

Epidemiology of Adult Obesity

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Update History

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KEY MESSAGES FOR POLICYMAKERS AND HEALTHCARE PROVIDERS IN CANADA

- Obesity is a chronic disease characterized by the presence of excessive and/or dysfunctional adipose tissue that impairs health and wellbeing.
- Obesity increases the risk of serious chronic illnesses such as heart disease, cancer, stroke, diabetes and nonalcoholic fatty liver disease, among others.
- Obesity impairs an individual's health-related quality of life and reduces life expectancy.
- In Canada, the prevalence of obesity in adults rose dramatically, increasing three-fold since 1985.
- Obesity, defined as a BMI ≥ 30 kg/m², affected 26.4% or 8.3 million Canadian adults in 2016.
- Severe obesity (BMI ≥ 35 kg/m²), the fastest growing obesity subgroup, increased disproportionately over this same period. Since 1985, severe obesity increased 455% and affected an estimated 1.9 million Canadian adults in 2016.
- Overweight, defined as a BMI between 25 and 29.9 kg/m², affected an additional 34% of adults in Canada (10.6 million individuals).
- Over the same 30-year time period, measures of abdominal obesity increased significantly, are more pronounced and are associated with significant increases in health risk.
- As or more concerning: the increase in childhood obesity mirrors this adult trend.
- One in three children and/or youths between six to 17 years have overweight or obesity, an increase from one in four in 1978/79.
- The prevalence of obesity among boys, in particular adolescent boys 12–17 years, is significantly higher than for adolescent girls (16.2% versus 9.3%).
- The causes of and contributors to obesity are complex and extend well beyond an individual's choice over calories in and out. Established contributors to obesity include socio-economic status, sex, ethnicity, access to healthcare, genetics, regional food and built environments.
- Health professionals should not rely solely on BMI to predict an individual's health risk but use it in conjunction with other screening and assessment tools.
- Weight bias, stigma and discrimination are pervasive in the healthcare system and society and result in the unjust treatment of individuals living with obesity.
- Obesity affects individuals, families and society. The economic burden is significant. In 2014, the global economic impact of obesity was estimated to be US \$2.0 trillion or 2.8% of the global gross domestic product (GDP).
- In Canada, obesity and its related illnesses result in a large cost to society due to increases in direct (i.e., physician, hospital, emergency room use) and indirect costs (i.e., lost productivity, absenteeism, disability), estimated to be \$7.1 billion in 2010.
- Successful management (i.e., prevention, management and treatment) of obesity requires collective effort at the policy, health system, community, and individual level.
- There is a need for continued and focused investment in research funding to support the scientific understanding of obesity. This includes non-experimental research on the biopsychosocial and environmental causes and contributors, and experimental research to develop and test interventions to prevent, manage and treat obesity. Research on how best to implement evidence-based practice and policy is a priority.

RECOMMENDATIONS

1. Healthcare providers can recognize and treat obesity as a chronic disease, caused by abnormal or excess body fat accumulation (adiposity), that impairs health, with increased risk of premature morbidity and mortality (Level 2b, Grade B).¹⁻⁶
2. The development of evidence-informed strategies at the health system and policy level can be directed at managing obesity in adults (Level 2b, Grade B).²⁻⁶
3. Continued longitudinal national and regional surveillance of obesity that includes self-reported and measured data (i.e., heights, weights, waist circumference) may be collected on a regular basis (Level 2b, Grade B).²⁻⁶

Introduction

Obesity rose dramatically in Canada and in many other countries over the last 30 years and is a global public health priority. Obesity is estimated to affect 13% of the adult population worldwide, affecting over 650 million individuals.¹⁻³ Globally, obesity is one of the largest contributors to poor health, with annual costs estimated to be \$2 trillion US dollars, equivalent to 2.8% of the world's gross domestic product (GDP) and equal to the costs of smoking.⁷ In Canada, annual direct medical care costs for hospital admissions, medication use, physician fees and emergency room visits were estimated to be \$3.9 billion CAD in 2010.⁸ When indirect costs are included, such as short and long-term disability, absenteeism, presenteeism and premature death, this increases to \$7.1 billion.⁹

Obesity impacts the health and psychosocial wellbeing of individuals living with obesity. Health-related quality of life is significantly lower for individuals living with obesity when compared to the general population due to impaired mental health, increased depression and anxiety, problems with pain and discomfort, and reduced mobility.¹⁰ People living with obesity experience pervasive weight bias, stigma and discrimination that further impacts their wellbeing and leads to health and social inequalities.¹¹

Obesity is a chronic disease characterized by the presence of excessive and/or dysfunctional adipose tissue that impairs health and wellbeing. Obesity is a complex disease in both its etiology and pathophysiology.¹² In epidemiological research, obesity is often determined using the body mass index (BMI), calculated as weight in kilograms divided by height in metres squared (kg/m^2). Obesity is defined as a BMI greater than or equal to $30 \text{ kg}/\text{m}^2$ and further divided into subgroups: Class I: BMI $30\text{--}34.9 \text{ kg}/\text{m}^2$, Class II: BMI $35\text{--}39.9 \text{ kg}/\text{m}^2$ and Class III: BMI $\geq 40 \text{ kg}/\text{m}^2$. The term severe obesity is used for individuals with a BMI $\geq 35 \text{ kg}/\text{m}^2$.

