderate alcohol consumption	+1			
Psychosocial stress	+1	+1		
Summary Score†	**+1**	**-2**	**-1**	**0**

Females	White	South Asian	Chinese	Black
Current smoking	+1			
Diabetes	-1			-1
Hypertension	-1			
Weight-related risk factor	-1			
Inadequate physical activity	+1			
Inadequate fruit and vegetable consumption				
Non-moderate alcohol consumption	+1			
Psychosocial stress				
Summary Score†	**0**	**0**	**0**	**-1**

Figure 4: Summary of trends in 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. Green (+1) indicates an improving trend significant at p<0.05 based comparing the estimates for 2009-2012 to estimates for 2001-2004. Red (-1) indicates a significant worsening trend (p<0.05). White indicates no significant trends were found.
†The summary score was the difference between the number of risk factors for which there was a significant improvement in the prevalence over the study period and the number of risk factors for which there was a significant worsening over the study period. Positive scores represent favourable and negative scores represent unfavourable changes in cardiovascular risk profiles. Definitions: Weight-related risk factor (i.e. mean BMI, overweight, or obesity), inadequate physical activity, inadequate fruit and vegetable consumption, non-regular alcohol consumption, and psychosocial stress.

Supplementary Table 1. Temporal trends in major cardiovascular risk factors, by ethnicity, Ontario, Canada (2001-2012)

	White				South Asian				Chinese				Black			
	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*
Current smoking																
Male+Female	25.4	22.7	21.2	*-16.8§*	9.4	8.5	7.5	*-20.4*	9.5	9.4	9.4	*-1.3*	11.8	10.3	11.6	*-1.4*
Male	27.7	24.7	24.0	*-13.2§*	14.2	14.3	12.7	*-11.0*	15.6	16.3	16.7	*6.8*	16.7	13.9	15.5	*-7.2*
Female	23.3	20.7	18.4	*-21.0§*	4.8	3.0	2.5	*-47.6*	3.6	2.9	2.4	*-35.1*	7.1	6.9	7.9	*11.6*
Diabetes																
Male+Female	4.2	4.7	5.5	*30.4§*	7.9	10.2	11.6	*46.6‡*	4.7	3.6	4.7	*-0.01*	7.0	9.2	11.1	*58.0*
Male	4.5	5.2	6.1	*33.7§*	6.7	12.5	15.2	*126.9§*	4.2	4.1	3.9	*-5.3*	7.8	8.3	9.9	*27.6*
Female	3.9	4.3	4.9	*26.7§*	9.1	8.0	8.1	*-10.6*	5.3	3.2	5.5	*4.0*	6.3	10.1	12.2	*94.2‡*
Hypertension																
Male+Female	13.8	15.2	15.6	*13.0§*	15.1	18.1	17.3	*14.6*	14.9	14.5	14.1	*-5.7*	18.2	21.3	22.0	*20.7*
Male	13.2	14.5	15.5	*17.7§*	13.5	17.5	16.6	*23.0*	15.5	11.9	15.4	*-0.6*	15.9	18.1	17.2	*8.3*
Female	14.4	15.8	15.7	*8.8§*	16.7	18.6	18.1	*8.1*	14.4	17.0	12.8	*-11.1*	20.4	24.4	26.6	*30.0*
Body mass index (BMI)																
Male+Female	25.4	25.6	25.8	*1.8§*	23.9	24.2	24.5	*2.2‡*	22.2	22.6	22.6	*1.8‡*	25.2	25.9	25.8	*2.2*
Male	26.0	26.2	26.4	*1.5§*	24.2	24.4	25.0	*3.2‡*	22.7	23.4	23.5	*3.2‡*	24.9	25.8	25.5	*2.2*
Female	24.7	25.0	25.2	*2.0§*	23.7	24.0	24.0	*1.3*	21.6	21.7	21.7	*0.4*	25.5	26.1	26.0	*2.1*
Overweight (BMI>=25 kg/m2)																
Male+Female	47.4	48.7	50.3	*6.2§*	35.8	38.4	39.9	*11.2*	18.3	19.9	22.3	*21.6*	46.7	54.7	50.7	*8.5*
Male	55.5	56.8	57.9	*4.3§*	37.7	40.6	45.5	*20.6‡*	22.2	26.7	29.9	*34.5‡*	46.3	54.7	50.0	*7.9*
Female	39.5	40.9	43.0	*8.8§*	34.1	36.3	34.4	*1.1*	14.6	13.3	14.9	*2.6*	47.1	54.7	51.3	*9.0*
Obesity (BMI>=30 kg/m2)																
Male+Female	15.1	16.0	18.1	*20.1§*	7.4	8.9	9.6	*29.5*	2.5	3.1	4.2	*69.9*	13.6	17.2	17.9	*31.3*
Male	16.3	17.2	19.4	*18.6§*	7.5	7.6	9.2	*22.8*	2.8	3.2	5.9	*114.0‡*	9.3	16.0	16.0	*72.0*
Female	13.9	15.0	17.0	*21.7§*	7.4	10.1	10.1	*35.9*	2.2	3.0	2.6	*16.7*	17.8	18.3	19.7	*10.7*

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- and sex-standardized to the 2001 Ontario Census population weighted by the survey sample weight.

†Percent change for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004.

‡ indicates significant at $p<0.05$. § indicates significant at $p<0.001$

Supplementary Table 2. Temporal trends in the prevalence of other cardiovascular risk factors, by ethnicity, Ontario, Canada (2001-2012)

	White				South Asian				Chinese				Black			
	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*
Inadequate physical activity																
Male+Female	63.4	60.0	58.0	*-8.5§*	76.3	70.6	71.7	*-6.0‡*	70.7	70.7	70.8	*0.2*	66.2	70.7	66.5	*0.4*
Male	62.1	59.5	57.0	*-8.3§*	74.2	67.3	70.3	*-5.2*	71.9	66.2	70.6	*-1.9*	62.3	67.1	64.6	*3.6*
Female	64.7	60.6	59.1	*-8.7§*	78.3	73.8	73.1	*-6.7*	69.5	75.0	71.0	*2.3*	70.1	74.2	68.4	*-2.4*
Inadequate fruit/vegetable consumption																
Male+Female	22.9	21.3	23.2	*1.3*	18.7	20.0	22.3	*19.2*	25.8	22.2	25.1	*-2.7*	23.6	24.1	25.2	*7.0*
Male	27.0	26.0	27.9	*3.5*	20.9	24.2	27.5	*31.9‡*	31.0	26.0	28.7	*-7.4*	27.0	29.7	28.3	*4.9*
Female	19.0	16.8	18.6	*-1.8*	16.6	16.0	17.3	*3.7*	20.7	18.5	21.6	*4.1*	20.3	18.7	22.3	*9.7*
Non-regular alcohol consumption																
Male+Female	65.2	62.0	62.9	*-3.5§*	88.6	87.5	88.9	*0.4*	91.3	88.6	92.4	*1.2*	85.3	86.1	88.1	*3.3*
Male	55.3	51.9	53.8	*-2.6‡*	81.5	78.7	81.2	*-0.3*	87.7	81.6	89.8	*2.3*	77.6	77.4	83.5	*7.7*
Female	78.8	71.7	71.7	*-9.1§*	95.4	96.0	96.4	*1.0*	94.7	95.4	95.0	*0.3*	92.7	94.5	92.5	*-0.2*
Psychosocial stress																
Male+Female	24.8	22.2	23.4	*-5.7‡*	23.5	20.9	19.6	*-16.7*	19.9	18.6	20.1	*1.1*	20.8	19.1	19.7	*-5.4*
Male	23.3	20.9	21.4	*-8.4§*	25.7	19.4	19.3	*-24.7‡*	20.1	18.8	19.4	*-3.4*	20.6	16.1	15.3	*-25.8*
Female	26.3	23.5	25.4	*-3.5*	21.4	22.3	19.8	*-7.4*	19.7	18.4	20.8	*5.5*	20.9	21.9	23.9	*14.1*

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- and sex-standardized to the 2001 Ontario Census population weighted by the survey sample weight.

