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Trends in obesity and multimorbidity in Canada.

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Abbreviations:
Body mass index (BMI)
National Population Health Survey (NPHS)
Canadian Community Health Surveys (CCHS)
Chronic obstructive pulmonary disease (COPD)
Odds Ratio (OR)

Abstract:

Very few studies have examined trends in multimorbidity over time and even fewer have examined trends over time across different body mass index (BMI) groups. Given general decline in death rates but increased cardiovascular risk factors among individuals with obesity, the trend in the association between obesity and multimorbidity is hypothesized to be increasing over time. The data for our study came from the 1996-97 National Population Health Survey and the 2005-06 and 2012-13 Canadian Community Health Surveys (N = 277,366 across all 3 surveys). We examined trends in the association between BMI groups and multimorbidity using a logistic regression model. We also investigated trends in the prevalence of specific chronic conditions, pairs of chronic conditions and different levels of multimorbidity across BMI groups. We found significantly greater levels of multimorbidity in 2005-06 (OR = 1.42; $p<0.001$) and 2012-13 (OR = 1.58; $p<0.001$) relative to 1996-97. Changes in multimorbidity levels were much greater among individuals with class II/III (OR = 1.48; $p=0.005$) and class I obesity (OR = 1.38; $p=0.001$) in 2012-13 relative to 1996-97. Much of the increase in multimorbidity among individuals living with obesity was due to increases in 3+ chronic conditions and conditions in combination with hypertension, and the greatest increase was found among seniors living with obesity. Our results highlight the need for interventions aimed at preventing obesity and the prevention of chronic conditions among individuals with obesity, especially among seniors.

Introduction

In recent decades, the prevalence of obesity has risen considerably across the developed world (Ng, et al, 2014). This has been alarming given the association between obesity and numerous chronic conditions, including type II diabetes, hypertension, heart disease, osteoarthritis, and numerous cancers (Guh, et al, 2009). Not surprisingly, obesity is associated with an elevated risk of mortality, disability (Reuser, et al, 2009), and reduced health related quality of life (Jia and Lubetkin, 2005). Obesity places a significant financial burden on health care systems throughout the developed world (Kim and Basu, 2016,Anis, et al, 2010).

We are witnessing a change in the risks of mortality and the burden of diseases across various populations. In the United States (US), the mortality risks associated with obesity have been declining (Flegal, et al, 2007), likely due to better management of cardiovascular risk factors and declining cardiovascular related mortality. There has been increasing prevalence of severe obesity (i.e. class II ($35 \leq$ body mass index (BMI) ≤ 40)) and class III (BMI > 40) obesity) and increasing non-mortality burden of disease among individuals with obesity, including stronger associations with diabetes, arthritis and disability (Peeters and Backholer, 2012). In Canada, there have been parallel improvements in the treatment of cardiovascular risk factors such as hypertension (McAlister, et al, 2009) and high cholesterol (Neutel, et al, 2007), and decreases in the death due to cardiovascular disease (Tu, et al, 2009). Meanwhile, there have also been increases in severe obesity (Katzmarzyk and Mason, 2006) and in the prevalence of cardiovascular risk factors such as diabetes and hypertension (Lee, et al, 2009).

These changes in survival and population aging are likely contributing to a greater prevalence of multimorbidity, defined as the presence of two or more chronic conditions in the same individual. The prevalence of multimorbidity is rising in the United States, (Paez, et al, 2009) Canada, (Pefoyo, et al, 2015) England (Dhalwani, et al, 2016a), Germany (Tetzlaff, et al, 2017) and the Netherlands (Uijen and van de Lisdonk, Eloy H, 2008). Although obesity is associated with a greater levels of multimorbidity (Agborsangaya, et al, 2013,Booth, et al, 2014), to what extent obesity is contributing to the rise in multimorbidity across countries is unclear given that there have been few studies examining trends in multimorbidity over time; even fewer studies have examined the trends in multimorbidity with respect to obesity (Canizares, et al, 2017). Examining these trends are important for identifying the population health status of individuals with and without obesity over time. If obesity is contributing to the rise in multimorbidity, this suggests potential intervention strategies targeting specific chronic conditions and/or specific populations.