Due to its ease of measurement, BMI is often used to estimate the health risks associated with excess body weight. Increasing BMI is associated with increased health risks.^{13,14} Other anthropometric measures such as waist circumference, waist-to-hip ratio and skinfold measures are used as proxies of total or abdominal adiposity and to estimate how obesity and abdominal obesity impact. These measures also have limitations related to validity and reliability, and as with BMI do not directly measure total or regional body fat.¹⁵ Of

these anthropometric measures, waist circumference is a measure frequently used to assess excess body weight or girth around the abdominal area. Increasing waist circumference is associated with increased health risks for diabetes, hypertension and coronary heart disease. Threshold cut-off values used to assess health risk have been determined to be $> 102 \text{ cm}$ (40 inches) in men and $> 88 \text{ cm}$ (35 inches) in women.¹⁶

Other assessment criteria have been developed to assess obesity-related health risks, including the Edmonton Obesity Staging System (EOSS), a five-point ordinal (0–5) classification system that examines comorbidity and functional status and its relationship with mortality. The EOSS predicts mortality independent of BMI and may be more applicable for use independent of or in addition to BMI and waist circumference in a clinical setting when screening for and assessing an individual's health risk for obesity.¹⁷

In Canada, the prevalence of obesity in adults (18 years +) increased dramatically over the last three decades independent of whether actual or self-report measures are examined. Using actual measures of heights and weights, obesity, defined using BMI, increased more than 300% from 6.1% in 1985 to 26.4% in 2015/2016.¹⁸ When using self-report measures, the prevalence was 20.1% equating to just over a 200% increase (Figures 1a and 1b).¹⁸ As self-reported height and weight underestimate actual measures and therefore the prevalence of obesity in Canada, continued surveillance using actual measures is important (Figure 2).

In Canada, the prevalence of obesity varies by geographical region. In 2015–2016, the prevalence of obesity was highest among the Atlantic Provinces (Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick) and lowest in British Columbia and Quebec (Figure 3).¹⁹ Since 1985, the proportion of people affected by severe obesity increased disproportionately. Between 1985 and 2016, Class II and III obesity increased by 455% (from 1.1% to 6.0%) affecting an estimated 1.9 million adults (Figure 1b).²⁰ This increase in prevalence is a major concern as severe obesity (Class II and III) is associated with a much higher risk of ill health and premature mortality than Class I obesity.^{5,20} In Canada, although the prevalence of obesity (BMI $\geq 30 \text{ kg}/\text{m}^2$) has continued to increase over the last ten years, data suggest the prevalence of obesity has remained largely stable between 2007 and 2017.^{20,21}

Figure 1a: The Prevalence (%) of Obesity in Canada, 1985–2016*

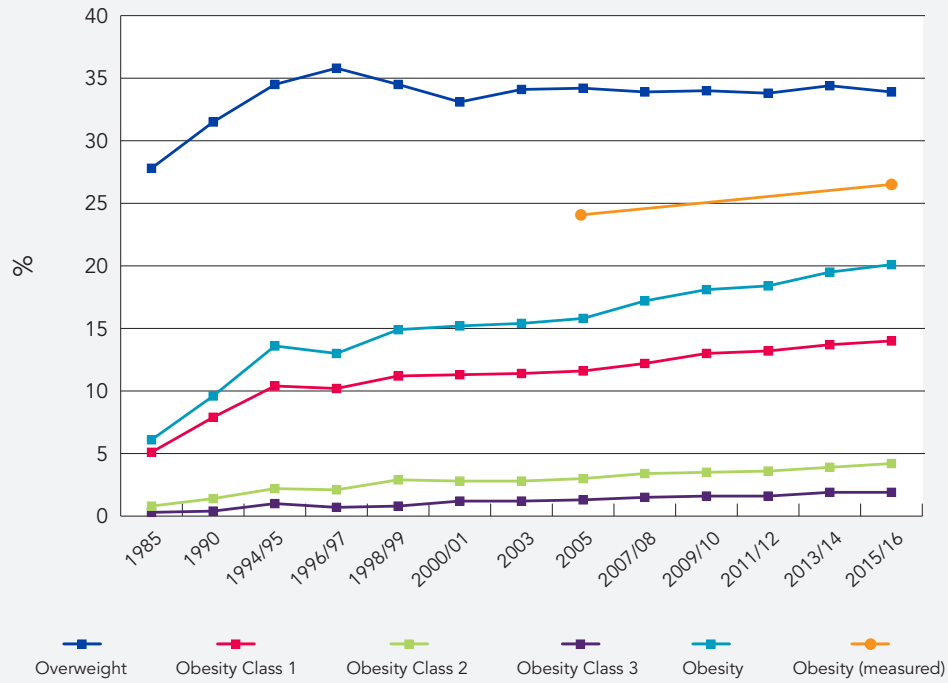


Figure 1b: Percentage Change (%) in the Prevalence of Obesity in Canada, Using 1985 as a Baseline (Self Report)*