†Percent change for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004.

‡ indicates significant at p<0.05; § indicates significant at p<0.001. 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).

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	11-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-12
		(*b*) Report category boundaries when continuous variables were categorized	6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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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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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-standardized ethnic-sex-specific prevalence of cardiovascular risk factors for three time periods: 2001 to 2004, 2005 to 2008 and 2009 to 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/m^2) 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 per cent 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 multi-ethnic populations.

Article Summary

Article Focus

- To examine temporal trends in the prevalence of cardiovascular risk factors across white, South Asian, Chinese and black ethnic groups living in Ontario, Canada (2001-2012)

Key Messages

- The prevalence rates of cardiovascular risk factors are changing differently over time for different ethnic groups.
- The prevalence of diabetes doubled in the past decade among South Asian males and black females
- The prevalence of hypertension increased the most among black females
- Smoking prevalence declined by more than 20 per cent among South Asian, Chinese and white females
- The prevalence of obesity increased in all ethnic-sex groups, with the largest relative increase observed among Chinese males

Strengths and limitations of the 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

INTRODUCTION

Cardiovascular disease risk factors, such as tobacco use, high blood pressure, obesity, and 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 both developing and developed regions of the world due in part to increasing urbanization 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 United States (US) [7] and the United Kingdom (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 among white, South Asian, Chinese, and black Ontario residents.[12] Evidence suggests that South Asians generally have a higher prevalence of diabetes and hypertension [12,13] [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 US.[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 & 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 analyzed Ontario residents who identified their racial-cultural group as white, Chinese, South Asian (i.e. those of Indian, Pakistani, Bangladeshi, or Sri-Lankan origin), or black (i.e. 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 analyzed a total of 8 cardiovascular risk factors, including 4 major risk factors (i.e., current smoking, diabetes, hypertension, and weight-related risk factor (i.e., mean body-mass index (BMI), overweight/obesity (BMI≥25 kg/m^2) and obesity (BMI≥30 kg/m^2)); and 4 other risk factors (i.e., inadequate physical activity, inadequate fruit and vegetable consumption, non-regular alcohol consumption, and psychosocial stress). Inadequate physical activity was defined as participating in ≤15 minutes of daily physical activity (e.g. walking for exercise, jogging, swimming, bicycling, etc.); inadequate fruit and vegetable intake was defined as eating fruits or vegetables fewer than 3 times a day[21]; psychosocial stress was defined as an individual feeling

"extremely" or "quite a bit" vs. "not at all", "not very" or "a bit" stressed in most days. Non-regular alcohol consumption was defined as consuming fewer than 3 drinks per week.[22] Diabetes and hypertension were self-reported physician-diagnosed and included both treated and untreated conditions.

Statistical Analyses

We calculated the age- and sex-standardized prevalence of sociodemographic characteristics and the age-standardized sex-specific prevalence of cardiovascular risk factors for each of the three time periods across the four ethnic groups. We used direct standardization 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 generalizability of the estimates. Percent changes in the prevalence of risk factors between the 2009-2012 and 2001-2004 periods were calculated and bootstrap methods were used for variance estimation.[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 analyzed 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 2001-2012.

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. However, during the most recent time period (2009-2012), the nonwhite ethnic groups reported on average $10,866 to $27,959 lower household income than the white group. The proportion of individuals who were single, never-married increased significantly over time in white, South Asian and black ethnic groups.

Table 1 Age- and sex-standardized 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	69416	66876	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
Married or common law	58.7	57.2	64.3	66.6	59.4	60.1	47.5	40.2
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

Table 1 (Cont'd) Age- and sex-standardized 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
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 $)	73858	90337	62600	74414	60339	79471	49515	62378
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- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. The age and sex distributions appear almost identical due to age- and sex-standardization Definitions--n/a: not applicable.
; prevalence estimates up to five decimal places were used in the calculation of percent changes

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 2.3-fold (p=0.0001) among South Asian males and 1.9-fold among black females (p=0.02) (Supplementary Table 1). 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 per cent among South Asian, Chinese and white females. Among white males and females, the prevalence of diabetes, hypertension, overweight/obesity increased, while smoking prevalence improved. (Supplementary Table 1 and 2)

The percentage of people reporting at most 15 minutes of daily leisure physical activity declined 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 3 times per day (20.9% in 2001-2004 vs. 27.5% in 2009-2012, p=0.02) (Supplementary Table 2), 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 decline 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 summarizes the trends in the major cardiovascular disease risk factors among males and females of the different ethnic groups. Trends for which the percent change was more than 20 per cent are shown—overall, the prevalence of cardiovascular disease risk factors appeared to be worsening the most in South Asian males (i.e. large increases in diabetes, hypertension and overweight/obesity prevalence), black males (i.e. large increases in diabetes and obesity prevalence) and black females (i.e. 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 multi-ethnic jurisdictions. In the UK, Bhopal et al. 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.[17]

In the US, 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 11.0% 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 in Chinese males. We reported significant increases in mean BMI among Chinese and South Asian males; both groups showing an absolute 0.8 kg/m^2 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 to 0.5 kg/m^2 among East Asians and an increase of 0.4 kg/m^2 among South Asian females.[4] An analysis of NHANES data from 1988 to 2004 [19] 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 this trend is occurring in some ethnic-sex groups but not all. Consistent with our findings, previous studies in the UK have shown significant declines in smoking prevalence among Indian and Irish white populations.[17] Smoking rates among Chinese and

South Asian people living in Canada are generally lower than rates found in men in China (52.9%) [27] and men in India (33.7%).[28] However, it is disconcerting that smoking rates appear to be increasing, albeit non-significantly, among Chinese males in Ontario. Further analysis is needed to understand these trends, particularly among Chinese youth 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.[29]

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 cost and greater availability in Canada.[30] Similarly, Chinese populations have been found to decrease their consumption of traditional foods and increase consumption of fats, sweets and meats upon immigration.[31] In this study, we also found significantly lower mean household income among nonwhite ethnic groups 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.[32] Studies in the US 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. [19,33] 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 policy makers 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.[34] When we

consider that the metabolic impact of excess weight is particularly pronounced for Chinese, black and South Asian groups[35,36], 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 result in misclassification. Also, body-mass index 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 body-mass index, irrespective of ethnicity.[35] 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 analyze other risk factors for cardiovascular diseases (e.g. 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 (i.e. the tendency for immigrants' cardiovascular health to decline with longer duration of residence in western cultures).[37] 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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Conflicts of Interest Disclosure:

The authors have no conflicts of interest to disclose.