Therefore, our objective was to examine the prevalence of multimorbidity over time by BMI groups and the relationship between obesity and multimorbidity over time in Canada. Our hypothesis was that the trends in the association between obesity and multimorbidity have been increasing over time. Our secondary objectives were to examine specific chronic conditions, chronic disease combinations, and severity of multimorbidity (i.e. presence of three or more conditions) over time by BMI groups to help inform which conditions can be targeted to reduce the burden of multimorbidity.

Materials and Methods

Data

We analysed the relationship between obesity and multimorbidity using pooled cross-sectional survey data. We used the 1996-97 National Population Health Survey (NPHS), and the 2005 and 2012-13 Canadian Community Health Surveys (CCHS). These cross-sectional surveys were conducted by Statistics Canada using computer assisted interview methods and multi-stage stratified cluster sampling designs; details of the survey design can be found elsewhere (Tambay and Catlin, 1995,Béland, 2002). Each survey collected measures of BMI, chronic conditions, and a rich set of sociodemographic and lifestyle characteristics. All surveys are nationally representative, have large sample sizes, have nearly identical sample inclusion and exclusion criteria, and identical or very similar questions asked on each of the included variables. All surveys excluded full-time members of Canadian Forces and residents of Indian Reserves, Crown Lands, institutions and certain remote regions. We excluded respondents who were less than 18 years of age at the time of interview, residents of the three Canadian Territories, pregnant women, and individuals who had missing data on BMI.

Outcomes

Individuals were classified as having multimorbidity if they reported having at least two chronic conditions among a list of conditions commonly included in studies of multimorbidity and available in all survey periods (Prados-Torres, et al, 2014,Willadsen, et al, 2016). Our list included ten such conditions: asthma, arthritis, high blood pressure, diabetes, heart disease, cancer, stroke, chronic obstructive pulmonary disease (COPD), and Alzheimer's disease and dementia. COPD and dementia were only available among adults aged 35+ due to the design of the surveys.

Exposures

All variables were derived from self-reported responses to the survey questions. BMI was defined as weight (kg)/height (m^2). We categorized BMI into underweight (BMI < 18.5), normal weight (18.5 ≤ BM < 25), overweight (25 ≤ BMI < 30), class I obesity (30 ≤ BMI < 35), and severe or class II/III obesity (35 ≤ BMI).

We controlled for age, sex, marital status, immigrant status, home ownership, rural residence, education, income quintile, smoking status, and alcohol consumption in all multivariable logistic regressions. Age and age squared were included to capture a quadratic relationship of an outcome variable with respect to age. Marital status was defined as married, single, and divorced/separated/widowed. We identified individuals as recent immigrants (i.e. <10 years in Canada), long-term immigrant (i.e. ≥10 years), or non-immigrants. We derived educational status based on the highest degree completed by the respondent at the of survey interview. We generated household income quintiles where income was adjusted by the square root of the number of the people in the household (Murphy, et al, 2010). We categorized smoking status into never smoker, former smoker, or current smoker. Alcohol consumption was categorized as none in the prior 12 months, occasional (drink alcohol < 1 time per month) or regular drinkers.

Statistical Analysis

We used a logistic regression model to analyze multimorbidity. In order to examine trends over time and test for statistical significance of any changes in the relationship between obesity and each outcome, we pooled all surveys and included an interaction between BMI category and survey year. We assessed the prevalence of each chronic condition and of the 10 most prevalent disease pairs among all individuals as well as normal weight individuals and individuals with obesity in 1996-97 and 2012-13. In 1996-97 and 2012-13, we assessed the prevalence of 0, 1, 2, and 3+ chronic conditions among all BMI groups, overall and by age group (<45, 45-64, 65+). We used survey and bootstrap weights provided by Statistics Canada in all analyses in order to produce nationally representative estimates and account for the complex survey design features in variance estimation. A binary indicator was included for the respondents with missing income, while a small proportion of respondents with missing data (3.8%) on all other variables were excluded from the analysis. We conducted all analyses with Stata 14.