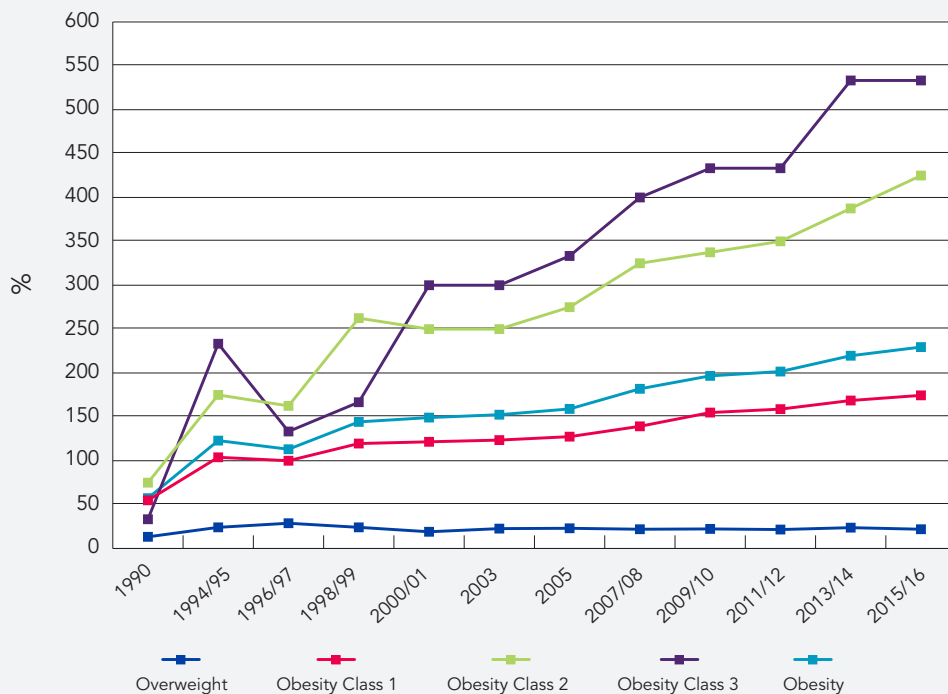


Figure 2: The Prevalence of Adult Obesity (18+ Years) in Canada by Province, Comparing Self-Report Versus Measured Heights and Weights: 2004, 2005 and 2015*

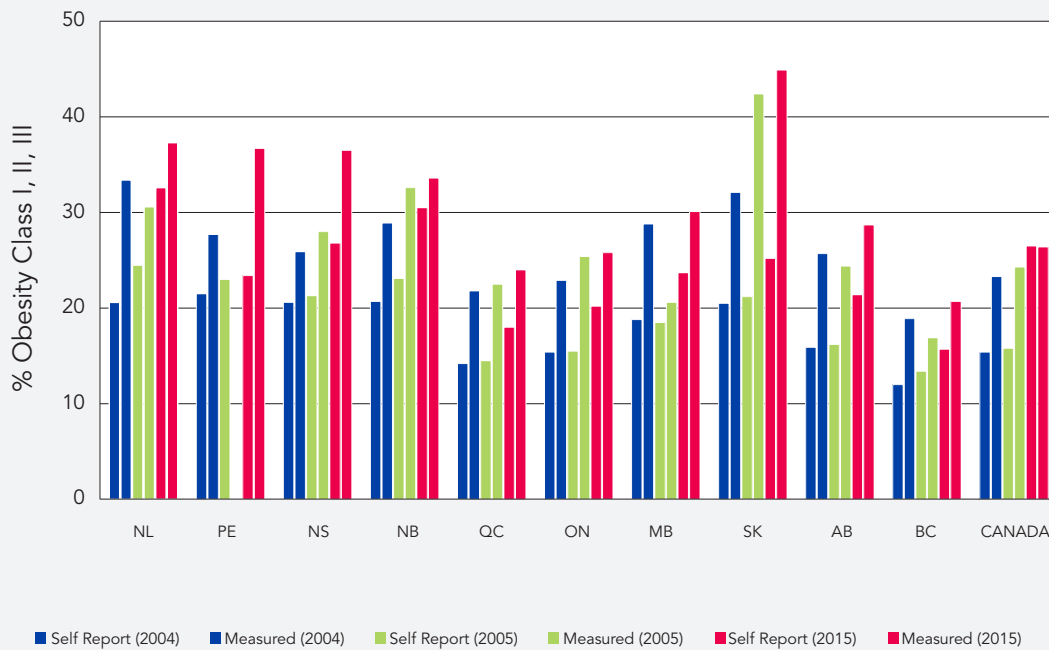
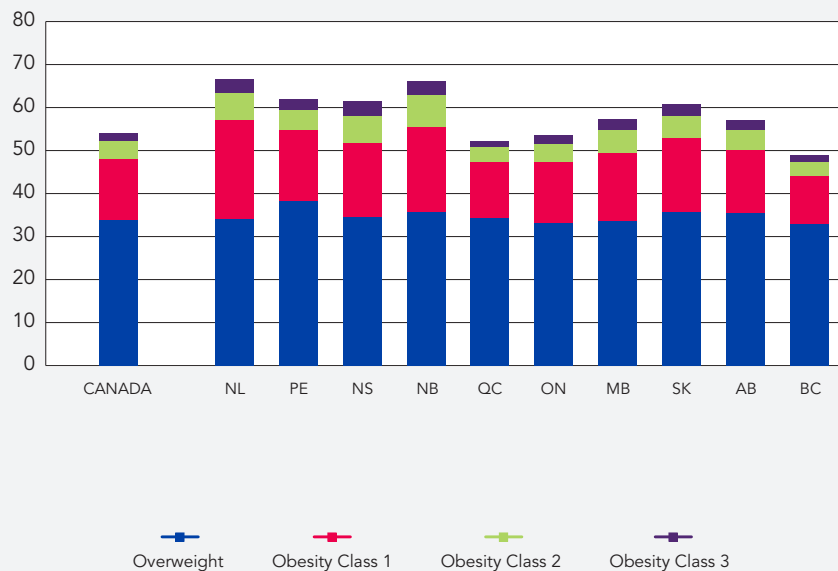