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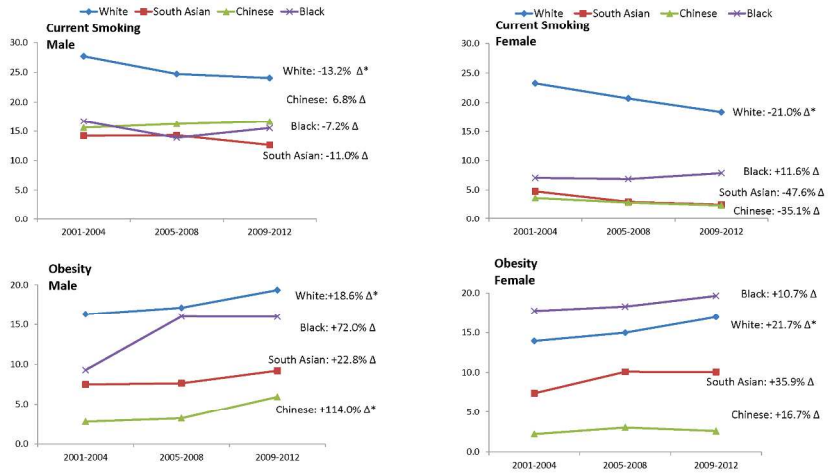

Figure 1: Temporal trends in the prevalence (%) of major cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004. Definition: Obesity, body-mass index ≥ 30 kg/m2. * p <0.05

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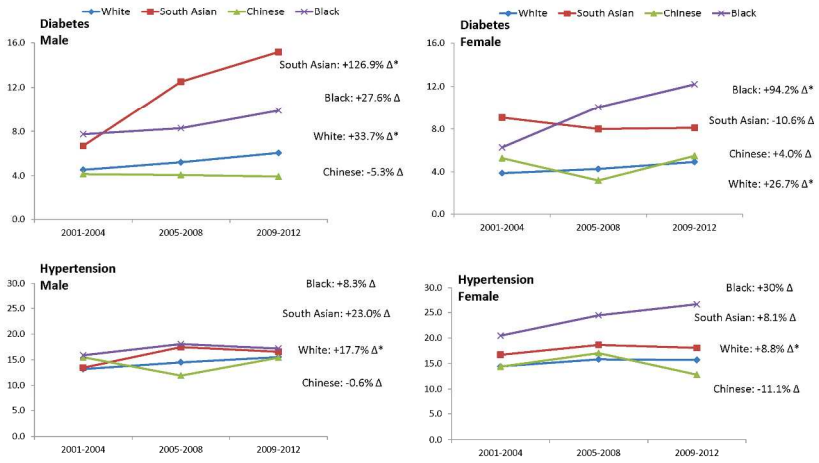

Figure 1 cont'd: Temporal trends in the prevalence (%) of major cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004. Definition: Obesity, body-mass index ≥ 30 kg/m2. * p <0.05

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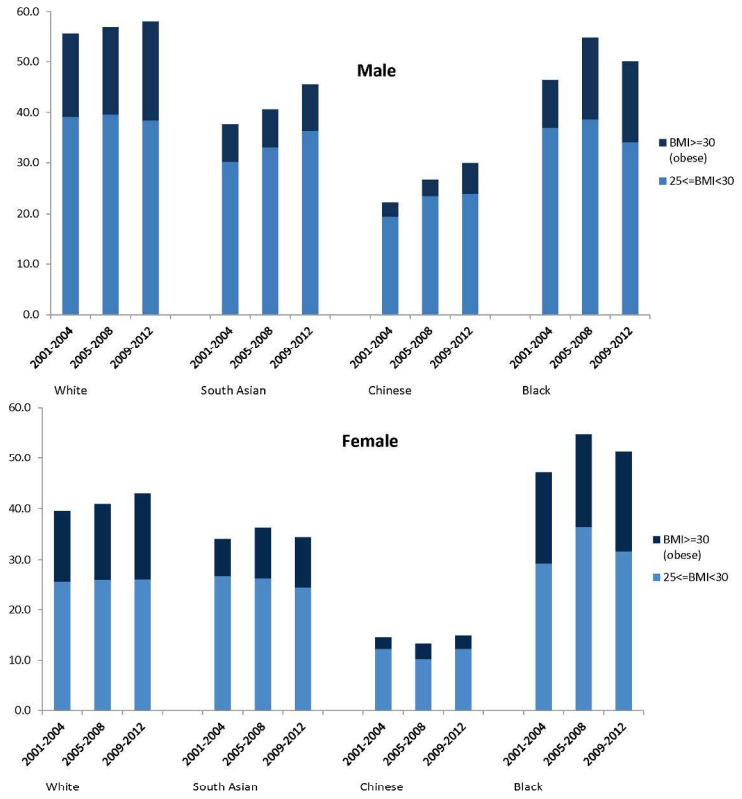

Figure 2: Temporal trends in age- and sex-standardized prevalence of overweight/obesity, by ethnicity and sex. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population using 5-year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

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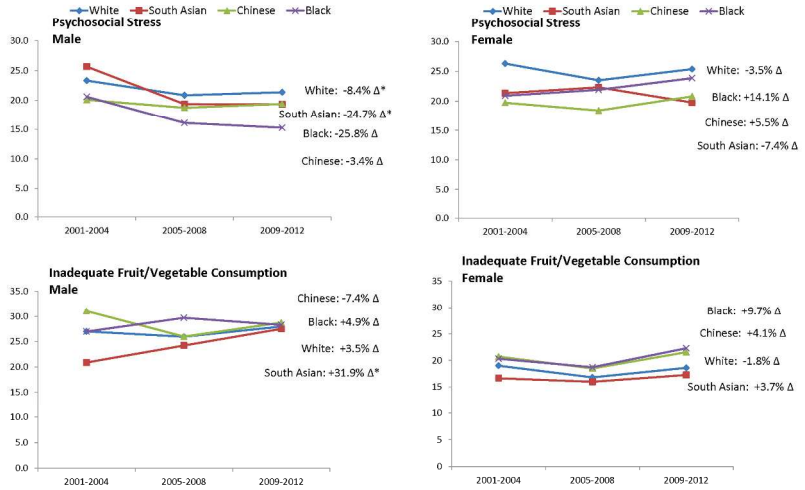

Figure 3: Temporal trends in the prevalence (%) of other cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*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).

279x215mm (300 x 300 DPI)

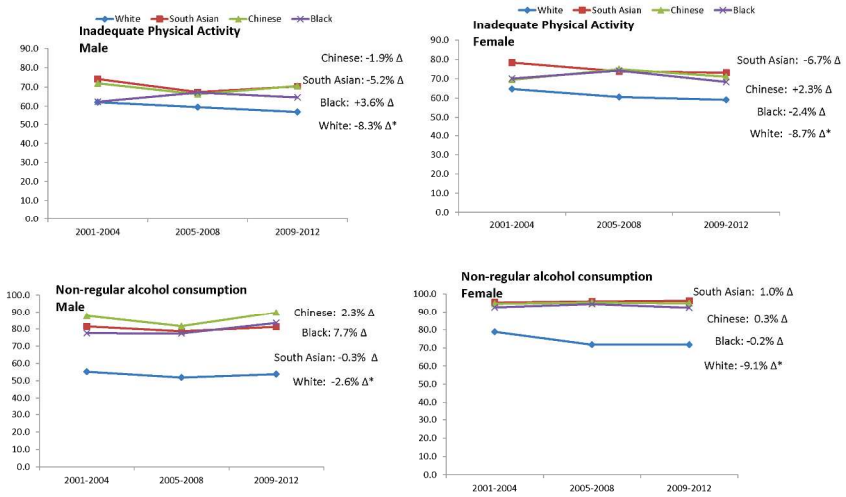

Figure 3 cont'd: Temporal trends in the prevalence (%) of other cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*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).

