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Obesity Trends and the Impact on Morbidity and Mortality Costs

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A look at the latest trends in obesity and an estimate of the impact of obesity on mortality and morbidity costs in the U.S. and Canada

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Executive Summary

Obesity is a significant public health issue resulting in poor health outcomes, increased medical costs, reduced productivity, increased disability and increased mortality. In the U.S., 42.4% of adults are obese (as of 2017–2018), and in Canada, 24.3% of adults are obese (as of 2019).

The prevalence of obesity varies by race and ethnicity and by key socioeconomic factors. By race and ethnicity, Asian adults had significantly lower rates of obesity than all other groups. White adults had the second-lowest rates of obesity, followed closely by Hispanic/Latino adults. Black/African American adults had the highest levels of obesity. Obesity levels are not significantly different by age in adulthood, but obesity levels for youths are lower than for adults. Measuring obesity in youths is different from measuring it in adults, given that youths are still growing and developing. Higher levels of education appear to be associated with lower levels of obesity. This relationship between education and obesity also influences an individual's children: higher rates of obesity were observed in children whose parents had less than a high school education. Where an individual lives also is associated with obesity levels. Rural areas tend to have higher rates of obesity than urban areas. These themes are fairly consistent between the U.S. and Canada.

Behavioral factors also have a relationship with obesity levels. Low physical activity and low consumption of fruits and vegetables were found to be associated with higher levels of obesity. Higher amounts of screen time also were associated with higher levels of obesity. Smoking was found to have a somewhat negative association with obesity; however, the health impacts of smoking are known to be very negative and should be considered separately.

Obesity rates have risen significantly since the 1960s and 1970s. This dramatic growth can be seen across states in the U.S. In 1985, no state in the U.S had an obesity rate above 15%, but this threshold rapidly increased to 20% in 1991, 25% in 2000, and 35% in 2012. By 2019, 12 states had obesity rates above 35%. From 1960–1962 to 2017–2018, the rates of obesity quadrupled for males and more than tripled for females in the U.S. Prior to 1980, obesity rates differed significantly by age and sex, but the differences had decreased significantly by the late 2010s. These trends were fairly consistent across all racial and ethnic groups except for Asian/Asian American adults, who experienced a flatter trend. In Canada, obesity rates saw significant increases from the 1980s to the early 2000s and leveled off starting in 2011. These changes are primarily driven by the rate of obesity for females, while the rate for males has been fairly stable.

Although there is no single driver of the increase in obesity levels, one hypothesis focuses on the impact of changes in the food environment. Access to low-cost junk food has increased, and the amount and distribution of wealth has changed over time. Individuals may have less access to fruits and vegetables and more access to processed high-sugar food and drinks.

Using the preceding obesity prevalence rates and other data points from our literature review, we analyzed the economic burden of obesity in the U.S. and Canada. Our analysis focused on obesity's impact on morbidity costs (measured as the difference in the cost of health care services between an individual with obesity and one without obesity) and to the loss of productivity due to disability and premature mortality (measured as the loss in potential earnings). The annual estimated morbidity cost impact in 2019 dollars is $172.0 billion in the U.S. and C$7.8 billion in Canada. The annual estimated economic impact of disability and premature mortality on productivity cost in 2019 dollars for the U.S. is $211.8 billion, comprising $130.9 billion for disability and $80.9 billion for mortality. The total economic impact for Canada is C$16.1 billion, comprising C$11.8 billion for disability and C$4.4 billion for mortality.

Our current estimate for the total combined U.S and Canadian costs (morbidity and productivity loss) attributed to obesity is approximately 6.2% higher on an annualized U.S. dollar basis than the 2009 estimates in a 2010 study published by The Society of Actuaries (Behan et al. 2010). The primary drivers of the difference between our estimate and the prior estimate include higher prevalence rates of obesity, cost growth due to inflation, and methodology differences (our analysis did not combine the overweight and obese population).

Additional research is needed to assess the more recent cost drivers, as there have been few cost studies in the last decade. The impact of obesity on comorbidities is well documented, but additional research is needed to understand the interrelation of COVID-19 and obesity in the short term and long term.

Section 1: Background and Scope

1.1 Background

Obesity has a far-reaching impact and has been the subject of extensive research following a rapid increase in obesity rates beginning in the 1980s in the U.S. (Fryar 2018) and the 1990s in Canada (Hodgson et al. 2011). Obesity rates have generally continued to rise, although at a slower rate, through 2018 (Fryar 2020). Obesity is associated with morbidity and mortality costs. As the prevalence of obesity rises for a given population or maintains a high level, these costs will be a significant burden for that population. Understanding the prevalence (the percentage of the population affected at a given time), trends in the prevalence (which could be driven by prolonged survival of individuals with obesity, as well as an increase in the number of individuals who are obese), and the cost of obesity for a given population is fundamental for key stakeholders. These stakeholders include policy makers who want to determine ways to reduce the cost and prevalence of obesity, public and private payers of life and health insurance who fund the cost of obesity, employers who want to increase the productivity of their workforce, and individuals who experience the impact of health and financial outcomes related to obesity.

1.2 Objectives

The objectives of this research are to examine the latest trends in obesity and develop an estimate of obesity's impact on morbidity, productivity loss from disability and productivity loss from premature mortality in the U.S. and Canada. The research addresses obesity prevalence and trends broken out by the following demographic and socioeconomic factors:

- Sex
- Age
- Race/ethnicity
- Social determinants (in general and specific to income and education)
- Smoking status
- Occupation/industry

The research also addresses the cost of obesity, focusing on the incremental (relative to non-obesity) cost associated with obesity. Morbidity costs include the cost of doctor visits, hospitalization and drug utilization. Morbidity costs as used in this paper include the additional utilization of medical care, as opposed to focusing only on the total cost per use. Costs related to productivity are generally measured by absenteeism (the cost of missed workdays) and "presenteeism" (the cost of reduced productivity due to obesity while at work). Lost productivity can result from disability or premature mortality.

1.3 Approach

The research conducted in preparing this report was based on a literature review, which was limited to articles published in 2010 or later. (Their source data could be prior to this period, given the time it takes to complete and publish research.) The articles were classified into three main categories: prevalence, trend and cost. An article may appear in multiple categories. The time periods, source data, methods, study objectives, variables studied and level of detail varied significantly across the articles. The final list of articles included was agreed upon with the SOA's Project Oversight Group (POG).

For the most part, the articles used the definition of obesity that is commonly used by the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) in the U.S. for adults. That definition uses body mass index (BMI) to define three weight categories in kg/m^2: normal weight, 18.50–

24.99; overweight, 25.00–29.99; and obese, 30.00 or higher. Although the BMI measurement is criticized because it is a surrogate measure of body fat (according to the CDC), it is commonly used because it is the easiest metric to measure. Obesity is frequently subdivided into categories: Class I, 30.00–34.99 kg/m^2; Class II, 35.00–39.99; and Class III, 40.00 or higher. Some articles combine overweight and obese. Some articles refer to Class II as severely obese and Class III as morbidly obese. Within this report, severely obese represents the combined Class II and Class III obesity categories.

The criteria used to measure BMI for youths differ from the criteria used for adults, as youths are still in the growth phase. In addition, BMI is a limited measurement of obesity in youths, since it does not account for other factors related to their growth and development. The two most common criteria used to estimate BMI in youths are the International Obesity Task Force (IOTF) criteria, which vary by age and sex, and the CDC age- and sex-specific growth charts. The IOTF provides age- and sex-specific BMI cutoff points for the classification of overweight and obese. The CDC growth charts classify BMI based on percentile: BMI less than the fifth percentile is underweight, BMI between the fifth and 85th percentiles is healthy weight, BMI between the 85th and 95th percentiles is overweight, and BMI greater than the 95th percentile is obese. The CDC growth charts were updated in 2000 to include two new BMI-for-age charts by sex for ages 2–20.