Figure 3: Percentage of the Population Aged 18+ Years Classified as Overweight, Obesity Class 1, Obesity Class 2 and Obesity Class 3, by Provinces Across Canada, 2015-2016 (Self-Report)*



*Data Sources for Figures 1a-3: i) Compiled by the Health Analytics and Evaluation Services Department, NL Centre for Health Information using Statistics Canada, Canadian Community Health Survey, Share File, 2001 – 2015–2016 ii) Twells et al. 2014.³

Increasing abdominal obesity is associated with significant health risks. In Canada, over the last three decades, abdominal obesity measured by waist circumference presents a concerning picture. Using measured waist circumference data and threshold cut-offs from Canadian health surveys conducted in 1981, 1988 and 2007–2009, the prevalence of abdominal obesity increased from 11.4% to 14.2% to 35.6%, respectively. Differences in waist circumference by sex are also reported. Over this time period men's average waist circumference increased by 6.5 cm while for women the average increase was 10.6 cm.²² Temporal changes in obesity, based on waist circumference, are more pronounced than changes in BMI. In 1981, for each unit increase in BMI, the equivalent increase in waist circumference was 1.98 cm compared to in 2007–2009, when a unit increase in BMI was equivalent to an increase in waist circumference of 2.22 cm. In adults affected by obesity, 93% have a waist circumference that places them at an increased health risk.^{22,23} This data illustrates that the obesity phenotype or what obesity looks like may be changing and the risks associated with this change in abdominal obesity may be even more significant and place a larger burden on individuals, the health system and society than increasing health risk associated with BMI.

In Canada, the prevalence of excess body weight (overweight and obesity) in children (six to 17 years) has increased over the last four decades. Using the World Health Organization criteria for children,²⁴ the prevalence of overweight and obesity increased from 23.3% in 1978/79 to 31.4% in 2014. However, similar to adult trends, data from the last ten years suggest the prevalence of overweight and obesity in children may have stabilized.²⁵ Excess body weight differs significantly in children depending on sex, level of household income and place of residence. For example, obesity rates are higher: among 12–17-year-old boys (16.2%) than girls of the same age (9.3%), and in lower household income children (16.9%) than in higher income households (9.3%). Further, regional variations exist; in some regions of Canada the prevalence of overweight and obesity is 28.9%, while in others it is 65%.²⁵

Health risks of obesity

Obesity increases the risk of developing a number of complications.²⁶ Most concerning, it increases the risk of developing cardiovascular disease⁵ and cancer,^{27–30} two primary causes of premature mortality in Canada, resulting in a reduction of life expectancy by six to 14 years.^{5,31} It is estimated that 20% of all cancers can be attributed to obesity, independent of diet. Obesity increases the risk of colon, kidney, esophageal and pancreatic cancers in both sexes and endometrial and postmenopausal breast cancers in women.³⁰ Obesity also increases the risk of developing type 2 diabetes,³² gallbladder disease³³ and gout.³⁴ In addition to the aforementioned health problems, obesity is associated with functional limitations and psychological symptoms that impair quality of life. Obesity is associated with a nearly three-fold increased risk of osteoarthritis and changes in gait that negatively impact mobility. Pain associated with osteoarthritis leads to the avoidance of physical

activity, thus further contributing to functional limitations and increased risk for depression and anxiety and reduced quality of life.³⁵ Obesity is also associated with a higher risk of many mental health conditions. For example, individuals living with obesity are twice as likely to be diagnosed with a mood disorder compared to individuals.³⁶