279x215mm (300 x 300 DPI)

Males	White	South Asian	Chinese	Black
Current smoking				
Diabetes	↑*	↑*		↑
Hypertension		↑		
Weight-related factor		↑*	↑*	↑

Females	White	South Asian	Chinese	Black
Current smoking	↓*	↓	↓	
Diabetes	↑*			↑*
Hypertension				↑
Weight-related factor	↑*	↑		

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 ↑↓ indicate ≥20% increases or decreases in major cardiovascular risk factor prevalences comparing the estimates for 2009-2012 to estimates for 2001-2004. *P<0.05.
Definitions: Weight-related risk factor (i.e. mean BMI, overweight/obesity, or obesity). Changes in weight related- factors were indicated if any of the three factors showed a ≥20% change.

215x279mm (300 x 300 DPI)

Supplementary Table 1. Temporal trends in major cardiovascular risk factors, by ethnicity, Ontario, Canada (2001-2012)

	White				South Asian				Chinese				Black			
	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*
Current smoking																
Male+Female	25.4	22.7	21.2	*-16.8§*	9.4	8.5	7.5	*-20.4*	9.5	9.4	9.4	*-1.3*	11.8	10.3	11.6	*-1.4*
Male	27.7	24.7	24.0	*-13.2§*	14.2	14.3	12.7	*-11.0*	15.6	16.3	16.7	*6.8*	16.7	13.9	15.5	*-7.2*
Female	23.3	20.7	18.4	*-21.0§*	4.8	3.0	2.5	*-47.6*	3.6	2.9	2.4	*-35.1*	7.1	6.9	7.9	*11.6*
Diabetes																
Male+Female	4.2	4.7	5.5	*30.4§*	7.9	10.2	11.6	*46.6‡*	4.7	3.6	4.7	*-0.01*	7.0	9.2	11.1	*58.0*
Male	4.5	5.2	6.1	*33.7§*	6.7	12.5	15.2	*126.9§*	4.2	4.1	3.9	*-5.3*	7.8	8.3	9.9	*27.6*
Female	3.9	4.3	4.9	*26.7§*	9.1	8.0	8.1	*-10.6*	5.3	3.2	5.5	*4.0*	6.3	10.1	12.2	*94.2‡*
Hypertension																
Male+Female	13.8	15.2	15.6	*13.0§*	15.1	18.1	17.3	*14.6*	14.9	14.5	14.1	*-5.7*	18.2	21.3	22.0	*20.7*
Male	13.2	14.5	15.5	*17.7§*	13.5	17.5	16.6	*23.0*	15.5	11.9	15.4	*-0.6*	15.9	18.1	17.2	*8.3*
Female	14.4	15.8	15.7	*8.8§*	16.7	18.6	18.1	*8.1*	14.4	17.0	12.8	*-11.1*	20.4	24.4	26.6	*30.0*
Body mass index (BMI)																
Male+Female	25.4	25.6	25.8	*1.8§*	23.9	24.2	24.5	*2.2‡*	22.2	22.6	22.6	*1.8‡*	25.2	25.9	25.8	*2.2*
Male	26.0	26.2	26.4	*1.5§*	24.2	24.4	25.0	*3.2‡*	22.7	23.4	23.5	*3.2‡*	24.9	25.8	25.5	*2.2*
Female	24.7	25.0	25.2	*2.0§*	23.7	24.0	24.0	*1.3*	21.6	21.7	21.7	*0.4*	25.5	26.1	26.0	*2.1*
Overweight/obesity (BMI>=25 kg/m2)																
Male+Female	47.4	48.7	50.3	*6.2§*	35.8	38.4	39.9	*11.2*	18.3	19.9	22.3	*21.6*	46.7	54.7	50.7	*8.5*
Male	55.5	56.8	57.9	*4.3§*	37.7	40.6	45.5	*20.6‡*	22.2	26.7	29.9	*34.5‡*	46.3	54.7	50.0	*7.9*
Female	39.5	40.9	43.0	*8.8§*	34.1	36.3	34.4	*1.1*	14.6	13.3	14.9	*2.6*	47.1	54.7	51.3	*9.0*
Obesity (BMI>=30 kg/m2)																
Male+Female	15.1	16.0	18.1	*20.1§*	7.4	8.9	9.6	*29.5*	2.5	3.1	4.2	*69.9*	13.6	17.2	17.9	*31.3*
Male	16.3	17.2	19.4	*18.6§*	7.5	7.6	9.2	*22.8*	2.8	3.2	5.9	*114.0‡*	9.3	16.0	16.0	*72.0*
Female	13.9	15.0	17.0	*21.7§*	7.4	10.1	10.1	*35.9*	2.2	3.0	2.6	*16.7*	17.8	18.3	19.7	*10.7*

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- and sex-standardized to the 2001 Ontario Census population weighted by the survey sample weight.

†Percent change for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100; Prevalence estimates up to five decimal places were used in the calculation of percent changes. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004.

‡ indicates significant at p<0.05. § indicates significant at p<0.001

Supplementary Table 2. Temporal trends in the prevalence of other cardiovascular risk factors, by ethnicity, Ontario, Canada (2001-2012)

	White				South Asian				Chinese				Black			
	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*	2001-2004	2005-2008	2009-2012	*Relative % change†*
Inadequate physical activity																
Male+Female	63.4	60.0	58.0	*-8.5§*	76.3	70.6	71.7	*-6.0‡*	70.7	70.7	70.8	*0.2*	66.2	70.7	66.5	*0.4*
Male	62.1	59.5	57.0	*-8.3§*	74.2	67.3	70.3	*-5.2*	71.9	66.2	70.6	*-1.9*	62.3	67.1	64.6	*3.6*
Female	64.7	60.6	59.1	*-8.7§*	78.3	73.8	73.1	*-6.7*	69.5	75.0	71.0	*2.3*	70.1	74.2	68.4	*-2.4*
Inadequate fruit/vegetable consumption																
Male+Female	22.9	21.3	23.2	*1.3*	18.7	20.0	22.3	*19.2*	25.8	22.2	25.1	*-2.7*	23.6	24.1	25.2	*7.0*
Male	27.0	26.0	27.9	*3.5*	20.9	24.2	27.5	*31.9‡*	31.0	26.0	28.7	*-7.4*	27.0	29.7	28.3	*4.9*
Female	19.0	16.8	18.6	*-1.8*	16.6	16.0	17.3	*3.7*	20.7	18.5	21.6	*4.1*	20.3	18.7	22.3	*9.7*
Non-regular alcohol consumption																
Male+Female	65.2	62.0	62.9	*-3.5§*	88.6	87.5	88.9	*0.4*	91.3	88.6	92.4	*1.2*	85.3	86.1	88.1	*3.3*
Male	55.3	51.9	53.8	*-2.6‡*	81.5	78.7	81.2	*-0.3*	87.7	81.6	89.8	*2.3*	77.6	77.4	83.5	*7.7*
Female	78.8	71.7	71.7	*-9.1§*	95.4	96.0	96.4	*1.0*	94.7	95.4	95.0	*0.3*	92.7	94.5	92.5	*-0.2*
Psychosocial stress																
Male+Female	24.8	22.2	23.4	*-5.7‡*	23.5	20.9	19.6	*-16.7*	19.9	18.6	20.1	*1.1*	20.8	19.1	19.7	*-5.4*
Male	23.3	20.9	21.4	*-8.4§*	25.7	19.4	19.3	*-24.7‡*	20.1	18.8	19.4	*-3.4*	20.6	16.1	15.3	*-25.8*
Female	26.3	23.5	25.4	*-3.5*	21.4	22.3	19.8	*-7.4*	19.7	18.4	20.8	*5.5*	20.9	21.9	23.9	*14.1*