Results

From an initial 81,804, 132,947, and 126,449 respondents available in three cross-sectional surveys, a total of 64,904, 114,301 and 109,095 respondents met the inclusion criteria in 1996-97, 2005-06 and 2012-13, respectively, yielding a total sample size of 288,300 for our analysis. There was a minimal missing data: a total of 10,934 (3.8%) respondents missing on all other variables who were excluded from the analyses. A total of 25,164 (8.7%) respondents were missing on income and were included in the analysis using a binary indicator for missing. The prevalence of class I obesity increased by 35.1% from 9.7% in 1996-97 to 13.1% in 2012-13 and class II/III obesity increased by 112% from 2.6% in 1996-97 to 5.5% in 2012-13. The prevalence of obesity was 18.6% in 2012-13. Other descriptive characteristics of the samples are reported in Table 1.

The prevalence of multimorbidity in the population and across BMI groups is shown in Figure 1. The prevalence of multimorbidity significantly increased across surveys both overall (OR = 1.42; $p<0.001$ for 2005-06 vs. 1996-97; OR = 1.58; $p<0.001$ for 2012-13 vs. 1996-97) and across all BMI groups (OR = 1.36-1.65, all $p < 0.001$ for 2012-13 vs. 1996-97) except for the underweight group. Individuals with class II/III obesity also experienced the largest increase in multimorbidity (OR = 1.65; $p<0.001$ for 2012-13 vs. 1996-97).

The results of logistic regression results are reported in Table 2. The omnibus test was significant for multimorbidity ($p < 0.05$), therefore BMI group and time interaction terms were included in the analysis. Multimorbidity among normal weight individuals was significantly greater in 2005-06 (OR = 1.22; $P < 0.001$) and 2012-13 (OR = 1.15; $P =0.013$) relative to 1996-97. Both class I (OR = 2.30; $p < 0.001$) and class II/III obesity (OR = 3.91; $p <0.001$) were positively associated with multimorbidity and these associations were significantly greater in the later time periods relative to 1996-97 (OR for class II/III obesity X 2012-13 interaction = 1.48; $p = 0.005$).
The prevalence of individual and pairs of chronic conditions, for respondents who are normal weight, obesity class I, and obesity class II/III for 1996-97 and 2012-13 are reported in Table 3.

The prevalence of high blood pressure, diabetes, cancer, stroke, dementia and COPD significantly increased for normal weight individuals (all $p<0.05$). The prevalence of high blood pressure, diabetes, and heart disease significantly increased for individuals with obesity class I (all $p<0.05$). Asthma, high blood pressure, diabetes, and COPD prevalence significantly increased for individuals with class II/III obesity (all $p<0.05$). The ten most common pairs of chronic conditions among the overall population are included in Table 3 and consisted of asthma, arthritis, high blood pressure, and diabetes combined with each other and other conditions. Seven, eight, and six of the top ten pairs significantly increased from 1996-97 to 2012-13 for individuals living with class II/III obesity, class I obesity, and normal weight, respectively (all $p<0.05$). In 2012-13, the most common pairs of conditions for all three groups included high blood pressure including arthritis, diabetes, and heart disease.

The prevalence of 0, 1, 2, and 3+ chronic conditions, overall and by 3 age strata (<45, 45-64, 65+) are presented in Table 4. There are large increases in multimorbidity with increasing BMI group for all age groups and large increases in multimorbidity for all BMI groups with increasing age category. Overall, individuals with class II/III obesity have much higher prevalence of 2 and especially 3+ conditions relative to individuals of normal weight, and this is greater in 2012-13 (~5 times the prevalence of 3+) than it was in 1996-97 (~3 times). The prevalence of multimorbidity is greater among individuals with class II/III obesity than among normal weight individuals in the next age category. Furthermore, much of the increase in multimorbidity among individuals with class II/III obesity has been increasing in individuals with 3+ rather than 2 conditions, with the prevalence of 2 conditions being very similar in 1996-7 and 2012-13 for those age 45-64 and decreasing for individuals age 65+. Except for normal weight individuals 65+ in 2012, multimorbidity was less common than single chronic condition among normal weight individuals in other age groups/time periods. Meanwhile, individuals with obesity class II/III who were 45+ years had greater levels of multimorbidity than a single condition.