Some articles use BMI that is measured professionally, while others use self-reported BMI. Self-reported BMI is generally lower than BMI measured professionally, but self-reported data are easier and less expensive to collect in population-level surveys (Hodgson et al. 2011). Three main data sources are referenced for the U.S.: National Health and Nutrition Examination Survey (NHANES), which uses professionally measured BMI; Behavioral Risk Factor Surveillance System (BRFSS), which uses self-reported BMI; and Medical Expenditure Panel Survey (MEPS), which uses self-reported BMI. In some articles, the authors made an adjustment to account for the bias in self-reporting. Two main data sources are referenced for Canada: Canadian Community Health Survey (CCHS), which uses self-reported BMI (except 2005–2008, when both self-reported and professionally measured were collected), and Canadian Health Measures Survey (CHMS), which also uses self-reported data but has correction factors applied by Statistics Canada to adjust for respondent biases.

The terminology for races/ethnicities and sex differs across sources for this study. This report uses consistent terminology throughout based on the Society of Actuaries Research Institute's (SOA) preferred terminology. The OA prefers the categories "male" and "female" for sex, which is a biological concept, whereas the terms "men" and "women" apply to gender, which is a social, behavioral and legal concept. Fryar et el., Hales et al., Warren et al., Ogden et al., Dai et al., Wang et al., and Masters et al. are the sources that differ and use the categories "men" and "women" for sex. Additionally, Fryar et al., Hales et al., Ogden et.al. and Warren et al. use terminology for race/ethnicity that is inconsistent with the Institute's preferred language as follows:

This Report	Fryar et al., Hales et al., Ogden et al.	Warren et al.
Asian/Asian American	Non-Hispanic Asian	Asian
Black/African American	Non-Hispanic black	Black
Hispanic/Latino	Hispanic	LatinX
White	Non-Hispanic white	White

1.3.1 U.S. Analysis

In performing the U.S. cost analysis in section 3 of this report, we made the following assumptions:

1. Medical costs per use are trended forward to 2019 dollars, using the U.S. Medical Consumer Price Index (CPI) trend.
2. Nonmedical costs per use are trended forward to 2019 dollars, using the U.S. CPI All Items Less Food and Energy trend.
3. Utilization statistics are not trended.
4. Prevalence estimates used in the cost analysis are based on 2017–2018 prevalence data and not adjusted.

1.3.2 Canadian Analysis

In performing the Canadian cost analysis in section 3 of this report, we made the following assumptions:

1. Medical costs per use are trended forward to 2019 dollars, using the Price Index published in the 2020 National Health Expenditure Trends (NHEX) report from the Canadian Institute for Health Information (CIHI).
2. Nonmedical costs per use are trended forward to 2019 dollars, using Canadian CPI All Items Less Food and Energy trend.
3. Utilization statistics are not trended.
4. Prevalence estimates used in the cost analysis are based on 2019 prevalence data and not adjusted.

Section 2: Obesity Prevalence and Trends

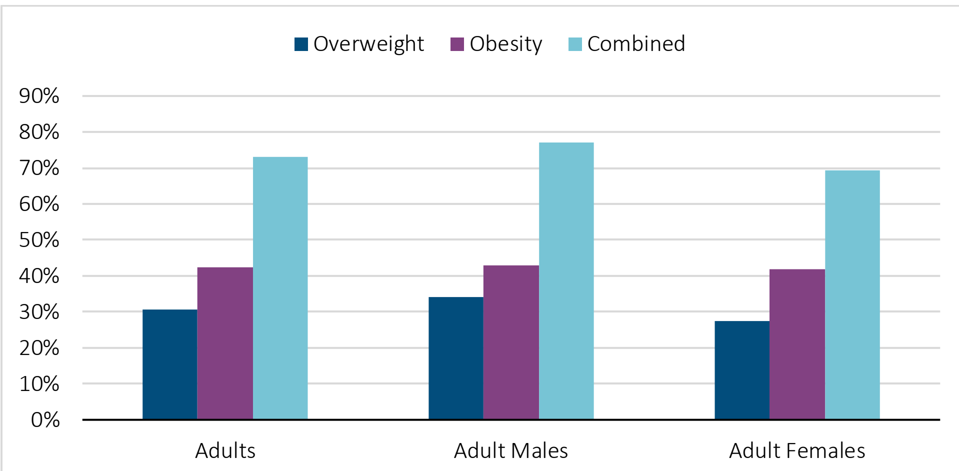
The prevalence of obesity is higher in the U.S. than in Canada, but patterns of differences by demographic factors are similar for the two countries. Both countries began to see a marked rise in obesity starting in the 1980s, but while the U.S. rate has continued to trend upward, it stabilized in Canada.

2.1 Obesity Prevalence

In 2017–2018, the age-adjusted prevalence of adult obesity in the U.S. was 42.4% when all ethnic groups were considered together, and the rate of Class III obesity was 9.2%, as shown by data collected from NHANES (Hales et al. 2020). In addition, 30.7% of adults were overweight. Figure 1 shows the percentage of the adult U.S. population that was overweight or obese in 2017–2018. However, these rates differ by education, sex, age, race/ethnicity, income and behavioral factors.

Figure 1

PREVALENCE OF OVERWEIGHT AND OBESITY AMONG ADULTS IN THE U.S., 2017–2018



Source: Fryar et al. (2020), based on NHANES 2017–2018.[1]

While Hales and his team found little effect of age on obesity rates among U.S. adults and little difference in rates of obesity between males and females based on the 2017–2018 NHANES data,they did find that while 6.9% of U.S. males were severely obese, 11.5% of U.S. females met that same description. Breaking out the data by race and Hispanic/Latino origin, they found that Asian/Asian American adults had the lowest rates of obesity and severe obesity (17.4% and 2.0%, respectively), whereas Black/African American adults had the highest rates (49.6% and 13.8%, respectively). White adults had rates of obesity and severe obesity closer to the national average (42.2% and 9.3%), as did Hispanic/Latino adults (44.8% and 7.9%). Broken out by sex, the obesity rates of Asian/Asian American males and females fell within two percentage points of one another, as did the rates of Hispanic/Latino males and females. However, there were significant differences in the rates of obesity between white and Black/African American males and females. Specifically, white males had higher rates of obesity than white females (44.7% versus 39.8%), whereas Black/African American females had higher rates of obesity than Black/African American males (56.9% versus 41.1%). Adult obesity rates are summarized in Figure 2.

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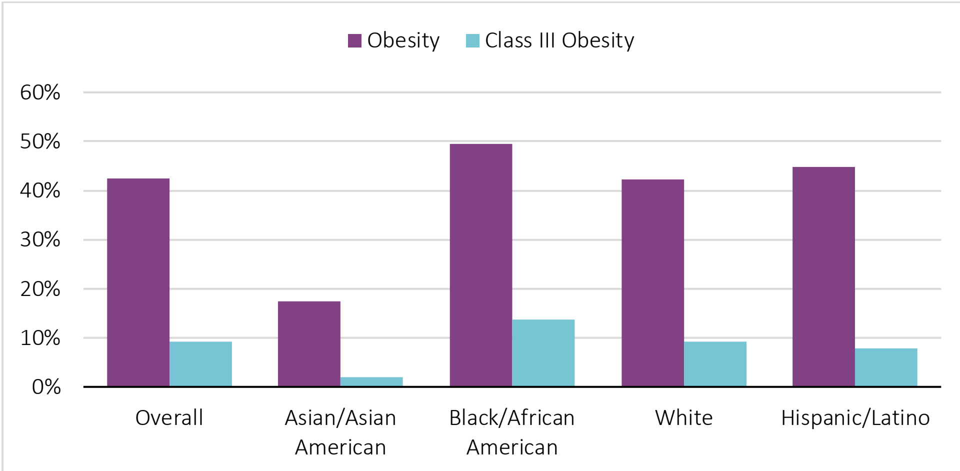
Figure 2

PREVALENCE OF OBESITY AND CLASS III OBESITY[1] AMONG ADULTS IN THE U.S., 2017–2018, BY RACE/ETHNICITY



[1]Class III obesity is a subset of obesity. Hales et al. (2020) define Class III obesity (BMI ≥40.00) as severe obesity, which differs from the definition of severe obesity used in this report.