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- and sex-standardized to the 2001 Ontario Census population weighted by the survey sample weight.
†Percent change for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100;
Prevalence estimates up to five decimal places were used in the calculation of percent changes. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004.

‡ indicates significant at p<0.05; § indicates significant at p<0.001. 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).

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	N/A

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	11-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-12
		(*b*) Report category boundaries when continuous variables were categorized	6-7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16-17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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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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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No. of main tables/figures: 5
No. of Supplementary Tables: 2

Key words: ethnic groups, trends, risk factors, cardiovascular diseases

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-standardized ethnic-sex-specific prevalence of cardiovascular risk factors for three time periods: 2001 to 2004, 2005 to 2008 and 2009 to 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/m^2) 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 per cent 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 multi-ethnic populations.

Article Summary

Article Focus

- To examine temporal trends in the prevalence of cardiovascular risk factors across white, South Asian, Chinese and black ethnic groups living in Ontario, Canada (2001-2012)

Key Messages

- The prevalence rates of cardiovascular risk factors are changing differently over time for different ethnic groups
- The prevalence of diabetes doubled in the past decade among South Asian males and black females
- The prevalence of hypertension increased the most among black females
- Smoking prevalence declined by more than 20 per cent among South Asian, Chinese and white females
- The prevalence of obesity increased in all ethnic-sex groups, with the largest relative increase observed among Chinese males

Strengths and limitations of the 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

INTRODUCTION

Cardiovascular disease risk factors, such as tobacco use, high blood pressure, obesity, and 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 both developing and developed regions of the world due in part to increasing urbanization 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 United States (US) [7] and the United Kingdom (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 among white, South Asian, Chinese, and black Ontario residents.[12] Evidence suggests that South Asians generally have a higher prevalence of diabetes and hypertension [12,13] [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 US.[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 & 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 analyzed Ontario residents who identified their racial-cultural group as white, Chinese, South Asian (i.e. those of Indian, Pakistani, Bangladeshi, or Sri-Lankan origin), or black (i.e. 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 analyzed a total of 8 cardiovascular risk factors, including 4 major risk factors (i.e., diabetes, obesity (body-mass index, BMI≥30 kg/m^2), current smoking, and hypertension); and 4 other risk factors (i.e., 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 minutes of daily leisure physical activity (e.g. walking for exercise, jogging, swimming, bicycling, etc.); inadequate fruit and vegetable intake was defined as eating fruits or vegetables fewer than 3 times a day[21]; psychosocial stress was defined as an individual feeling “extremely” or “quite a bit” vs. “not at all”, “not very”

or "a bit" stressed in most days. Non-regular alcohol consumption was defined as consuming fewer than 3 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 (BMI ≥25kg/ m^2) by ethnic group.

Statistical Analyses

We calculated the age- and sex-standardized prevalence of sociodemographic characteristics and the age-standardized sex-specific prevalence of cardiovascular risk factors for each of the three time periods across the four ethnic groups. We used direct standardization 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 generalizability of the estimates. Percent changes in the prevalence of risk factors between the 2009-2012 and 2001-2004 periods were calculated. 95% confidence intervals 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 analyzed 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 2001-2012.

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 nonwhite ethnic groups reported on average $10,866 to $27,959 lower household income than the white group.

Table 1 Age- and sex-standardized 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	69416	66876	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
Married or common law	58.7	57.2	64.3	66.6	59.4	60.1	47.5	40.2
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

Table 1 (Cont'd) Age- and sex-standardized 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
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 $)	73858	90337	62600	74414	60339	79471	49515	62378
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- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. The age and sex distributions appear almost identical due to age- and sex-standardization

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 (Supplementary Table 1). 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 per cent among South Asian, Chinese and white females. Among white males and females, the prevalence of diabetes, hypertension, overweight/obesity increased, while smoking prevalence improved. (Supplementary Table 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 3 times per day (20.9% in 2001-2004 vs. 27.5% in 2009-2012, p=0.02) (Supplementary Table 2), 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 decline 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 summarizes the trends in the major cardiovascular disease risk factors among males and females of the different ethnic groups. Trends for which the percent change was more than 20 per cent are shown—overall, the prevalence of cardiovascular disease risk factors appeared to be worsening the most in South Asian males (i.e. large increases in diabetes, hypertension and overweight/obesity prevalence), black males (i.e. large increases in diabetes and obesity prevalence) and black females (i.e. 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 multi-ethnic jurisdictions. In the UK, Bhopal et al. 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.[17]

In the US, 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 11.0% 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/m^2 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 to 0.5 kg/m^2 among East Asians and an increase of 0.4 kg/m^2 among South Asian females.[4] An analysis of NHANES data from 1988 to 2004 [19] 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 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 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 upon immigration.[29] In this study, we also found significantly lower mean household income among nonwhite ethnic groups 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 US 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 policy makers 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, body-mass index 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 body-mass index, 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 analyze other risk factors for cardiovascular diseases (e.g. 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 (i.e. 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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Author Contributions: M.C. was the Principal Investigator, conceived the study, performed the analyses, and wrote the first draft of the paper. M.C., L.C.M., B.R.S., and J.V.T. interpreted the data, critically revised the manuscript for important intellectual content, and approved the final version of the manuscript. J.V.T. obtained funding for the study. Administrative, technical, and logistic support was provided by all authors.

Conflicts of Interest Disclosure:

The authors have no conflicts of interest to disclose.