Discussion

We found increasing prevalence of multimorbidity with significantly larger increases in multimorbidity among individuals who are either overweight or with obesity and the largest increases in multimorbidity among individuals with class II/III obesity. Nearly one-third of individuals with class II/III obesity had multi-morbidity in 2012-13. Although previous studies have shown increasing prevalence of multimorbidity overall (Paez, et al, 2009,Uijen and van de Lisdonk, Eloy H, 2008,Pefoyo, et al, 2015) and higher levels of multimorbidity among individuals with obesity (Booth, et al, 2014,Agborsangaya, et al, 2013,Jackson, et al, 2015), few studies have examined time trends in multimorbidity by BMI groups. Our results demonstrate that the obesity epidemic may be a significant contributor of the increase in multimorbidity given the increases in the prevalence of obesity and class II/III obesity and increases in the prevalence of multimorbidity among individuals living with obesity. In addition, we found relatively low levels of multimorbidity and small increases in multimorbidity among individuals with normal weight. These results suggest that health promotion and preventative interventions aimed at preventing weight gain and obesity among the general population and the prevention of chronic conditions among individuals with obesity may help to combat the rising prevalence of chronic conditions and multimorbidity, especially among those aged 45 and older.

There were increasing levels of hypertension, diabetes, asthma and COPD among individuals living with class II/III obesity and increasing levels of hypertension, diabetes and heart disease among class I obese individuals. Furthermore, we observed large increases in the combinations of these conditions among individuals with obesity, especially hypertension and diabetes and hypertension and COPD. Among all individuals, there was nearly equivalent increase in the prevalence of 2 and 3+ conditions. Other studies, have found the rise in multimorbidity was largely explained by increases in the higher levels of multimorbidity (i.e. 3+ chronic conditions) rather than the rise in 2 conditions (Uijen and van de Lisdonk, Eloy H, 2008,Paez, et al, 2009). We found this among individuals with obesity, where the increase in multimorbidity was largely due to an increase among those with 3+ conditions. This was most pronounced in seniors with class II/III obesity for whom the prevalence of 3+ conditions more than doubled from 20.4% to 42.8%, and became more prevalent than only 2 conditions. These findings demonstrate that the increase in multimorbidity among individuals with obesity also reflects growing clinical complexity requiring effective management in primary and specialty care settings. Furthermore, obesity often does not occur in isolation, co-occurring with physical inactivity and other lifestyle risk factors. The accumulation of multiple lifestyle risk factors results in even greater risks in a dose-response manner of chronic conditions (Sasazuki, et al, 2012,Åkesson, et al, 2007) and multi-morbidity, and individuals with both obesity and physical inactivity are much greater risk of multi-morbidity than individuals with either risk factor (Dhalwani, et al, 2016b). Future research into interventions for individuals with multimorbidity should take into account that for some sub-populations such as seniors living with obesity and the norm is 3+ chronic conditions and that lifestyle risk factors often co-occur.

Likely contributors of multimorbidity include population aging and increasing survival, especially among individuals with cardiovascular disease (Tu, et al, 2009), leading to an expansion of morbidity (Canizares, et al, 2017). It is not clear how much of the increase in hypertension is due to true increases in the prevalence of disease as opposed to greater detection/awareness, given there were initiatives during this time period to improve detection and treatment such as the Canadian Hypertension Education Program (McAlister, et al, 2009). Similar campaigns have contributed to the rise in multimorbidity found in other countries (Uijen and van de Lisdonk, Eloy H, 2008). Research from National Health and Nutrition Examination Survey in the United States suggests that one consequence of the obesity epidemic has been the rising prevalence of diabetes (Gregg, et al, 2007) and hypertension (Cutler, et al, 2008).