Source: Hales et al. (2020).

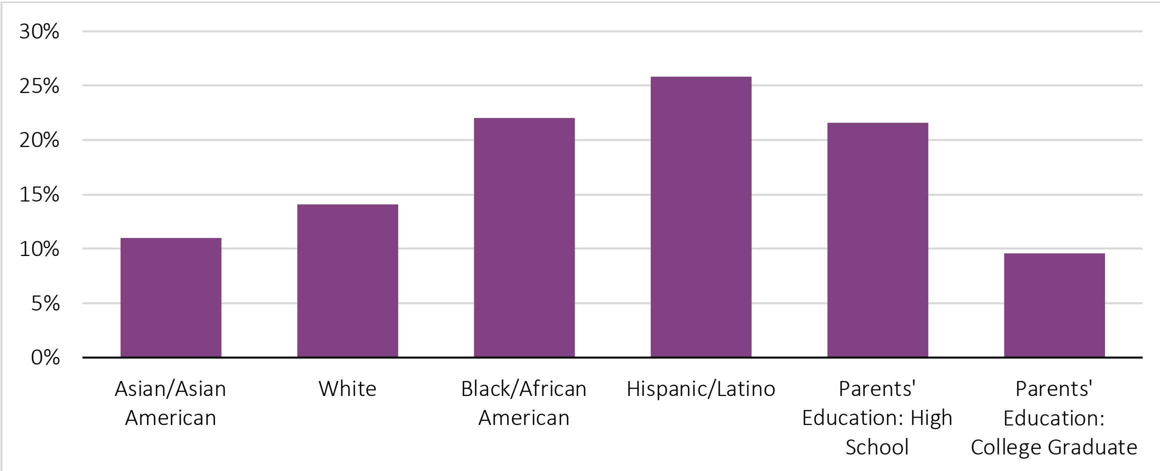
In addition to these factors, location and socioeconomic status also correlate with obesity rates. In particular, males in rural areas have higher rates of obesity and severe obesity than males in urban areas: 34.2% versus 28.7% and 9.9% versus 4.1%, respectively (Warren et al. 2020). In general, based on a review of 2011–2014 NHANES data, the more someone earns, the less likely they are to be obese. However, when the rates are broken out by sex, it becomes clear this trend is driven mainly by females. The prevalence of obesity among females decreases from 45.2% to 29.7% as their incomes increase, while males' obesity rates decrease from 32.6% to 31.5%, a change of barely more than one percentage point (Ogden et al. 2017).

While age was not observed to have a direct effect on obesity rates for U.S. adults (Hales et al. 2020), rates of obesity in youths are significantly lower than those for adults. Drawing from the same database as Hales and his team, Warren and colleagues (2020) found that rates of obesity among U.S. youths ranged from 11.0% to 25.8% when broken out by race and ethnicity. In a pattern resembling the data for adults, Asian/Asian Americans youths had the lowest rate of obesity, at 11.0%, followed by white youths, at 14.1%. Black/African Americans and Hispanic/Latino youths had obesity rates of 22.0% and 25.8%, respectively.

Based on unadjusted self-reported BMI from the 2017 BRFSS data, higher levels of education appear to be associated with lower levels of obesity. Specifically, 35.6% of those with a high school education or less were obese, compared with 22.7% of college graduates. Based on data from 2011–2014 NHANES, this association of education and obesity extends to children: obesity rates for children of parents with a high school education or less were measured at 21.6%, versus 9.6% for children with parents who had attained a college-level education or more. Childhood obesity rates are summarized in Figure 3.

Figure 3

PREVALENCE OF OBESITY AMONG CHILDREN IN THE U.S., 2015–2016, BY RACE/ETHNICITY AND PARENTS' EDUCATION



Source: Warren et al. (2020).

Based on the self-reported CCHS data for 2000–2005, the risk factors studied that were strong behavioral predictors of obesity were low physical activity and low consumption of fruits and vegetables. In contrast, smoking was negatively associated with obesity, and alcohol consumption was negatively associated with obesity for females but not for males (Hodgson et al. 2011). In addition, Hodgson's research, using 2007–2008 CCHS professionally measured information, showed that increased screen time correlates positively with obesity in both adults and youths. Based on unadjusted self-reported BMI from 2019 BRFSS data, physical inactivity differs across racial and ethnic lines in the U.S. in a way that roughly mirrors differential rates of obesity, with rates of 31.7% among Hispanic/Latino adults, 30.3% among Black/African American adults and 23.4% among white adults (Warren et al. 2020). Furthermore, differences in activity level correlate with neighborhood safety and access to parks, gyms, sidewalks, bike trails and other resources for physical activity. Convenient access to these leisure activities and a secure supply of fruits and vegetables are both correlated with socioeconomic status, suggesting that access to recreation and fruits and vegetables may serve as mediating variables in the correlation between socioeconomic status and obesity rates.

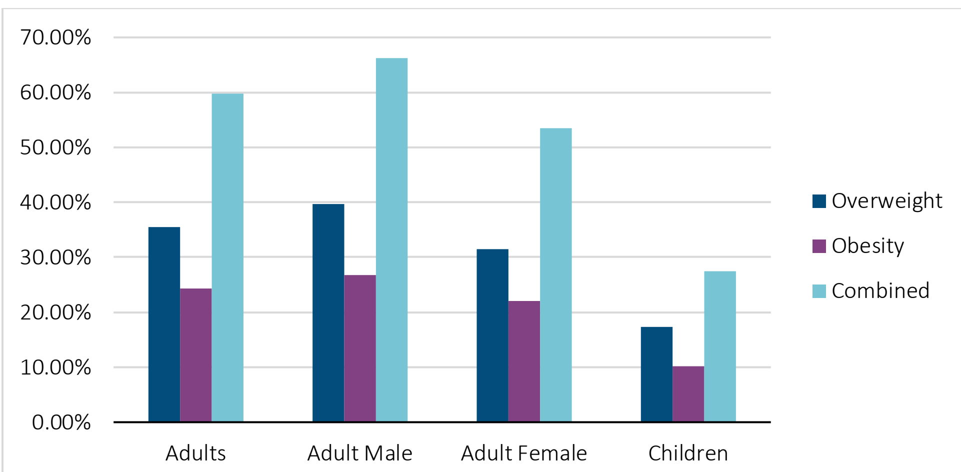
Researchers have also used professionally measured BMI to study the relationship between job type (blue-collar, white-collar or service workers) and health risk factors that potentially contribute to obesity. After adjusting for demographic factors—including sex, age, marital status, level of educational achievement, annual household income, race and ethnicity—in a review of Rhode Island employees, Gans and colleagues (2015) found no significant difference in BMI by job type. The Gans study indicates that although the prevalence of obesity varies by job type, the primary drivers are the underlying demographic and health risk factors for the individuals.