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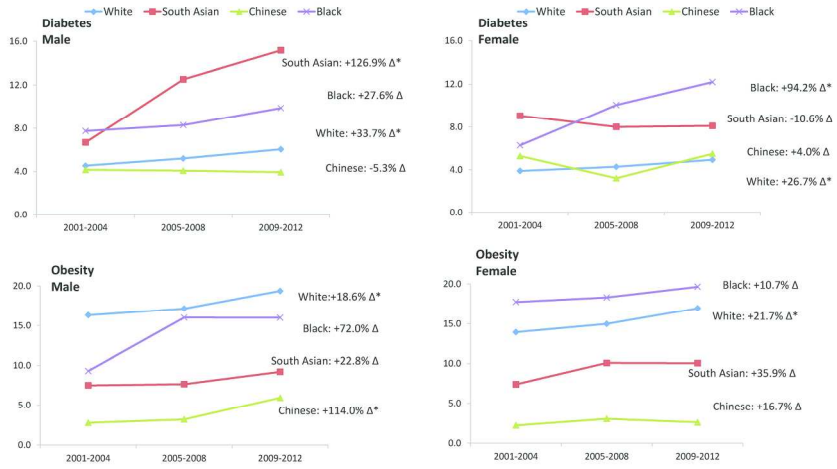

Figure 1: Temporal trends in the prevalence (%) of major cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004. Definition: Obesity, body-mass index ≥ 30 kg/m2. * p <0.05

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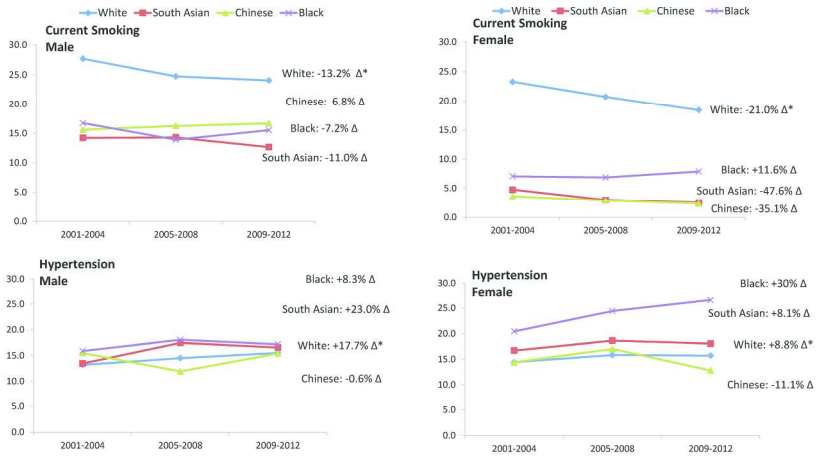

Figure 1 cont'd: Temporal trends in the prevalence (%) of major cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004. Definition: Obesity, body-mass index ≥ 30 kg/m2. * p <0.05

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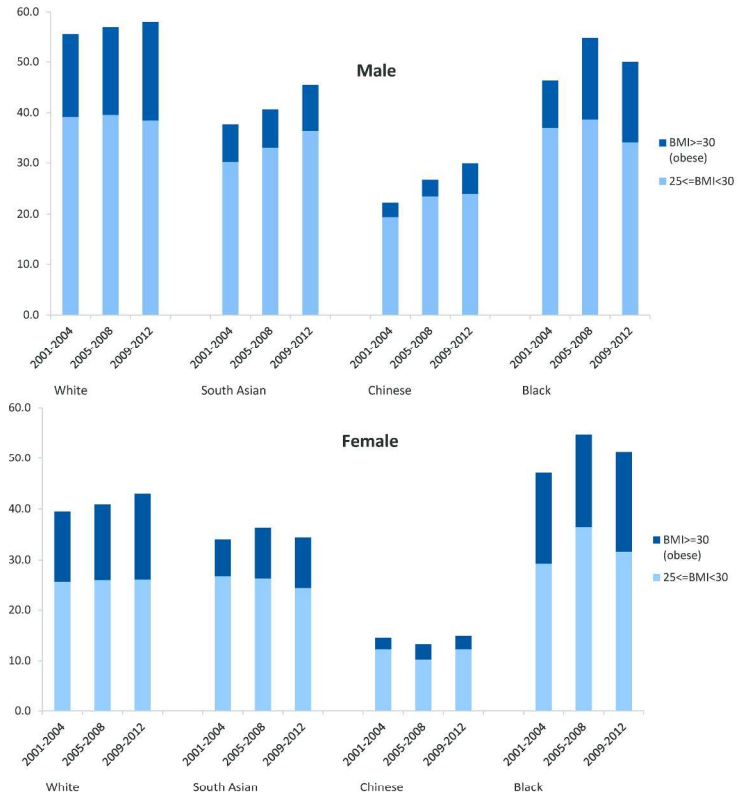

Figure 2: Temporal trends in age- and sex-standardized prevalence of overweight/obesity, by ethnicity and sex. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population using 5-year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

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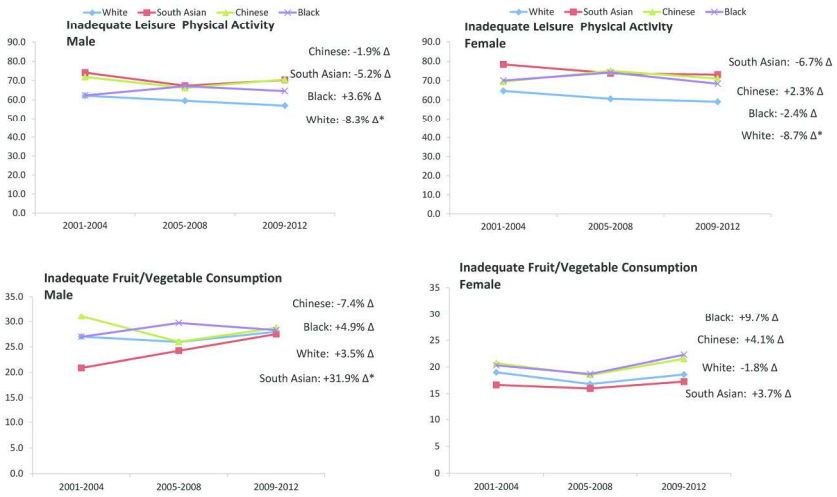

Figure 3: Temporal trends in the prevalence (%) of other cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*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).

215x166mm (300 x 300 DPI)

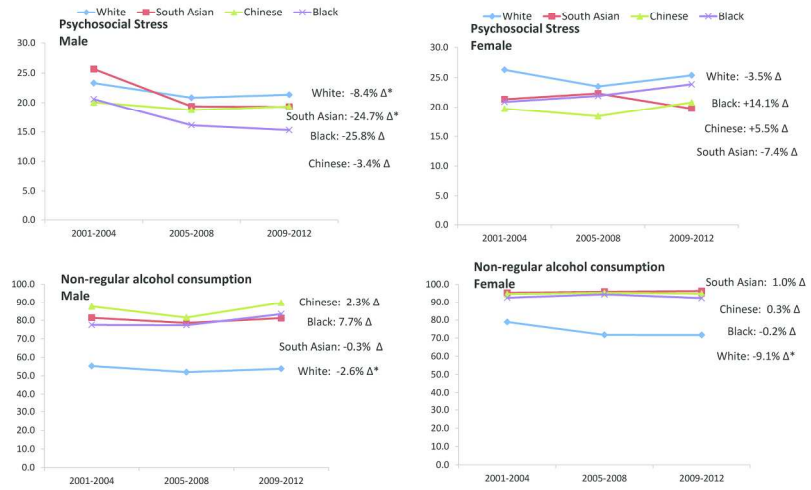

Figure 3 cont'd: Temporal trends in the prevalence (%) of other cardiovascular risk factors, by ethnicity. Data were derived from the Ontario components of Statistics Canada's Canadian Community Health Surveys. Estimates were age- and sex-standardized to the 2001 Ontario Census population and weighted by the survey sample weight. Percent changes Δ are reported for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*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).