Weight-related stigma is highly prevalent and occurs at home, places of employment, healthcare facilities, educational institutions and in the media. Negative societal attitudes, stigma and prejudice toward individuals living with obesity contribute to the large mental health burden observed. This bias negatively impacts the health of individuals through increased anxiety and depression, employment inequities, avoidance of healthcare professionals and inequitable treatment received in the healthcare system. Bias likely also contributes to the increased risk of mortality observed in individuals with obesity.⁶

Excess body weight, defined using BMI, increases the risk of mortality. This relationship has been clearly demonstrated in several large-scale studies, independent of sex and ethnicity. A meta-analysis of 239 studies of more than ten million individuals across four continents demonstrated that all classes of overweight and obesity were associated with an increased risk of all-cause mortality in every region in the world, with the exception of South Asia.⁴ The relationship between BMI and mortality risk in Asian populations has been demonstrated in other studies.³⁷ In another meta-analysis of 57 prospective cohort studies, including close to one million individuals living in Western Europe and North America, mortality risk in both men and women was lowest in the BMI range between 22.5–25 kilogram / square meter,⁵ and each 5 kg/m² increase in BMI above a BMI of 25 kg/m² was associated with a 30% increased risk of all-cause mortality. A dose response relationship has been shown to exist between increasing BMI classes and an increased risk of mortality.³⁸

Causes and contributors for obesity risk

The prevalence of obesity differs across demographic factors such as age, sex and ethnicity, as well as Indigenous and immigration status. In Canada, the prevalence of adult obesity increases with age.³ Between 2001 and 2012, a similar increase was observed in obesity (BMI \geq 30 kg/m²) for men and women, although there were differences in the obesity subgroups. A higher prevalence of Class I obesity was observed for men compared to women (15% versus 11.3%), while a lower prevalence of Class II and III obesity was observed for men compared to women (4.6% versus 5.7%) in 2011–2012.³⁹

Ethnicity appears to have an influence on the risk of developing obesity and obesity-related conditions. Within Ontario, there are similar rates of obesity in adults of white and black ethnicity (~18%), with much lower rates of obesity in South Asian (9.6%) and Chinese (4.2%) populations.⁴⁰ While this may seem a positive finding, there is evidence to suggest that cardiometabolic health

risk is increased at lower BMIs among Asian populations than among Caucasian populations. For example, despite a lower obesity prevalence in Asians, there is a higher prevalence of diabetes in South Asians and a comparable prevalence of diabetes in Chinese populations compared to white populations. When a BMI cut-off of 27.5 kg/m² is used, the rates of obesity in South Asian (19.3%) and West Asian (19.5%) populations, compared to the national Canadian average are comparable over a similar time frame (~17%), while East Asian and South East Asian populations still report a much lower rate even with the lower BMI cut-offs (8.2 to 14.9%).⁴¹

According to self-reported data from the 2006 Aboriginal Peoples Survey, the prevalence of adult obesity was similar for Inuit, Metis and off-reserve First Nations populations (i.e. 23.9%, 26.4% and 26.1%, respectively). For on-reserve First Nation adults, self-reported estimates of obesity were much higher (36%). As self-reported data generally underestimates the prevalence of measured obesity, the actual prevalence of obesity in Indigenous populations is likely higher.⁴²

Immigration status is associated with the prevalence of obesity. According to the 2016–2017 Canadian Health Measures Survey, immigrants are less likely to be living with obesity (17%) compared to non-immigrants (30%).²¹

Socio-cultural factors such as education and income and environmental factors such as whether individuals live in urban versus rural areas are associated with differences in obesity risk.⁴³ Although education and income are correlated, it appears they are associated with obesity differently in men and women. While income and education are inversely associated with obesity in Canadian women, the relationship between socioeconomic status is weaker in Canadian men, with income demonstrating a positive relationship with obesity.⁴⁴ The relationship between socioeconomic status and obesity is complex and may be mediated in part by socio-cultural factors at the individual level. Differences in the prevalence of obesity across geographical regions in Canada are not entirely predicted by income, education and health behaviour factors.⁴⁵ This points to other system-level factors including government policy, the provision of and access to healthcare services, and regional food and built environments that influence how people live and work.

While a significant amount of research has focused on individual level behaviours such as food intake and levels of physical activity that are associated with obesity, the relationship is not well defined.⁴⁶ While obesity rates have increased in Canada over the last three decades, data collected from population level surveys report that calorie intake has in fact decreased and leisure time physical activity increased over the same time periods.^{47,48} Other contributors within our modern environment increase the risk of developing obesity, such as medication use, chronic stress, insufficient sleep, decreased smoking rates and modern energy-saving conveniences such as cars, remote controls, washing machines, etc. Many of these factors are associated with small changes in appetite or energy expenditure and demonstrate secular trends that mirror the rise in obesity.^{49,50} In the case of medications, several pharmaceuticals used for treating comorbidities commonly associated with

obesity, such as depression, hypertension and diabetes, are known to promote weight gain.⁵¹ Thus, patients can find themselves in a paradoxical situation in that treatment for their obesity-related conditions also exacerbates their obesity.