A focused review of Washington state employees used self-reported BMI from the 2003, 2005, 2007 and 2009 BRFSS data (excluding later years due to changes in the BRFSS methodology in 2011) before adjusting for demographic factors. The researchers found that obesity prevalence and health risk factors varied substantially by occupation. Workers in protective services were 2.46 times more likely to be obese than workers in diagnosing occupations. Truck drivers and workers in transportation and material moving, protective services, and cleaning and building services had the highest prevalence of obesity. Healthy diets and physically demanding jobs were protective against obesity. Physically demanding jobs were self-reported into two categories: “mostly sitting or standing” or “mostly walking / mostly heavy labor or physically demanding job.” The occupations that reported having physically demanding jobs were cleaning and building services, farming, forestry, fishing and construction. Those providing cleaning and building services appear to have contradictory results, given their high obesity rate and physically demanding jobs. However, this contradiction is partially explained by two demographic factors: a higher concentration of Hispanic/Latino individuals and a higher concentration of low-income individuals. The study also found that obesity was associated with certain demographic and health risk factors. Obesity rates were higher at older working ages, in males and for those with the lowest income (Bonauto et al. 2014).

Many of the themes noted for the U.S. data were similar for Canada. In Canada, on an adjusted self-reported basis from the 2019 CHMS data, 35.5% of adults aged 18–79 were overweight, and 24.3% were obese. Rates for males were slightly higher, with 39.6% being overweight and 26.7% being obese. Rates for females were slightly lower: 31.4% overweight and 22.0% obese. Among children aged 5 to 17, 17.4% were overweight, and 10.1% were obese (Statistics Canada 2019b). These rates are summarized in Figure 4. As of 2018, overweight and obesity rates were lower for ages 20–34 than for ages 35–49 and 50–64, which had comparable rates. Obesity rates in Canada also vary by geography, with Quebec and British Columbia having lower adult obesity rates than the national average (Statistics Canada 2019a). Based on self-reported information from the 2000–2005 CCHS data, low income (especially for females) and rural residence were both associated with higher obesity rates.

Figure 4

PREVALENCE OF OVERWEIGHT AND OBESITY IN CANADA, 2019



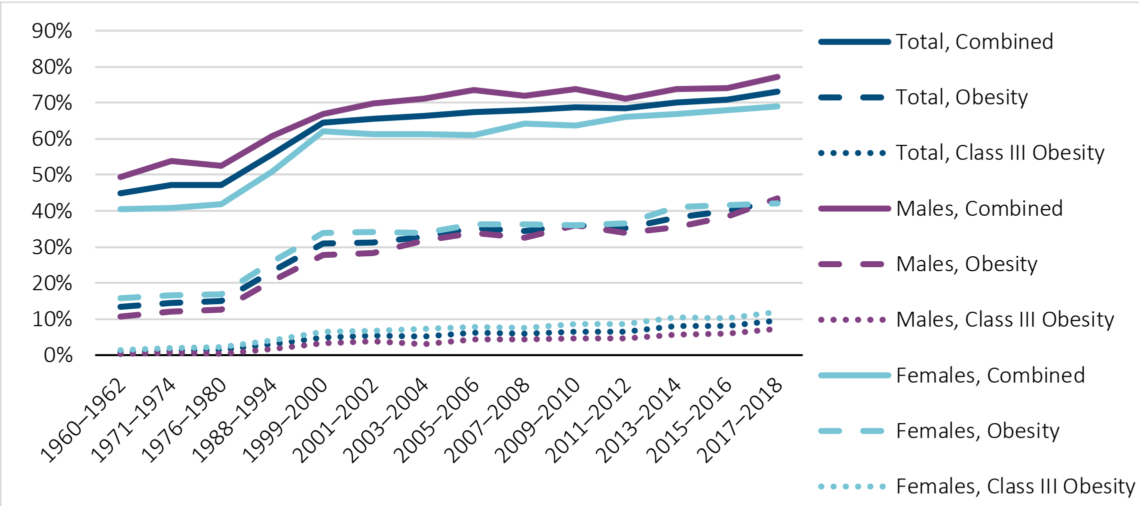
Source: Statistics Canada website, Table 13-10-0373-01.

2.2 Obesity Trends

Based on unadjusted self-reported BMI from the 2019 BRFSS data, in 1985 no state in the U.S. had an adult obesity rate above 15%. This threshold increased to 20% in 1991, 25% in 2000, and 35% in 2012. As of 2019, 12 states had an obesity rate above 35%, more than double the maximum rate just decades prior (Warren et al. 2020). In fact, the increase in BMI across the industrialized world since the 1960s–1970s possibly represents the fastest shift in observable human traits in world history, based on self-reported BMI data (Bentley et al. 2018). From 1960–1962 through 2017–2018, using data from NHANES, the rates of obesity quadrupled for males, from 10.7% to 43.5%, and almost tripled for females, from 15.8% to 42.1%. Similarly, for Class III obesity (defined by NHANES as BMI of 40.00 or more), there was an increase from 0.3% to 7.3% among males and from 1.4% to 12.0% among females. These trends are graphed in Figure 5.

Figure 5

TREND IN OVERWEIGHT, OBESITY, AND CLASS III OBESITY IN ADULTS IN THE U.S., 1960–1962 TO 2017–2018



[1]Combined includes overweight and obesity. Obesity includes Class III obesity. Fryar et al. (2020) define Class III obesity (BMI ≥40.00) as severe obesity, which is a different definition for severe obesity than used in this report.

Source: Fryar et al. (2020), based on NHANES 2017–2018 data.

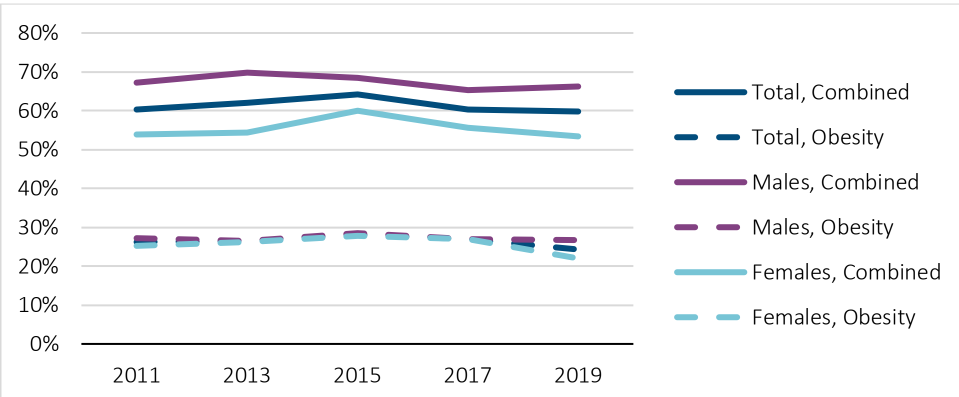
Prior to the 1980s, obesity rates differed significantly by age and sex (14.8% for males ages 20–39 versus 30.3% for females ages 40–59, for example), but by the late 2010s, the differences had decreased to, at most, a spread of 6.7 percentage points. At the same time, obesity rates among adults in the U.S. increased across all age groups to between 39.7% and 46.4%. Over that time frame, obesity rates increased across U.S. adults of all ethnic groups studied (white, Black/African American and Hispanic/Latino) by at least 18.9 percentage points overall. These rates increased more for males than for females across all ethnic groups: a 24.4-percentage-point increase among white males and a 16.9-percentage-point increase among white females, for example. Black/African Americans adults showed a smaller disparity, with a 20.0-percentage-point increase for males and an 18.5-percentage-point increase for females. Data for non-Hispanic Asians/Asian Americans was first reported in the 2011–2012 survey and for Hispanics/Latinos was first reported in the 2007–2008, so trends over the same period are not available. However, they do show that the one exception to these trends is Asian/Asian American adults, who have kept relatively low obesity levels (Fryar et al. 2020). Although this group seems like a stark outlier, Fryar and colleagues note that for Asians/Asian Americans, health problems due to obesity may occur at lower BMI levels than for other ethnic groups.