215x166mm (300 x 300 DPI)

Males	White	South Asian	Chinese	Black
Diabetes	↑*	↑*		↑
Obesity		↑	↑*	↑
Current smoking				
Hypertension		↑		

Females	White	South Asian	Chinese	Black
Diabetes	↑*			↑*
Obesity	↑*	↑		
Current smoking	↓*	↓	↓	
Hypertension				↑

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 ↑↓ indicate ≥20% increases or decreases in major cardiovascular risk factor prevalences comparing the estimates for 2009-2012 to estimates for 2001-2004. *P<0.05.

279x361mm (300 x 300 DPI)

Supplementary Table 1. Temporal trends in major cardiovascular risk factors, by ethnicity, Ontario, Canada (2001-2012)

	White			South Asian			Chinese			Black		
	2001-2004, % (95% CI)	2009-2012, % (95% CI)	*Relative % change†*	2001-2004, % (95% CI)	2009-2012, % (95% CI)	*Relative % change†*	2001-2004, % (95% CI)	2009-2012, % (95% CI)	*Relative % change†*	2001-2004, % (95% CI)	2009-2012, % (95% CI)	*Relative % change†*
Diabetes												
Male+Female	4.2 (4.0 to 4.4)	5.5 (5.2 to 5.8)	*30.4§*	7.9 (6.0 to 10.0)	11.6 (9.4 to 13.3)	*46.6‡*	4.7 (3.3 to 6.4)	4.7 (3.6 to 6.3)	*-0.01*	7.0 (4.5 to 9.5)	11.1 (8.0 to 13.7)	*58.0*
Male	4.5 (4.3 to 4.8)	6.1 (5.7 to 6.5)	*33.7§*	6.7 (4.4 to 9.2)	15.2 (11.7 to 18.0)	*126.9§*	4.2 (2.1 to 6.5)	3.9 (2.2 to 5.9)	*-5.3*	7.8 (3.7 to 12.6)	9.9 (6.3 to 14.2)	*27.6*
Female	3.9 (3.7 to 4.2)	4.9 (4.6 to 5.3)	*26.7§*	9.1 (6.1 to 12.4)	8.1 (5.9 to 10.3)	*-10.6*	5.3 (3.1 to 8.0)	5.5 (3.8 to 7.9)	*4.0*	6.3 (3.8 to 9.5)	12.2 (8.0 to 15.8)	*94.2‡*
Obesity (BMI≥30 kg/m^2)												
Male+Female	15.1 (14.7 to 15.5)	18.1 (17.6, 18.7)	*20.1§*	7.4 (5.5, 9.4)	9.6 (7.6 to 11.8)	*29.5*	2.5 (1.5 to 3.4)	4.2 (2.6 to 5.8)	*69.9*	13.6 (10.7 to 16.7)	17.9 (14.6 to 21.8)	*31.3*
Male	16.3 (15.8 to 16.9)	19.4 (18.6 to 20.1)	*18.6§*	7.5 (5.1 to 10.0)	9.2 (6.8 to 11.7)	*22.8*	2.8 (1.4 to 4.2)	5.9 (2.9 to 8.4)	*114.0‡*	9.3 (5.8 to 12.9)	16.0 (10.6 to 22.3)	*72.0*
Female	13.9 (13.4 to 14.4)	17.0 (16.4 to 17.6)	*21.7§*	7.4 (4.9 to 10.4)	10.1 (7.2 to 13.3)	*35.9*	2.2 (0.9 to 3.9)	2.6 (1.1 to 4.2)	*16.7*	17.8 (13.4 to 22.8)	19.7 (15.5 to 23.8)	*10.7*
Overweight/obesity (BMI≥25 kg/m^2)												
Male+Female	47.4 (46.8 to 47.9)	50.3 (49.7 to 51.0)	*6.2§*	35.8 (32.1 to 39.0)	39.9 (36.9 to 42.8)	*11.2*	18.3 (15.5 to 21.2)	22.3 (18.2 to 25.5)	*21.6*	46.7 (43.2 to 50.5)	50.7 (46.8 to 55.1)	*8.5*
Male	55.5 (54.7 to 56.2)	57.9 (56.9 to 58.7)	*4.3§*	37.7 (33.1, 42.0)	45.5 (41.3, 49.3)	*20.6‡*	22.2 (17.9 to 26.1)	29.9 (23.1 to 34.9)	*34.5‡*	46.3 (40.5 to 52.6)	50.0 (43.6 to 56.6)	*7.9*
Female	39.5 (38.7 to 40.3)	43.0 (42.1 to 43.9)	*8.8§*	34.1 (28.8 to 39.4)	34.4 (30.2 to 38.8)	*1.1*	14.6 (10.8 to 18.8)	14.9 (11.3 to 19.4)	*2.6*	47.1 (42.1 to 53.1)	51.3 (45.8 to 56.9)	*9.0*
Body mass index (mean BMI, kg/m^2)												
Male+Female	25.4 (25.3 to 25.4)	25.8 (25.8 to 25.9)	*1.8§*	23.9 (23.4 to 24.2)	24.5 (24.2 to 24.8)	*2.2‡*	22.2 (21.9 to 22.4)	22.6 (22.3 to 22.8)	*1.8‡*	25.2 (24.6 to 25.5)	25.8 (25.4 to 26.2)	*2.2*
Male	26.0 (26.0 to 26.1)	26.4 (26.3 to 26.5)	*1.5§*	24.2 (23.7 to 24.5)	25.0 (24.7 to 25.3)	*3.2‡*	22.7 (22.4 to 23.0)	23.5 (23.0 to 23.8)	*3.2‡*	24.9 (24.0 to 25.3)	25.5 (25.0 to 26.1)	*2.2*
Female	24.7 (24.7 to 24.8)	25.2 (25.2 to 25.3)	*2.0§*	23.7 (22.9 to 24.1)	24.0 (23.4 to 24.4)	*1.3*	21.6 (21.2 to 22.0)	21.7 (21.3 to 22.2)	*0.4*	25.5 (24.9 to 26.0)	26.0 (25.5 to 26.6)	*2.1*
Current smoking												
Male+Female	25.4 (24.9 to 26.0)	21.2 (20.6 to 21.7)	*-16.8§*	9.4 (7.6 to 11.2)	7.5 (6.3 to 9.1)	*-20.4*	9.5 (7.7 to 11.5)	9.4 (7.0 to 11.5)	*-1.3*	11.8 (9.4 to 14.6)	11.6 (9.1 to 14.4)	*-1.4*
Male	27.7 (26.9 to 28.4)	24.0 (23.2 to 24.9)	*-13.2§*	14.2 (11.2 to 17.1)	12.7 (10.2 to 15.5)	*-11.0*	15.6 (12.1 to 19.5)	16.7 (11.9 to 20.8)	*6.8*	16.7 (12.6 to 22.0)	15.5 (11.1 to 19.7)	*-7.2*
Female	23.3 (22.6 to 23.9)	18.4 (17.7 to 19.2)	*-21.0§*	4.8 (2.8 to 7.0)	2.5 (1.5 to 3.8)	*-47.6*	3.6 (2.0 to 5.1)	2.4 (1.2 to 4.0)	*-35.1*	7.1 (5.1 to 9.3)	7.9 (5.2 to 11.3)	*11.6*