The findings of greater multimorbidity are concerning given the implications for multi-morbidity for a number of important health outcomes. A systematic review demonstrated an inverse relationship between the number of chronic conditions and physical dimensions of health related quality of life (Fortin, et al, 2004). The rise in multimorbidity among obese seniors is particularly troubling given the strong association between multimorbidity and mortality in the elderly (Nunes, et al, 2016). Multimorbidity is linked to higher health care costs in a dose-response manner (Glynn, et al, 2011). Therefore, the findings of our study suggest that obesity may exacerbate the mortality risk in this population and increase health care costs.

The prevalence of multimorbidity has been reported in numerous countries and the rates varied widely across studies. This is likely due to methodological differences in the data collection, sample sizes, the age group, the number of chronic conditions measured, the definition (2+ vs.

3+ conditions) and analysis of multimorbidity (e.g. 2+ vs. 0-1 or vs. 0 conditions) (Fortin, et al, 2012,Nicholson, 2017). The overall prevalence of 15.7% found in our study is closer to the lower end of the published literature. This is likely due to our reliance on a sample from a surveys of the non-institutionalized general population rather than clinical populations or those age 55+ or 65+, and from a country with relatively high socioeconomic status and better population health (Fortin, et al, 2012,Nicholson, 2017). With respect to ascertainment of chronic conditions, the number varies widely across studies. We included 10common conditions, which is below the average number of conditions included in previous studies and excluded common mental health conditions such as depression or anxiety due to the lack of data availability in all surveys (Fortin, et al, 2012,Nicholson, 2017). Furthermore, given the interest in the prevalence of multimorbidity among individuals with obesity, we did not include obesity in our list of conditions to define multimorbidity. Obesity is both highly prevalent and has often been included as a chronic condition in some definitions of multimorbidity (Nicholson, 2017). In a previous study, the exclusion of obesity led to a 5.2% absolute decrease in the prevalence of multimorbidity (Agborsangaya, et al, 2013). Similar variations in methodology can be found among studies of multimorbidity and obesity, resulting in variation in both the prevalence of multimorbidity as well as the association between obesity and multimorbidity (Booth, et al, 2014,Agborsangaya, et al, 2013,Taylor, et al, 2010,Pache, et al, 2015,Jovic, et al, 2016). However, regardless of these methodological differences, these studies consistently find that obesity is significantly associated with multimorbidity.

We found that individuals with class II/III obesity age < 45 years had greater multimorbidity than individuals of normal weight aged 45-65 years and individuals with class II/III obesity had greater multimorbidity then normal weight seniors aged 65 and older. Given the average age difference between the categories was approximately 20 years, this suggests the effect of class II/III obesity on multimorbidity is approximately equivalent to aging two decades. This highlights the impact of different levels of obesity on multimorbidity, which only a limited number of previous studies have explored (Jovic, et al, 2016,Booth, et al, 2014). These studies have demonstrated stronger associations between greater severity of obesity and multimorbidity (Jovic, et al, 2016,Booth, et al, 2014). This population should be prioritized to receive greater continuity and coordination of care to minimize the consequences of multimorbidity.

Strengths and Limitations

The strengths of our study include its use of three large samples based on nationally representative surveys, which enabled detailed examination of the multimorbidity burden over time while accounting for a wide variety of demographic and socio-economic factors, enabled us to examine specific comorbidities, examination of the presence of three or more conditions, and extend the analysis to individuals with class II/III obesity. Since we applied survey and bootstrap weights provided by Statistics Canada in the variance estimation, our results are generalizeable to the Canadian general population.

Our study has several limitations. First, use of the self-reported height and weight underestimates BMI. Individuals tend to over-estimate their height and under-estimate their weight resulting in an under-estimation of self-reported BMI (Shields, et al, 2011). However, samples with measured BMI are often much smaller which makes assessment of higher levels of