While there is no single cause behind this increase in obesity, regressions of physical activity over obesity rates favor what researchers call the human behavior ecology hypothesis over the social-learning hypothesis (Bentley et al. 2018). Essentially, rather than spreading from person to person like a social norm, the increase in obesity seems to have come about because of changes in both the food environment and the amount and distribution of wealth. Evolved mechanisms that increase fat stores in response to food scarcity promote obesity in wealthy countries, especially among poorer people with abundant access to cheap junk food (Bentley et al. 2018). In line with this claim, the two strongest behavioral predictors of obesity for males and females are low physical activity and low consumption of fruits and vegetables (Hodgson et al. 2011). Obesity is also positively correlated with food insecurity, which can reduce access to healthy food options (e.g., fruits and vegetables) and increase stress hormones that increase hunger as well as fat storage (Warren et al. 2020). Increasing commercial oversupply of processed foods and cheap access to high-sugar food and drink may alter choices in a way that drives people to overconsume and gain fat (Bentley et al. 2018).

In Canada, obesity rates saw significant increases from the 1980s to the early 2000s and leveled off starting in 2011 (Hodgson et al. 2011 and Statistics Canada 2019b), based on adjusted self-reported BMI data from the CHMS. Rates of obesity in adults have been fairly stable from 2011 to 2019 with a slight increase in 2015 to 28.1% and dropping in 2019 to the lowest level in this period: 24.3%. This differs from obesity trends in the U.S., which have continued to rise over the same period. The percentage of adults who were overweight in 2019 was up slightly from 2011, moving from 34.2% to 35.5%. These changes are primarily driven by the rates of overweight and obesity for females, while the rates for males have been fairly stable. These trends are illustrated in Figure 6. Among children aged 5–17, the rates of obesity and overweight have decreased from 2011 to 2019.

Figure 6

TREND IN OVERWEIGHT AND OBESITY AMONG ADULTS IN CANADA, 2011–2019



Note: Overweight and obesity based on measured body mass index by age group and sex. Combined includes overweight and obesity.

Source: Statistics Canada, Table 13-10-0373-01.

In a 2021 study of trends in cardiovascular risk factors, such as obesity, Dai and colleagues noted many similar themes for obesity trends in Canada as seen in the U.S. Their analysis was based on CCHS data for 2005–2016. They observed a continued increase in obesity and a decline in smoking prevalence. They also noted the geographic variation in obesity and the more notable impact on low-income individuals. They found that low income primarily affected females, which they hypothesized could be because males who earn a low income may be engaged in manual-labor jobs (Dai et al. 2021).

Section 3: Estimated Morbidity and Mortality Cost Associated With Obesity

This section provides our estimates of obesity-related morbidity and mortality cost, looking first at morbidity in the U.S. and Canada and then at mortality cost in each country.

3.1 Morbidity Costs Attributable to Obesity

We estimate total morbidity costs attributable to obesity in the U.S. and Canada were $177.9 billion in 2019, with the U.S. bearing $172.0 billion of that total. The following paragraphs break down our analysis.

3.1.1 U.S. Analysis

The morbidity costs attributable to obesity include the cost for services such as doctor visits, hospitalization and prescription drug utilization. The incremental cost associated with obesity is typically calculated in research studies as the difference in these costs for an individual with obesity and one without. The exact definition of morbidity costs differs by study. In a 2010 study, Goetzel and colleagues defined morbidity costs as doctor visits, emergency room visits and hospitalization. They reviewed a sample from over 10,000 individuals at National Heart, Lung, and Blood Institute sites in the U.S. from 2005 to 2007. They found that, after adjusting for covariates (age, sex, race/ethnicity, education, profession and smoking status), individuals classified as obese had 20% more doctors' visits and 26% more emergency room visits than normal-weight individuals. This resulted in an additional $76 for doctors' visits and $104 for emergency room visits per individual per year (adjusted from 2006 dollars used in the study to 2019 dollars). They did not find a statistically significant difference in hospitalization costs between obese and normal-weight individuals. They also did not observe a difference in utilization between overweight individuals and normal-weight individuals (Goetzel et al. 2010).

In a 2015 U.S. study, Wang and colleagues estimated morbidity costs by examining medical expenditures for adults with obesity relative to adults without obesity, based on 2007–2012 MEPS data. These expenditures are defined as the sum of direct payments for care provided, including out-of-pocket payments and payments by private insurance, Medicaid, Medicare and other sources. They adjusted for the following covariates: age, sex, race/ethnicity, insurance status, smoking status, marital status, education and geography. They found that health care expenditures attributable to obesity for individuals categorized as severely obese (BMI ≥35.00) was more than double the health care expenditures of those with moderate obesity (BMI 30.00–34.99). In addition, they looked at the percentage of spending paid by private and public programs. For ages 65 and older, 73% of the spending attributed to obesity was paid for by public programs, and 5% was paid for by private plans (Wang et al. 2015). This finding appears to be driven by the fact that individuals ages 65 and older are covered under the public Medicare program. For ages 18–64, 20% to 28% was paid by public programs, and 35% to 41% was paid by private plans (varied by age band, sex and obesity level) (Wang et al. 2015). The incremental per capita costs by age band and sex are shown in Table 1, adjusted from 2014 to 2019 dollars. The incremental costs were provided separately for moderate obesity (Class I) and severe obesity (Classes II and III). We blended the per capita costs by obesity level to create an overall estimate for obesity.

Table 1

ESTIMATED 2019 U.S. MORBIDITY COSTS ATTRIBUTABLE TO OBESITY

Sex	Age Band	U.S. Adult Population (Millions)	Incremental Annual Cost per Individual With Class I Obesity	Incremental Annual Cost per Individual With Class II & III Obesity	Class I Obesity Prevalence Estimate	Class II & III Obesity Prevalence Estimate	Total Annual Cost Estimate[1] (Billions)
Males	18–44	59.6	$505	$1,081	26.7%	13.6%	$16.8
	45–64	40.6	$1,108	$2,403	30.3%	16.1%	$29.4
	65+	24.0	$1,840	$3,804	28.7%	13.5%	$25.0
Females	18–44	58.3	$630	$1,380	17.9%	21.8%	$24.1
	45–64	42.7	$1,270	$2,751	21.3%	22.0%	$37.4
	65+	30.0	$2,124	$4,522	27.1%	16.2%	$39.3
Total	Total	255.3	$1,077	$2,267	24.6%	17.6%	$172.0

[1]Total cost is calculated as the product of the population times the annual cost times the prevalence for Class I and Class II & III. Totals in the table may not foot due to rounding.

Source: U.S. population data from U.S. Census Bureau, 2019 American Community Survey, Table ID S0101; additional data on annual cost per individual with Class I obesity and Class II and III obesity from Wang et al. (2015), adjusted to 2019 dollars; obesity prevalence from Hales et al. (2020).

The total estimated morbidity cost attributable to obesity was $172.0 billion, which is about 5.1% of the total health care expenditures for adults in the U.S. in 2019. Based on the National Health Expenditure Accounts (NHEA) from the Centers for Medicare and Medicaid Services (CMS), total health expenditures for the U.S. in 2019 were $3.8 trillion, or about 17.7% of the GDP. Age-specific data is not collected each year in the NHEA data, but we reviewed the available age-specific data from 2002–2014 and found that the percentage of spending for youths was fairly constant, ranging from 11.4% to 11.9%. We assumed that 88.6% of the total expenditures in 2019 were for adults. Although the prevalence of obesity does not vary dramatically by age, the cost per obese individual does increase with age.

3.1.2 Canadian Analysis

The health care delivery system in Canada differs significantly from the U.S. health care delivery system in both funding and payment. In addition, the Canadian obesity rates are lower than the U.S., and trends in obesity prevalence have been lower in Canada than the U.S.