Assessment of obesity risk is challenging

Health professionals should not rely solely on BMI to predict an individual's health risk. Although high BMIs are associated with an increase in morbidity and mortality risk at a population level, a high BMI may not be associated with poor health at the individual or patient level.⁵² Thus, while BMI may be used for initial screening, the assessment and diagnosis of obesity and its impact on patient health requires additional assessment and diagnosis. This is very important because there is substantial variation in health profiles observed between individuals with the same BMI. To add to this complexity, individuals with an elevated BMI may be described as “metabolically healthy” if they present without other obesity-related complications.⁵² However it may be that metabolically healthy individuals affected by obesity, defined using BMI are in transition to developing obesity-related complications. Therefore, health professionals should be aware of this risk and any mediating factors, such as levels of physical activity.^{53,54}

Conclusion

In Canada, the prevalence of obesity increased three-fold over the last three decades and now affects one in four adults. Obesity, when defined by BMI, appears to have levelled off in the last ten years. In contrast, when based on waist circumference, obesity continues to increase and is changing the obesity phenotype, which is concerning. Obesity and related complications negatively impact health and quality of life, taking years off life expectancy. In Canada, the increasing humanistic, health system and societal burden of obesity is significant and does not discriminate, affecting individuals across age, sex, ethnicity, geographical region and socioeconomic class. The complex etiology of obesity has contributed to pervasive bias and stigma in the healthcare system and within society as a whole, and has hindered progress in managing obesity as a chronic disease. An urgent mobilization of knowledge and resources, and a collective effort is required to reduce the far-reaching and significant impact of obesity, a life-threatening disease, on the Canadian population.

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The summary of the Canadian Adult Obesity Clinical Practice Guidelines is published in the [Canadian Medical Association Journal](https://www.cma.ca/journal/), and contains information on the full methodology, management of authors' competing interests, a brief overview of all recommendations and other details. More detailed guideline chapters are published on the Obesity Canada website at www.obesitycanada.ca/guidelines.