multimorbidity (i.e. 3+ conditions) difficult, especially among populations with severe obesity. This limitation is of greater concern in our study if this bias is changing over time. However, it is unclear whether this bias is changing in Canada given a lack of comparable design across studies (Shields, et al, 2011). Second, there are minor differences in survey questions over time shown in Supplementary table 1. However, these changes are unlikely to affect the conclusions. Third, this study is limited in its cross-sectional nature, which does not enable us to make statements regarding causality. However, longitudinal follow-up studies (Jackson, et al, 2015) have come to the same conclusion that obesity is associated with increased multimorbidity. Lastly, we only included 10 common conditions and were not able to assess other conditions that are commonly included in multimorbidity studies such as chronic kidney disease or depression because they were not collected in all three surveys, the inclusion of which would result in non-comparable time trend over the period examined. This suggests our prevalence of multimorbidity is likely to be an underestimate and conservative. Furthermore, we relied on self-reported chronic conditions which enabled the analysis to be conducted at the national level given the lack of nationally representative administrative or electronic medical records data available for Canada. Although self-reported data have shown good agreement for diabetes and hypertension, variable agreement for other conditions with ascertainment using administrative databases were documented (Muggah, et al, 2013). Future studies can assess these trends with linkage to administrative databases where a different method of obtaining disease diagnoses is possible, including prospective measures of disease incidence.

Conclusions

The prevalence of multimorbidity has significantly risen during our study period, especially among individuals with obesity. Our findings demonstrate the obesity epidemic is a significant contributor to the rise in multimorbidity in Canada. The findings of our study emphasize the need for interventions and policies to reverse the rising prevalence of multimorbidity as well as minimize the health impacts of multimorbidity, especially among individuals with severe obesity and seniors.

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Table 1. Descriptive characteristics for the sample for each year*

	1996-97	2005-06	2012-13
BMI Category			
Obesity Class II/III	2.6	4.3	5.5
Obesity Class I	9.7	11.5	13.1
Obesity	12.3	15.8	18.6
Normal Weight	35.4	34.2	34.5
Overweight	49.9	47.3	44.3
Underweight	2.4	2.6	2.6
Age			
Age (mean)	44.5	46	47.4
Age < 45 years	55.7	49.6	45.4
Age 45-64 years	28.8	34.3	36.1
Age ≥ 65 years	15.5	16.1	18.5
Male	50.2	50.3	50.4
Marital Status			
Single Never Married	23.2	22.7	23.8
Widowed, Separated, Divorced	13.6	12.6	13.4
Married	63.2	64.7	62.8
Missing	0.1	0	0.2
Immigrant Status			
Non-Immigrant	80.4	77.9	75.1
Recent Immigrant (duration < 10 years)	4.6	5.6	6.7
Long-term Immigrant (duration ≥ 10 years)	15	16.5	18.1
Missing	0.4	2.5	3.5
Rural	17.2	17.8	18
Income			
Income Quintile 1	16.9	18	20.9
Income Quintile 2	16.9	16.5	19.2
Income Quintile 3	16.9	17.6	21.4
Income Quintile 4	16.9	16.7	20.2
Income Quintile 5	16.9	16.6	18.3
Missing	15.4	14.6	0
Homeowner	72.1	76.3	72.7
Education			
Bachelors	15.7	21.2	24.4
Diploma or certificate	18.8	36.5	36.2
Secondary School	41.9	25.7	25.8

Less than Secondary	23.6	16.6	13.6
Missing	0.6	2.9	2.7
Smoking Status			
Current Smoker	29.2	23.4	21.2
Former Smoker	30	41.8	40.3
Never Smoker	40.8	34.8	38.5
Missing	0.3	0.5	0.7
Alcohol Consumption			
Regular Drinker	57.9	65.1	64.5
Occasional Drinker	20.3	16.8	15.8
Non Drinker	21.8	18.2	19.7
Missing	0.8	1.5	1.7
N	64904	114301	109095

*Proportions in all cases except means for Age

*Nationally representative surveys conducted in Canada in 1996-97, 2005-06, and 2012-13

Table 2. Multivariable logistic regression of the association between BMI category, year, their interaction and multimorbidity adjusted for all other characteristics