A limited number of recently published studies address the cost of obesity in Canada. In a 2016 study, Blouin and colleagues focused on the morbidity cost of obesity in Quebec, finding that 69% of obesity-related costs came from hospitalizations, while 6% came from medical visits and 25% came from pharmacy costs. After adjusting for possible confounding variables, including age, sex, education status, smoking status and consumption of fruits and vegetables, they also found that drug utilization was 17% higher for overweight compared with normal-weight individuals and 49% higher for individuals with obesity compared with normal-weight individuals. Krueger and colleagues (2015) focused on the economic burden attributable to obesity and other risk factors. They used a population attributable fractions method to estimate the cost of various risk factors including obesity. They found that by geography, British Columbia had the lowest obesity prevalence rate (adjusted for age and sex) in Canada. They also noted that from a risk factor perspective, the largest economic burden had shifted from smoking to excess weight since their 2012 study.

Based on Krueger and colleagues' cost estimates per obese individual, combined with estimates of the population and population obesity prevalence, we created Table 2 to illustrate the incremental cost of obesity for the population. The estimated total impact of obesity-attributable morbidity costs is C$7.8 billion. Based on data from the Canadian Institute for Health Information, total health expenditure in 2019 was expected to be C$265.5 billion, which represents approximately 11.5% of Canada's 2019 GDP. The obesity-attributable costs of C$7.8 billion also represent 2.9% of the total health expenditures in 2019.

Table 2
ESTIMATED 2019 CANADIAN MORBIDITY COSTS ATTRIBUTABLE TO OBESITY

Sex	Canadian Population (Millions)	Additional Annual Cost per Obese Individual	Obesity Prevalence Estimate	Total Annual Cost Estimate[1] (Billions)
Males	18.7	C$869	24.5%	C$4.0
Females	18.9	C$1,043	19.6%	C$3.9
Total	37.6	C$944	22.1%	C$7.8

[1]Total annual cost is calculated as the product of the prior three columns. Totals in the table may not foot due to rounding.

Source: Canadian population data from the Statistics Canada website, updated on Sept. 29,2020, and reflecting the population estimate as of July 1, 2019, Table ID 17-10-0005-01; additional annual cost per obese individual from Krueger et al. (2015), adjusted to 2019 dollars and including all ages; obesity prevalence from the Statistics Canada website for 2019, based on the Canadian Health Measures Survey, Table ID 13-10-0373-01.

3.2 Excess Mortality Attributable to Obesity

The significant impact that obesity has on health can affect an individual's mortality. Findings about the impact of obesity on mortality have been divergent—that is, obesity has been found to sometimes reduce mortality and sometimes increase mortality (Masters et al. 2013). To assess the impact of obesity on excess or premature mortality, we reviewed two U.S. studies. No recent Canadian studies that met our criteria were available on the subject.

The first study we reviewed was an observational study of mortality rates in the Center for Disease Control's WONDER database of vital records for 1999–2016. This study looked at death certificates, which included ICD-10 coding for obesity-related conditions. Although these deaths may not have been caused solely by obesity, they show that obesity contributed to death (D'Souza et al. 2018). The authors of the study found that obesity-related age-adjusted mortality rates increased by 142% from 1999 to 2016. They also found that the obesity-related age-adjusted mortality rate for males was 173% higher than for normal weight, and for females, it was 117% higher than for normal weight (D'Souza et al. 2018).

The second study used a population attributable fraction approach to help address potential bias in the estimate of the impact of obesity on mortality. This study found that of the adult deaths between 1986 and 2006, the estimated percentages associated with overweight and obesity were 5.0% for Black/African American males and 15.6% for white males; for females, they were 26.8% and 21.7% for Black/African American and white females, respectively (Masters et al. 2013). The authors also considered the impact of the birth cohort since it affects a person's exposure to an obesogenic (tending to cause obesity) environment.

Preston and colleagues looked at the potential impact of obesity on mortality improvement in the U.S. They used NHANES data for 1988 thro/ugh 2010 with death records through 2011. They looked at the maximum BMI over an individual's lifetime adjusted for age and sex. They found that the increase in the maximum BMI from 1988 to 2011 is estimated to have reduced life expectancy at age 40 by 0.9 years in 2011 and accounted for 186,000 excess deaths. Their study shows that rising BMI has had a negative impact on overall mortality improvement (Preston et al. 2018).

3.3 Loss of Productivity Attributable to Obesity

Obesity has a negative effect on productivity by contributing to disability and premature mortality. Disability's impact on productivity is measured from an employer's perspective and can be broken into two categories: absenteeism and presenteeism. Absenteeism caused by obesity results in missed workdays and therefore reduced productivity. Presenteeism (being present at work but working at a slower pace or in a less efficient way) caused by obesity results in a reduction in an employee's productivity while at work. We focused on the cost of absenteeism. The impact to productivity from premature mortality is measured using a human-capital perspective, which involves estimating the lost earnings due to early death.

In 2014, Andreyeva and colleagues conducted a U.S. study that looked at data collected from NHANES for 1998–2008 and from BRFSS for 2012 to estimate the impact of obesity on absenteeism. For the 14,975 employees in their sample, they found that obesity was associated with a significant increase in missed workdays due to health issues. They did not find a similar result for overweight individuals. Compared with normal-weight individuals, the incremental number of missed workdays per year was +0.22 for overweight, +1.17 for obesity Class I, +1.71 for obesity Class II, and +1.88 for obesity Class III. This means that those with Class I obesity missed 27.4% more workdays than normal-weight employees, those with Class II obesity missed 40.0% more workdays, and those with Class III obesity missed 44.0% more workdays. These findings are after adjusting for age, sex, race/ethnicity, education, marital status and household income.

Across the U.S., obesity-related absenteeism accounted for 6.5% to 12.6% of all absenteeism and 9.3% on average. To estimate the cost impact of these missed workdays, the study authors pulled state-specific data on earnings from the Integrated Public Use Microdata Series–Current Population Survey (IPUMS-CPS) and calculated state-specific estimates of average earnings per day of work. The missed workdays for the year cost the U.S. an estimated $20.2 billion in 2019 dollars and prevalence level (Andreyeva et al. 2014). According to the U.S. Bureau of Labor Statistics (2020b), the total U.S. working population in 2019 was 157.6 million. These statistics are summarized in Table 3. State-level results per individual with obesity, adjusted to 2019 dollars, are detailed in the appendix.

Table 3

ESTIMATED IMPACT OF OBESITY ON ABSENTEEISM FOR U.S. EMPLOYEES COMPARED WITH NORMAL-WEIGHT EMPLOYEES

Obesity Level	Additional Annual Number of Missed Workdays	Additional Annual Cost per Person With Obesity	Estimated Prevalence	Additional Cost of Missed Workdays Related to Obesity[1] (Billions)
Class I	1.17	$248	24.7%	$9.6
Class II	1.71	$364	10.6%	$6.1
Class III	1.88	$399	7.1%	$4.5
Total obesity		$302	42.4%	$20.2

[1]Additional cost of missed workdays related to obesity is calculated as the product of the prior two columns times the total U.S. working population estimate (+157.6 million). Totals in the table may not foot due to rounding.

Source: Additional annual number of missed workdays and additional annual cost per person with obesity from Andreyeva et al. (2014), adjusted to 2019 dollars; obesity prevalence from Hales et al. (2020), adjusted by obesity class; U.S. population data from U.S. Bureau of Labor Statistics (2020b).

In a 2010 U.S. study, Goetzel and colleagues used 2006 data, which we adjusted to 2019 dollars, to estimate that the incremental annual cost of lost productivity per obese individual due to absenteeism was $394, which is about 30% higher than the estimate shown in Table 3 and uses different underlying data and methodology. This study also provided an estimated incremental annual cost of lost productivity per obese individual due to presenteeism of $276, adjusted to 2019 dollars (Goetzel et al. 2010). In a 2016 U.S. study, Asay and colleagues estimated (using 2015 data, which we adjusted to 2019 dollars) that the incremental annual cost of lost productivity per obese individual due to absenteeism was $293—comparable to the $302 shown in Table 3.