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References

1. World Health Organization. Obesity and Overweight. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>. Published 2018.
2. Statistics Canada. Table 13-10-0096-20. Body mass index, overweight or obese, self-reported, adult, age groups (18 years and older). doi:10.25318/1310009601-eng
3. Twells LK, Gregory DM, Reddigan J, Midodzi WK. Current and predicted prevalence of obesity in Canada: A trend analysis. *CMAJ Open*. 2014;2(1):E18-E26. doi:10.9778/cmajo.20130016
4. Global BMI Mortality Collaboration, Di Angelantonio E, Bhupathiraju SN, et al. Body-mass index and all-cause mortality: Individual-participant-data meta-analysis of 239 prospective studies in four continents. *Lancet*. 2016;388(10046):776-786. doi:10.1016/S0140-6736(16)30175-1
5. Prospective Studies Collaboration, Whitlock G, Lewington S, et al. Body-mass index and cause-specific mortality in 900 000 adults: Collaborative analyses of 57 prospective studies. *Lancet*. 2009;373(9669):1083-1096. doi:10.1016/S0140-6736(09)60318-4
6. Sutin AR, Stephan Y, Terracciano A. Weight discrimination and risk of mortality. *Psychol Sci*. 2015;26(11):1803-1811. doi:10.1177/0956797615601103
7. Swinburn BA, Kraak VI, Allender S, et al. The global syndemic of obesity, undernutrition, and climate change: The Lancet Commission report. *Lancet*. 2019;393(10173):791-846. doi:10.1016/S0140-6736(18)32822-8
8. Anis AH, Zhang W, Bansback N, Guh DP, Amarsi Z, Birmingham CL. Obesity and overweight in Canada: An updated cost-of-illness study. *Obes Rev*. 2010;11(1):31-40. doi:10.1111/j.1467-789X.2009.00579.x
9. Public Health Agency of Canada. Obesity in Canada – Health and economic implications. <https://www.canada.ca/en/public-health/services/health-promotion/healthy-living/obesity-canada/health-economic-implications.html>. Published 2011.
10. Gupta S, Richard L, Forsythe A. The humanistic and economic burden associated with increasing body mass index in the EU5. *Diabetes, Metab Syndr Obes Targets Ther*. 2015;8:327-338. doi:10.2147/DMSO.S83696
11. Goettler A, Grosse A, Sonntag D. Productivity loss due to overweight and obesity: A systematic review of indirect costs. *BMJ Open*. 2017;7(10):e014632. doi:10.1136/bmjopen-2016-014632
12. James WPT. WHO recognition of the global obesity epidemic. *Int J Obes*. 2008;32:S120-S126. doi:10.1038/ijo.2008.247
13. WHO Consultation on Obesity. Obesity: Preventing and Managing the Global Epidemic: Report of a WHO Consultation. Geneva; 2000.
14. Health Canada. Canadian Guidelines for Body Weight Classification in Adults - Quick Reference Tool for Professionals. https://www.hc-sc.gc.ca/fn-an/alt_formats/hpfb-dgpsa/pdf/nutrition/cg_quick_ref-ldc_rapide_ref-eng.pdf. Published 2003.
15. Burkhauser R V., Cawley J. Beyond BMI: The value of more accurate measures of fatness and obesity in social science research. *J Health Econ*. 2008;27(2):519-529. doi:10.1016/j.jhealeco.2007.05.005
16. Health Canada. Canadian Guidelines for Body Weight Classification in Adults - Quick Reference Tool for Professionals. <https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating/healthy-weights/canadian-guidelines-body-weight-classification-adults/quick-reference-tool-professionals.html>. Published 2016.
17. Padwal RS, Pajewski NM, Allison DB, Sharma AM. Using the Edmonton obesity staging system to predict mortality in a population-representative cohort of people with overweight and obesity. *CMAJ*. 2011;183(14):E1059-E1066. doi:10.1503/cmaj.110387
18. Public Health Agency of Canada. Obesity in Canada – Snapshot. Figure 1. <https://www.canada.ca/en/public-health/services/reports-publications/obesity-canada-snapshot.html>. Published 2012.
19. Public Health Agency of Canada. Obesity in Canada – Snapshot. Figure 2. <https://www.canada.ca/en/public-health/services/reports-publications/obesity-canada-snapshot.html>. Published 2012.
20. Public Health Agency of Canada. Obesity in Canada – Snapshot. Figure 3a and 3b. <https://www.canada.ca/en/public-health/services/reports-publications/obesity-canada-snapshot.html>. Published 2012.
21. Statistics Canada. Obesity in Canadian Adults, 2016 and 2017. <https://www150.statcan.gc.ca/n1/en/pub/11-627-m/11-627-m2018033-eng.pdf?st=ltWJ3ou>. Published 2018.
22. Janssen I, Shields M, Craig CL, Tremblay MS. Prevalence and secular changes in abdominal obesity in Canadian adolescents and adults, 1981 to 2007-2009. *Obes Rev*. 2011;12(6):397-405. doi:10.1111/j.1467-789X.2010.00815.x
23. Janssen I, Shields M, Craig CL, Tremblay MS. Changes in the obesity phenotype within Canadian children and adults, 1981 to 2007-2009. *Obesity*. 2012;20(4):916-919. doi:10.1038/oby.2011.122
24. World Health Organization. WHO Child Growth Standards. *Dev Med Child Neurol*. 2009;51(12):1002-1002. doi:10.1111/j.1469-8749.2009.03503.x
25. Rao DP, Kropac E, Do MT, Roberts KC, Jayaraman GC. Childhood overweight and obesity trends in Canada. *Heal Promot Chronic Dis Prev Canada Res Policy Pract*. 2016;36(9):194-198. doi:10.24095/hpcdp.36.9.03
26. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: A systematic review and meta-analysis. *BMC Public Health*. 2009;9:88. doi:10.1186/1471-2458-9-88
27. Aune D, Greenwood DC, Chan DSM, et al. Body mass index, abdominal fatness and pancreatic cancer risk: A systematic review and non-linear dose-response meta-analysis of prospective studies. *Ann Oncol*. 2012;23(4):843-852. doi:10.1093/annonc/mdr398