	OR	p-value	95% LCL	95% UCL
BMI and Time Trends (Ref: 1996-7, normal weight)				
2005	1.22	<0.001	1.10	1.36
2012-13	1.15	0.013	1.03	1.29
Obesity II/III X 2005	1.47	0.005	1.12	1.92
Obesity II/III X 2012-13	1.48	0.005	1.13	1.95
Obesity I X 2005	1.33	0.003	1.10	1.62
Obesity I X 2012-13	1.38	0.001	1.14	1.68
Overweight X 2005	1.14	0.093	0.98	1.33
Overweight X 2012-13	1.18	0.037	1.01	1.37
Underweight X 2005	1.10	0.662	0.71	1.72
Underweight X 2012-13	1.26	0.335	0.79	2.02
Obesity II/III	3.91	<0.001	3.06	4.99
Obesity I	2.30	<0.001	1.94	2.74
Overweight	1.45	<0.001	1.26	1.66
Underweight	0.85	0.448	0.57	1.28
Age	1.17	<0.001	1.16	1.18
Age2	1.00	<0.001	1.00	1.00
Male	0.85	<0.001	0.81	0.89
Marital Status (Ref: Single)				
Widowed/Separated/Divorced	0.91	0.038	0.84	0.99
Married	0.90	0.007	0.83	0.97
Immigration status (Ref: Non-immigrant0				
Recent Immigrant (duration < 10 years)	0.52	<0.001	0.42	0.64
Long-term Immigrant (duration ≥ 10 years)	0.96	0.155	0.90	1.02
Rural	0.98	0.323	0.93	1.02
Income Quintile (Ref: Quintile 1)				
Income Missing	0.71	<0.001	0.66	0.77
Income Quintile 5	0.57	<0.001	0.52	0.62
Income Quintile 4	0.66	<0.001	0.62	0.72
Income Quintile 3	0.74	<0.001	0.69	0.79

Income Quintile 2	0.80	<0.001	0.75	0.85
Homeowner	0.82	<0.001	0.78	0.87
Education (Ref: Less than Secondary)				
Bachelors	0.74	<0.001	0.68	0.80
Diploma or certificate	0.95	0.063	0.89	1.00
Secondary	0.91	0.005	0.85	0.97
Smoking Status (Ref: Never Smoker)				
Current Smoker	1.46	<0.001	1.37	1.55
Former Smoker	1.31	<0.001	1.24	1.38
Alcohol Consumption (Ref: Non-Drinker)				
Occasional Drinker	0.89	0.001	0.83	0.96
Regular Drinker	0.67	<0.001	0.63	0.71
N = 277,366				

*Nationally representative surveys conducted in Canada in 1996-97, 2005-06, and 2012-13

Table 3. Prevalence of chronic conditions and top 10 pairs of chronic condition for individuals who are normal weight, living with obesity class I, and obesity class II/III for 1996-97 and 2012-13

	1996-97			2012-13		
	Normal Weight %	Obesity I %	Obesity II/III %	Normal Weight %	Obesity I %	Obesity II/III %
Individual conditions						
Asthma	6.4	7.7	10.7	6.5	9.2	14.9 a
Arthritis	12.2	22.3	28.3	12.3	22.6	28.5
High Blood Pressure	7.5	19.6	23.8	11.7 a	31.6 a	37.1 a
Diabetes	2.1	7.1	10.8	3.5 a	13.1 a	20.4 a
Heart Disease	3.5	6.3	5.5	3.9	7.8 a	7.4
Cancer	1.5	1.8*	1.8*	2.0 a	2.7	2.7
Stoke	0.8	1.5*	0.9*	1.1 a	1.5	1.7
Dementia	0.2	0.3*	F	0.5 a	0.5*	F
COPD	1.8	3.7	4.0	2.3 a	4.1	6.5 a
Top 10 pairs of chronic conditions#						
Asthma Arthritis	1.1	2.2	5.1*	1.1	2.9	6.1
Asthma & High blood pressure	0.4	1.8	2.5	0.9 a	3.4 a	6.7 a
Arthritis & High blood pressure	2.7	8.6	11.8	3.6 a	11.9 a	15.0 a
Arthritis & Diabetes	0.8	3.1	5.3	1.0	4.9 a	8.9 a
Arthritis & Heart disease	1.6	3.0	3.2	1.5	3.4	4.0
Arthritis & COPD	0.7	1.4	2.2*	0.9	2.1 a	3.9 a
High blood pressure & Diabetes	0.7*	3.7	4.8	1.7 a	8.4 a	13.5 a
High blood pressure & Heart disease	1.4	2.9	3.3*	1.8 a	5.1 a	5.3 a
High blood pressure & COPD	0.3	1.4*	1.6*	0.7 a	2.2 a	3.9 a
Diabetes & Heart disease	0.3	1.6*	2.6*	0.5 a	2.4 a	3.5