Another approach to estimating the incremental costs attributable to obesity is using a simulation model based on published incidence rates, relative risk associated with obesity, and estimated costs. Su and colleagues took this approach in their 2015 U.S. study based on underlying data for 5,221 individuals from 2005–2021 NHANES. In this study, they modeled the incremental cost associated with obesity by using three measures of the economic burden: lost personal income from unemployment, lower earnings from being employed but at a lower wage, Supplemental Security Income payments, and loss due to sick days for employers. They modeled these outcomes over a 10-year horizon by obesity level and by age band related to excess disability and mortality (Su et al. 2015). The results of the simulation model, adjusted to 2019 annual dollars, are shown in Tables 4a and 4b. The total U.S. working population taken from the U.S. Bureau of Labor Statistics (2020b) for 2019 is 157.6 million. Su and colleagues estimated that the additional annual cost per obese individual due to absenteeism, adjusted to 2019 dollars, was $248, which is about 20% below the estimate shown in Table 3. The estimate for the total incremental annual cost related to obesity is $211.8 billion.

Table 4a

ESTIMATED U.S. ECONOMIC BURDEN OF OBESITY ADJUSTED TO ANNUAL 2019 DOLLARS

Obesity Level	Incremental Lost Income per Capita	Incremental Lost Earnings per Capita	Incremental Supplemental Security Income Payments per Capita	Incremental Absenteeism Cost per Capita	Estimated Prevalence	Total Incremental Annual Cost Related to Obesity[1] (Billions)
Class I	$1,535	$124	$90	$237	24.7%	$77.3
Class II	$2,257	$1,162	$158	$271	10.6%	$64.3
Class III	$3,024	$2,584	$339	$316	7.1%	$70.1
Total obesity	$1,929	$767	$147	$248	42.4%	$211.8

[1]Total cost by obesity level is calculated as the sum of the per capita costs times the total U.S. working population estimate (+157.6 million) times the prevalence estimate. Totals in the table above may not foot due to rounding.

Source: Per capita estimates from Su et al. (2015), adjusted to 2019 dollars; U.S. population data from U.S. Bureau of Labor Statistics (2020b); obesity prevalence from Hales et al. (2020), adjusted by obesity class.

Table 4b

ESTIMATED U.S. ECONOMIC BURDEN OF OBESITY PER CAPITA BY AGE IN 2019 DOLLARS

Age Band	Incremental Lost Income per Capita	Incremental Lost Earnings per Capita	Incremental Supplemental Security Income Payments per Capita	Incremental Absenteeism Cost per Capita
20–44	$2,855	$767	$90	$260
45–64	$2,866	$1,873	$260	$305
65+	$598	$305	$34	$11

Source: Per capita estimates from Su et al. (2015), adjusted to 2019 dollars.

We used the formula to calculate the costs related to loss of productivity due to mortality, as presented in the 2010 SOA obesity study (Behan et al. 2010), to split the total incremental annual cost related to obesity of $211.8 billion into components for disability costs and mortality costs. We updated 2019 U.S. inputs for excess mortality, wages, benefits, population and obesity prevalence. The result is that the $211.8 billion U.S. annual cost estimate breaks down to $130.9 billion for disability costs and $80.9 billion for mortality costs.[2] Excess mortality is calculated as the difference in the expected working lifetime (ages 20–65) between the total population (including individuals with obesity) and the population not classified as obese. The 2019 period life table from the Social Security Administration is the basis for life expectancy, obesity prevalence is based on the obesity rate for ages 18–64 from Hales et al. (2020), and the hazard mortality rate (relative mortality rate for those with obesity relative to the non-obese population) by age is from a 2021 U.S. mortality study (Min et al. 2021). In this study, Min and colleagues found that the aggregate adjusted (by age, sex and smoking status) hazard mortality rate is 1.14 when comparing persons with and without obesity. Values for average wages, average benefits and the U.S. working population are sourced from the U.S. Bureau of Labor Statistics.

The economic burden of obesity increases with obesity level. In addition, the impact varies by age. Lost personal income and absenteeism cost are comparable for ages 20–44 and 45–64 but considerably lower for persons 65 and over, who generally are participating less in the workforce regardless of obesity. Lost earnings related to obesity are highest for persons aged 45–64, which shows the cumulative impact of not having been able to participate in the workforce over their lifetime in the same way as their counterparts not classified as obese, resulting in lower wages. Supplemental Security Income payments also are highest for this age band (the article does not clarify if this is due to frequency or size of the benefits but rather focuses on the total payments in the year), showing another significant difference between those who are or are not categorized as obese.

The Canadian studies we identified focused on the cost of disability (short-term and long-term) and premature mortality. Krueger and colleagues (2015) focused on the economic burden attributable to obesity for disability and mortality combined. They used a modified human capital approach to estimate the lost earnings over the individual's future lifetime due to disability or premature mortality. Based on their cost estimates per person with obesity, as well as estimates of the population and population obesity prevalence, we created Table 5 to illustrate the incremental cost of obesity for the population. The estimated total impact of obesity attributable to lost productivity from disability and premature mortality is C$16.1 billion.

Table 5

ESTIMATED 2019 CANADIAN DISABILITY AND MORTALITY COSTS ATTRIBUTABLE TO OBESITY

Sex	Canadian Population (Millions)	Additional Annual Cost per Person With Obesity	Obesity Prevalence Estimate	Total Annual Cost Estimate[1] (Billions)
Males	18.7	C$1,832	24.5%	C$8.4
Females	18.9	C$2,092	19.6%	C$7.8
Total	37.6	C$1,943	22.1%	C$16.1

[1]Total annual cost is calculated as the product of the prior three columns. Totals in the table may not foot due to rounding.

Source: Canadian population data from the Statistics Canada website, updated on September 29, 2020, and reflecting the population estimate as of July 1, 2019, Table ID 17-10-0005-01; additional annual cost per person with obesity from Krueger et al. (2015), adjusted to 2019 dollars and including all ages; obesity prevalence from the Statistics Canada website for 2019, based on the Canadian Health Measures Survey, Table ID 13-10-0373-01.

[2]U.S. mortality costs = average wages × average benefits × annual excess mortality × obesity prevalence at ages 18–64 × U.S. working population / years, so $55,135 × 145.66% × (8.025/12) × 43.0% × 157.6 million / 45 = $80.9 billion.

Using the same formula as the U.S. calculation with updated 2019 Canadian inputs for wages, benefits, population and obesity prevalence, the C$16.1 billion estimate breaks down to C$11.8 billion for disability costs and C$4.4 billion for mortality costs.[3] Average wages, Canadian working population and obesity prevalence (for ages 18–79) are sourced from Statistics Canada. Average benefits are from a 2015 Conference Board of Canada survey, adjusted to 2019 dollars. The estimate for excess mortality is assumed to be the same as in the U.S. calculation.

In the earlier SOA obesity study (Behan et al. 2010), the total 2009 estimate for loss of productivity (disability and premature mortality) attributed to the obese population was $132.0 billion (or $158.4 billion in 2019 dollars). The estimate was calculated in aggregate for U.S. and Canada on a U.S. dollar basis. Calculations were based on the overweight and obese population with extrapolation performed to calculate an obese-only estimate. After adjusting our 2019 Canadian estimate to a U.S. dollar basis, the current estimate of $223.9 billion (combined for U.S. and Canada) for productivity loss represents a 5.4% annualized trend from the previous study's estimate.