28. Aune D, Rosenblatt DAN, Chan DSM, et al. Anthropometric factors and ovarian cancer risk: A systematic review and nonlinear dose-response meta-analysis of prospective studies. *Int J Cancer*. 2015;136(8):1888-1898. doi:10.1002/ijc.29207
29. Aune D, Navarro Rosenblatt DA, Chan DS, et al. Anthropometric factors and endometrial cancer risk: A systematic review and dose-response meta-analysis of prospective studies. *Ann Oncol*. 2015;26(8):1635-1648. doi:10.1093/annonc/mdv142
30. Wolin KY, Carson K, Colditz GA. Obesity and cancer. *Oncologist*. 2010;15(6):556-565. doi:10.1634/theoncologist.2009-0285
31. Fontaine KR, Redden DT, Wang C, Westfall AO, Allison DB. Years of life lost due to obesity. *J Am Med Assoc*. 2003;289(2):187-193. doi:10.1001/jama.289.2.187
32. Abdullah A, Peeters A, de Courten M, Stoelwinder J. The magnitude of association between overweight and obesity and the risk of diabetes: A meta-analysis of prospective cohort studies. *Diabetes Res Clin Pract*. 2010;89(3):309-319. doi:10.1016/j.diabres.2010.04.012
33. Aune D, Norat T, Vatten LJ. Body mass index, abdominal fatness and the risk of gallbladder disease. *Eur J Epidemiol*. 2015;30(9):1009-1019. doi:10.1007/s10654-015-0081-y
34. Aune D, Norat T, Vatten LJ. Body mass index and the risk of gout: A systematic review and dose-response meta-analysis of prospective studies. *Eur J Nutr*. 2014;53(8):1591-1601. doi:10.1007/s00394-014-0766-0
35. Blagojevic M, Jinks C, Jeffery A, Jordan KP. Risk factors for onset of osteoarthritis of the knee in older adults: A systematic review and meta-analysis. *Osteoarthritis Cartil*. 2010;18(1):24-33. doi:10.1016/j.joca.2009.08.010
36. Gadalla TM. Association of obesity with mood and anxiety disorders in the adult general population. *Chronic Dis Can*. 2009;30(1):29-36.
37. Zheng W, McLerran D, Rolland B, et al. Association between body-mass index and risk of death in more than 1 million Asians. *N Engl J Med*. 2011;364(8):719-729. doi:10.1056/NEJMoa1010679
38. Kitahara CM, Flint AJ, Berrington de Gonzalez A, et al. Association between class III obesity (BMI of 40-59 kg/m²) and mortality: A pooled analysis of 20 prospective studies. *PLoS Med*. 2014;11(7):e1001673. doi:10.1371/journal.pmed.1001673
39. Navaneelan T, Janz T. Adjusting the scales: Obesity in the Canadian population after correcting for respondent bias. *Stat Canada Cat no 82-624-X*. 2014:1-10.
40. Chiu M, Maclagan LC, Tu J V., Shah BR. 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. *BMJ Open*. 2015;5(8):e007232. doi:10.1136/bmjopen-2014-007232
41. Nie JX, Ardern CI. Association between obesity and cardiometabolic health risk in Asian-Canadian sub-groups. *PLoS One*. 2014;9(9):e107548. doi:10.1371/journal.pone.0107548
42. Public Health Agency of Canada. Obesity in Canada – Prevalence among aboriginal populations. <https://www.canada.ca/en/public-health/services/health-promotion/healthy-living/obesity-canada/prevalence-among-aboriginal-populations.html>. Published 2011.
43. Public Health Agency of Canada. Obesity in Canada – Determinants and contributing factors. <https://www.canada.ca/en/public-health/services/health-promotion/healthy-living/obesity-canada/factors.html>. Published 2011.
44. Hajizadeh M, Karen Campbell M, Sarma S. Socioeconomic inequalities in adult obesity risk in Canada: Trends and decomposition analyses. *Eur J Heal Econ*. 2014;15(2):203-221. doi:10.1007/s10198-013-0469-0
45. Dutton DJ, McLaren L. How important are determinants of obesity measured at the individual level for explaining geographic variation in body mass index distributions? Observational evidence from Canada using Quantile Regression and Blinder-Oaxaca Decomposition. *J Epidemiol Community Health*. 2016;70(4):367-373. doi:10.1136/jech-2015-205790
46. Statistics Canada. Chart 3: Percentage at least moderately active in leisure-time, by province or territory, household population aged 12 or older, Canada, 2005. <https://www150.statcan.gc.ca/n1/pub/82-003-x/2006008/article/phys/c-g/4060706-eng.htm>. Published 2007.
47. Statistics Canada. Health Fact Sheets: Nutrient intakes from food, 2015. <https://www150.statcan.gc.ca/n1/pub/82-625-x/2017001/article/14830-eng.htm>. Published 2017.
48. Gray-Donald K, Jacobs-Starkey L, Johnson-Down L. Food habits of Canadians: Reduction in fat intake over a generation. *Can J Public Heal*. 2000;91(5):381-385. doi:10.1007/bf03404812
49. Levine JA. Nonexercise activity thermogenesis - Liberating the life-force. *J Intern Med*. 2007;262(3):273-287. doi:10.1111/j.1365-2796.2007.01842.x
50. Keith SW, Redden DT, Katzmarzyk PT, et al. Putative contributors to the secular increase in obesity: Exploring the roads less traveled. *Int J Obes*. 2006;30(11):1585-1594. doi:10.1038/sj.sjo.0803326
51. Wharton S, Raiber L, Serodio KJ, Lee J, Christensen RAG. Medications that cause weight gain and alternatives in Canada: A narrative review. *Diabetes Metab Syndr Obes Targets Ther*. 2018;11:427-438. doi:10.2147/DMSO.S171365
52. Kramer C, Zinman B, Retnakaran R. Are metabolically healthy overweight and obesity benign conditions?: A systematic review and meta-analysis. *Ann Intern Med*. 2013;159(11):758-769. doi:10.7326/0003-4819-159-11-201312030-00008
53. Phillips CM. Metabolically healthy obesity across the life course: Epidemiology, determinants, and implications. *Ann N Y Acad Sci*. 2017;1391(1):85-100. doi:10.1111/nyas.13230
54. Wildman RP, Muntner P, Reynolds K, et al. The obese without cardiometabolic risk factor clustering and the normal weight with cardiometabolic risk factor clustering: Prevalence and correlates of 2 phenotypes among the US population (NHANES 1999-2004). *Arch Intern Med*. 2008;168(15):1617-1624. doi:10.1001/archinte.168.15.1617