Hypertension												
Male+Female	13.8 (13.5, 14.2)	15.6 (15.2, 16.0)	*13.0§*	15.1 (12.5, 17.5)	17.3 (15.2, 19.5)	*14.6*	14.9 (12.1, 17.5)	14.1 (12.3, 16.2)	*-5.7*	18.2 (14.8, 20.9)	22.0 (18.7, 24.8)	*20.7*
Male	13.2 (12.7 to 13.7)	15.5 (14.9 to 16.1)	*17.7§*	13.5 (10.1 to 16.5)	16.6 (13.4 to 19.9)	*23.0*	15.5 (11.4 to 18.5)	15.4 (12.4 to 19.2)	*-0.6*	15.9 (10.6 to 19.5)	17.2 (13.1 to 21.7)	*8.3*
Female	14.4 (14.0 to 14.8)	15.7 (15.3 to 16.3)	*8.8§*	16.7 (12.2 to 20.3)	18.1 (15.2 to 21.3)	*8.1*	14.4 (11.0 to 18.2)	12.8 (10.3 to 15.4)	*-11.1*	20.4 (15.6 to 24.6)	26.6 (21.5 to 30.3)	*30.0*

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- and sex-standardized to the 2001 Ontario Census population weighted by the survey sample weight.

†Percent change for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100; Prevalence estimates up to five decimal places were used in the calculation of percent changes. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004.

‡ indicates significant at $p<0.05$. § indicates significant at $p<0.001$

Supplementary Table 2. Temporal trends in the prevalence of other cardiovascular risk factors, by ethnicity, Ontario, Canada (2001-2012)

	White			South Asian			Chinese			Black		
	2001-2004	2009-2012	*Relative % change†*	2001-2004	2009-2012	*Relative % change†*	2001-2004	2009-2012	*Relative % change†*	2001-2004	2009-2012	*Relative % change†*
Inadequate physical activity												
Male+Female	63.4 (62.8 to 63.9)	58.0 (57.2 to 58.7)	*-8.5§*	76.3 (72.8 to 78.6)	71.7 (68.5 to 74.5)	*-6.0‡*	70.7 (67.8 to 74.0)	70.8 (67.6 to 74.1)	*0.2*	66.2 (61.9 to 69.4)	66.5 (61.8 to 70.1)	*0.4*
Male	62.1 (61.1 to 62.8)	57.0 (55.8 to 57.8)	*-8.3§*	74.2 (69.5 to 78.0)	70.3 (65.8 to 74.1)	*-5.2*	71.9 (67.3 to 76.6)	70.6 (66.2 to 75.0)	*-1.9*	62.3 (55.6 to 67.5)	64.6 (58.1 to 69.8)	*3.6*
Female	64.7 (63.8 to 65.3)	59.1 (58.0 to 59.8)	*-8.7§*	78.3 (73.2 to 81.7)	73.1 (68.7 to 77.4)	*-6.7*	69.5 (65.2 to 74.5)	71.0 (66.8 to 75.9)	*2.3*	70.1 (64.9 to 74.6)	68.4 (62.2 to 72.2)	*-2.4*
Inadequate fruit/vegetable consumption												
Male+Female	22.9 (22.4 to 23.4)	23.2 (22.7 to 23.8)	*1.3*	18.7 (15.8 to 21.2)	22.3 (19.6 to 24.8)	*19.2*	25.8 (22.3 to 28.8)	25.1 (20.7 to 28.8)	*-2.7*	23.6 (20.3 to 27.5)	25.2 (22.1 to 28.9)	*7.0*
Male	27.0 (26.3 to 27.8)	27.9 (27.1 to 29.0)	*3.5*	20.9 (17.1 to 25.1)	27.5 (23.4 to 31.4)	*31.9‡*	31.0 (26.0 to 36.0)	28.7 (23.1 to 34.3)	*-7.4*	27.0 (22.0 to 34.0)	28.3 (23.0 to 34.2)	*4.9*
Female	19.0 (18.3 to 19.5)	18.6 (17.8 to 19.4)	*-1.8*	16.6 (12.2 to 20.5)	17.3 (13.9 to 21.4)	*3.7*	20.7 (16.3 to 24.8)	21.6 (15.7 to 26.3)	*4.1*	20.3 (16.2 to 24.3)	22.3 (18.3 to 27.2)	*9.7*
Psychosocial stress												
Male+Female	24.8 (24.4 to 25.4)	23.4 (22.9 to 24.0)	*-5.7‡*	23.5 (20.3 to 26.9)	19.6 (17.6 to 22.2)	*-16.7*	19.9 (17.7 to 22.6)	20.1 (17.1 to 23.1)	*1.1*	20.8 (17.3 to 24.2)	19.7 (16.6 to 22.7)	*-5.4*
Male	23.3 (22.7 to 24.1)	21.4 (20.6 to 22.2)	*-8.4§*	25.7 (21.2 to 31.0)	19.3 (15.7 to 22.2)	*-24.7‡*	20.1 (16.7 to 24.3)	19.4 (15.5 to 23.6)	*-3.4*	20.6 (15.6 to 26.5)	15.3 (11.4 to 20.1)	*-25.8*
Female	26.3 (25.6 to 27.0)	25.4 (24.7 to 26.2)	*-3.5*	21.4 (17.4 to 26.1)	19.8 (16.9 to 23.9)	*-7.4*	19.7 (16.4 to 23.5)	20.8 (16.9 to 25.0)	*5.5*	20.9 (16.2 to 24.9)	23.9 (18.6 to 28.8)	*14.1*
Non-regular alcohol consumption												
Male+Female	65.2 (64.7 to 65.8)	62.9 (62.3 to 63.7)	*-3.5§*	88.6 (85.8 to 90.3)	88.9 (87.2 to 90.9)	*0.4*	91.3 (89.2 to 93.4)	92.4 (90.6 to 94.1)	*1.2*	85.3 (82.1 to 87.8)	88.1 (85.2 to 90.0)	*3.3*
Male	55.3 (54.5 to 56.0)	53.8 (52.9 to 54.9)	*-2.6‡*	81.5 (77.2 to 84.8)	81.2 (78.0 to 85.0)	*-0.3*	87.7 (84.3 to 91.3)	89.8 (86.3 to 92.9)	*2.3*	77.6 (72.0 to 82.4)	83.5 (78.4 to 86.9)	*7.7*
Female	74.8 (74.1 to 75.5)	71.7 (70.9 to 72.6)	*-9.1§*	95.4 (91.5 to 97.5)	96.4 (94.9 to 97.5)	*1.0*	94.7 (92.4 to 96.4)	95.0 (92.8 to 96.8)	*0.3*	92.7 (89.4 to 94.9)	92.5 (89.7 to 95.0)	*-0.2*

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- and sex-standardized to the 2001 Ontario Census population weighted by the survey sample weight.

†Percent change for 2009-2012 vs. 2001-2004; i.e. [(estimate for 2009-2012 - estimate for 2001-2004) / (estimate for 2001-2004)]*100;
Prevalence estimates up to five decimal places were used in the calculation of percent changes. Bootstrap methods were used to derive p values comparing estimates for 2009-2012 to estimates for 2001-2004.

‡ indicates significant at $p<0.05$; § indicates significant at $p<0.001$. 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).

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	N/A

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	11-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-12
		(*b*) Report category boundaries when continuous variables were categorized	6-7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16-17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.