The estimated disability and premature mortality costs are more than twice the estimated morbidity costs associated with obesity in Canada. Looking at specific provinces, Blouin and colleagues (2016) estimated that the costs associated with disability for Quebec were C$0.72 billion, adjusted to a 2019 basis. In a 2011 Canadian study, Moffatt and colleagues focused on the impact of obesity in Alberta. They estimated that the costs associated with short-term disability were C$2.60 billion, and costs associated with long-term disability were C$0.78 billion. Their estimate includes both overweight and obese, while the other studies focused on obese only.

3.4 Discussion of Key Comorbidities

The impact of obesity is magnified by the associated impact of comorbidities. In adults, obesity increases the risk of many diseases, including type 2 diabetes, high blood pressure, heart disease, stroke, arthritis, depression, sleep apnea, liver disease, kidney disease, gallbladder disease, pregnancy complications and many types of cancer (Warren et al. 2020). For example, every additional 5 kg/m^2 in BMI increases a male's risk of esophageal cancer by 52%, a male's risk of colon cancer by 24%, a female's risk of endometrial cancer by 59%, a female's risk of gallbladder cancer by 59%, and a female's risk of postmenopausal breast cancer by 12% (Wang et al. 2011). In children, obesity increases the risk for certain diseases, including type 2 diabetes, high blood pressure and depression (Warren et al. 2020).

In addition to facing an increased risk of these comorbid conditions, individuals with obesity may also have worse outcomes. In a 2017 study, Ghanta and colleagues reviewed the medical records of individuals who underwent cardiac surgery. They found that the patients classified as morbidly obese had nearly 60% greater observed mortality than normal-weight patients. They also had a twofold increase in renal failure and 6.5 times the increase in deep sternal wound infection, as well as 17.2% higher medical costs (Ghanta et al. 2017).

This relationship was also observed in outcomes related to the recent COVID-19 outbreak. A primary cause of COVID-19 mortality is susceptibility to acute respiratory distress syndrome, which is significantly greater among individuals with obesity. Obesity increased the odds of hospitalization, and Class III obesity increased the odds of a COVID-19 patient being admitted to an intensive care unit (ICU). Based on a

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[3] Canadian mortality costs = average wages × average benefits × annual excess mortality × obesity prevalence at ages 18–79 × Canada working population / years, so C$54,204 × 116.55% × (8.025/12) × 22.1% × 19.1 million / 45 = C$4.4 billion.

systematic literature review, Popkin and colleagues (2020) found that individuals classified as obese were more at risk for being COVID-19 positive (+46%), hospitalization (+113%), ICU admission (+74%) and mortality (+48%). The study also notes that there is a potential for vaccines to be less effective in individuals with obesity, due to weakened immunity, but to date there have been no peer-reviewed articles documenting whether this is true.

Section 4: Conclusion

Our literature review shows obesity levels are continuing to increase in the U.S., while rates in Canada have leveled off in recent years. With prevalence rates for 2019 at 42.4% in the U.S. and 24.3% in Canada, obesity remains a public health concern. To help policy makers and society address this important issue, we developed cost estimates measuring the impact of obesity on morbidity and loss of productivity due to disability and premature death. Our estimates are summarized Table 6 with comparisons to the previous 2010 SOA obesity study (Behan et al. 2010).

Table 6

OBESITY COST IMPACTS

	U.S. 2019 Estimates (Billions)	Canada 2019 Estimates (Billions)	U.S. and Canada 2019 Estimates (Billions)	U.S. and Canada 2009 Estimates (Billions)	Estimated Annualized Trend Difference, U.S. and Canada, 2019 vs. 2009
Morbidity cost	$172.0	C$7.8	$177.9	$89.0	7.2%
Productivity cost (disability)	$130.9	C$11.8	$139.7	$89.0	4.6%
Productivity cost (premature mortality)	$80.9	C$4.4	$84.2	$43.0	6.9%
Total	$383.8	C$24.0	$401.8	$221.0	6.2%

Note: The 2009 morbidity cost estimate included excess costs from cancer, cardiovascular disease, diabetes, hypertension, kidney disease and stroke attributable to obesity, while the 2019 estimate includes all conditions. Totals in the table may not foot due to rounding.

Source: 2019 estimates from this report, with 2019 Canadian dollar estimates adjusted to a U.S. dollar basis, using a 0.75 conversion factor (Canadian to U.S. dollars) from December 2019; 2009 estimates from Behan et al. (2010).

More research is required to understand the cost impacts from more recent obesity trend drivers, including the toll of the COVID-19 pandemic, which is not reflected in our estimates.

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Appendix: State-Level Estimates of Obesity-Related Absenteeism Costs

Table A lists the state-level estimates of the percentage of absenteeism cost attributable to obesity and the annual cost of obesity-related absenteeism by obesity level from Andreyeva et al. (2014).

State	% of Absenteeism Cost Attributable to Obesity	Annual Cost per Person With Obesity			
		Class I	Class II	Class III	Total Obesity
Alabama	10.8%	$234	$344	$378	$283
Alaska	9.0%	$257	$378	$414	$313
Arizona	8.7%	$236	$348	$381	$283
Arkansas	12.6%	$226	$333	$365	$277
California	8.3%	$265	$389	$427	$312
Colorado	7.0%	$259	$382	$418	$308
Connecticut	8.7%	$305	$448	$491	$364
Delaware	8.9%	$270	$396	$435	$328
District of Columbia	6.5%	$332	$487	$534	$396
Florida	8.6%	$238	$349	$383	$283
Georgia	10.0%	$243	$357	$390	$293
Hawaii	8.2%	$210	$309	$339	$254
Idaho	8.9%	$216	$317	$348	$257
Illinois	9.1%	$267	$392	$430	$322
Indiana	10.2%	$244	$358	$392	$297
Iowa	10.3%	$226	$332	$364	$277
Kansas	10.0%	$233	$343	$375	$285
Kentucky	10.3%	$235	$345	$378	$287
Louisiana	11.7%	$234	$343	$376	$289
Maine	9.3%	$234	$343	$376	$282
Maryland	9.2%	$293	$430	$472	$349
Massachusetts	7.7%	$288	$423	$465	$344
Michigan	10.3%	$250	$368	$403	$304
Minnesota	8.6%	$254	$372	$407	$300
Mississippi	11.2%	$227	$334	$366	$280
Missouri	10.1%	$241	$355	$389	$295
Montana	8.5%	$203	$300	$328	$244
Nebraska	9.6%	$217	$319	$350	$258
Nevada	8.4%	$250	$367	$402	$295
New Hampshire	9.3%	$272	$399	$438	$330
New Jersey	8.2%	$312	$459	$503	$368
New Mexico	9.6%	$227	$334	$366	$277
New York	8.1%	$282	$414	$454	$339
North Carolina	9.7%	$242	$356	$390	$289
North Dakota	10.2%	$213	$313	$343	$257
Ohio	9.9%	$244	$358	$392	$297
Oklahoma	10.9%	$230	$336	$368	$279
Oregon	8.6%	$238	$349	$382	$280
Pennsylvania	9.5%	$258	$380	$415	$316
Rhode Island	8.5%	$254	$372	$407	$300
South Carolina	10.8%	$231	$339	$371	$283
South Dakota	9.5%	$200	$294	$321	$240
Tennessee	10.6%	$238	$349	$382	$290
Texas	9.7%	$246	$360	$396	$297
Utah	8.6%	$231	$340	$372	$279
Vermont	7.7%	$226	$332	$364	$269

Virginia	8.9%	$283	$417	$457	$342
Washington	8.8%	$271	$398	$436	$326
West Virginia	10.9%	$238	$349	$383	$291
Wisconsin	9.9%	$238	$349	$382	$287
Wyoming	8.5%	$235	$345	$379	$279
Total	9.3%	$248	$364	$399	$302

Source: Andreyeva et al. (2014), adjusted to 2019 dollars

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