#Top 10 most prevalent pairs in the general population; *Interpret with caution (i.e. 16.6 ≤ Coefficient of Variation (CV) ≤ 33.3); F Unreliable (i.e. CV > 33.3); [a]significantly greater compared to 1996-7; Nationally representative surveys conducted in Canada in 1996-97, 2005-06, and 2012-13

Table 4. Prevalence of each level of morbidity by Year, BMI category, and Age (years)

Level of Morbidity		0	1	2	3+
Overall	1996	69.0	20.5	7.2	3.3
	2012	61.1	23.2	10.0	5.7
Obesity II/III	1996	50.2	26.1	15.9	7.9
	2012	38.4	27.7	18.5	15.4
Obesity I	1996	56.6	25.7	11.6	6.1
	2012	47.4	27.2	15.1	10.2
Overweight	1996	65.7	22.3	8.3	3.7
	2012	57.1	25.8	11.2	5.8
Normal Weight	1996	74.4	18.2	5.1	2.3
	2012	70.5	19.7	6.6	3.2
Underweight	1996	73.9	15.7	8.6	1.8*
	2012	71.9	17.3	6.8	4.0
Age < 45 Years					
Overall	1996	84.4	13.2	2.0	0.3
	2012	83.1	14.4	2.1	0.5
Obesity II/III	1996	71.0	22.4	5.2*	1.3*
	2012	63.0	24.9	9.1	3.1*
Obesity I	1996	78.0	17.9	3.4*	0.7*
	2012	76.3	19.3	3.4	1.0*
Overweight	1996	83.5	13.9	2.2	0.3*
	2012	80.9	16.4	2.3	0.4*
Normal Weight	1996	86.2	12.0	1.6	0.2*
	2012	87.4	11.5	1.0	0.1*
Underweight	1996	88.3	8.7	3.0*a	
	2012	88.1	F	F	
Age 45-64 Years					
Overall	1996	59.9	27.2	9.0	3.9
	2012	53.2	29.8	11.7	5.4
Obesity II/III	1996	34.2	31.3	22.5	12.0
	2012	27.4	32.5	22.7	17.3
Obesity I	1996	47.6	31.8	14.1	6.6
	2012	37.6	34.3	18.3	9.7
Overweight	1996	59.8	27.7	8.7	3.8
	2012	52.9	31.1	11.4	4.6
Normal Weight	1996	66.2	25.0	6.3	2.5
	2012	64.3	26.1	7.5	2.2
Underweight	1996	54.5	28.1*	17.3* a	

	2012	56.4	29.2	14.4* a	
		Age 65+ Years			
Overall	1996	30.2	34.2	22.7	12.9
	2012	22.6	32.0	26.0	19.4
Obesity II/III	1996	17.9*	25.3*	36.4*	20.4*
	2012	7.2*	19.9	30.1	42.8
Obesity I	1996	21.7	32.2	27.1	19.0
	2012	12.9	27.4	30.7	29.0
Overweight	1996	27.8	35.0	24.5	12.7
	2012	21.2	33.2	27.4	18.2
Normal Weight	1996	34.2	34.9	19.4	11.6
	2012	28.6	33.8	22.8	14.8
Underweight	1996	43.0	28.4	22.1	6.5*
	2012	30.4	30.7	22.1	16.8

a Estimated only 2+; *Interpret with caution (i.e. 16.6 $\leq$ CV $\leq$ 33.3); F Unreliable (i.e. CV > 33.3); Nationally representative surveys conducted in Canada in 1996-97, 2005-06, and 2012-13

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