Catalogue no. 82-003-X
ISSN 1209-1367

Health Reports

Assessing obesity beyond body mass index: Integrating physiological and functional indicators of impairment in national health surveillance

by Tracey Bushnik, Rachel Colley and Douglas G. Manuel

Release date: March 18, 2026

Statistics Canada Statistique Canada

Canada

How to obtain more information

For information about this product or the wide range of services and data available from Statistics Canada, visit our website, www.statcan.gc.ca.

You can also contact us by

Email at infostats@statcan.gc.ca

Telephone, from Monday to Friday, 8:30 a.m. to 4:30 p.m., at the following numbers:

- Statistical Information Service 1-800-263-1136
- National telecommunications device for the hearing impaired 1-800-363-7629
- Fax line 1-514-283-9350

Standards of service to the public

Statistics Canada is committed to serving its clients in a prompt, reliable and courteous manner. To this end, the Agency has developed standards of service which its employees observe in serving its clients. To obtain a copy of these service standards, please contact Statistics Canada toll-free at 1-800-263-1136. The service standards are also published on www.statcan.gc.ca under "Contact us" > "Standards of service to the public."

Note of appreciation

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued co-operation and goodwill.

Assessing obesity beyond body mass index: Integrating physiological and functional indicators of impairment in national health surveillance

by Tracey Bushnik, Rachel Colley, and Douglas G. Manuel

DOI: https://www.doi.org/10.25318/82-003-x202600300001-eng

ABSTRACT

Background

Body mass index (BMI) is commonly used to estimate obesity prevalence; however, reliance on BMI alone can lead to an incomplete understanding of obesity's impact on health. In line with the 2025 recommendations of the *Lancet Diabetes & Endocrinology* Commission, this study combines population-level measures of excess adiposity with indicators of physiological dysfunction and activity limitation across eight body system domains to characterize clinical and preclinical obesity among Canadian adults.

Data and methods

Measured and self-reported data from the 2016 to 2019 Canadian Health Measures Survey were used to define excess adiposity as measured BMI in the obese range plus elevated waist circumference. A three-tier system was used to capture progressive obesity-related impairment. At each tier, clinical obesity was defined by excess adiposity and indicators of impairment in one or more domains (Tier 1), two or more domains (Tier 2), or three or more domains (Tier 3). Preclinical obesity at each tier was characterized by excess adiposity with fewer indicators of impairment than the corresponding clinical thresholds. Prevalence estimates for these indicators and characterizations of obesity were calculated by sex and age group.

Results

Just over one in four Canadian adults had excess adiposity. Prevalence of physiological dysfunction and activity limitation indicators varied across domains and sex and age groups. Clinical and preclinical obesity prevalences were 19% and 8% at Tier 1, 12% and 15% at Tier 2, and 7% and 20% at Tier 3, respectively. Preclinical obesity—especially at tiers 1 and 2—was more common in younger adults and females.

Interpretation

Younger adults and females with excess adiposity were less likely to present with obesity-related physiological dysfunction or activity limitation, indicating early-stage impairment and highlighting opportunities for targeted prevention. Integrating measures of impairment when assessing obesity can refine population surveillance efforts.

Keywords

body mass index, obesity, adiposity, diagnosis, epidemiology, adult, prevalence

AUTHORS

Tracey Bushnik, Rachel Colley, and Douglas G. Manuel are with the Health Analysis and Modelling Division at Statistics Canada. Douglas G. Manuel is also with ICES in Ottawa, Ontario; the Department of Family Medicine at the University of Ottawa; and the C.T. Lamont Primary Health Care Research Centre at the Bruyère Research Institute in Ottawa, Ontario, Canada.

What is already known on this subject?

- Obesity is a persistent public health issue in Canada.
- Canadian clinical guidelines recommend using body mass index (BMI) along with waist circumference (WC) to classify individuals as having obesity; however, national estimates of obesity prevalence have typically been based solely on BMI.
- Reliance on BMI alone can lead to an incomplete understanding of obesity's impact on health.
- The *Lancet Diabetes & Endocrinology* Commission published recommendations in 2025 for establishing diagnostic criteria for chronic illness in obesity. It defined clinical obesity as excess adiposity accompanied by evidence of obesity-related organ or tissue dysfunction or limitations in daily activities. Preclinical obesity was defined as excess adiposity without accompanying signs or symptoms of obesity-related ill health.

What does this study add?

- To the authors' knowledge, this is the first study to combine population-level measures of excess adiposity with indicators of obesity-related impairment—physiological dysfunction and activity limitations—across eight body system domains to characterize clinical and preclinical obesity among Canadian adults.
- Just over one in four Canadian adults had excess adiposity, defined as BMI in the obese range combined with elevated WC.
- The prevalence of indicators of impairment varied across body system domains and sex and age groups.
- Tier 1 clinical obesity was characterized as excess adiposity plus at least one indicator of impairment; it had a prevalence of 19%. Preclinical obesity was characterized as excess adiposity plus zero indicators, with a prevalence of 8%.
- Tiers 2 and 3 required indicators of impairment to be present in at least two and three body system domains, respectively. Clinical and preclinical prevalences were 12% and 15% at Tier 2, and 7% and 20% at Tier 3.
- Younger adults and females with excess adiposity were less likely to present with indicators of obesity-related impairment.

Obesity is a persistent public health issue in Canada.[1,2] In population health surveillance, body mass index (BMI) is the most commonly used metric to estimate the prevalence of obesity.[3,4] However, it is acknowledged that BMI-based definitions of obesity can misrepresent both body fat and health risks, producing an incomplete picture of obesity's impact on health.[3-5] Furthermore, the impact of obesity is often evaluated as a risk factor for other diseases, rather than as a direct contributor to chronic, systemic ill health.[5]

To address these concerns, a global expert group—the *Lancet Diabetes & Endocrinology* Commission—was convened to establish diagnostic criteria for chronic illness in obesity. In 2025, the commission released its recommendations, introducing a new diagnostic framework that emphasizes measures of body fat and objective indicators of obesity-related ill health.[5] The framework defines two categories of obesity—clinical obesity and preclinical obesity—each with its own management and treatment pathway. Clinical obesity is characterized by excess body fat—evidenced by at least two direct measures of body size, such as BMI indicative of obesity and an elevated waist circumference (WC), or by direct body fat measurements, such as a dual-energy X-ray absorptiometry (DEXA) scan—together with signs or symptoms of obesity-related organ or tissue dysfunction or reduced capacity to perform daily activities. Preclinical obesity is characterized by excess body fat without accompanying signs or symptoms of obesity-related ill health. The commission outlined diagnostic criteria for obesity-related impairment across 12 domains: (1) central nervous system, (2) upper airways, (3) respiratory system, (4) cardiovascular system, (5) metabolism, (6) renal, (7) urinary system, (8) liver, (9) musculoskeletal, (10) reproductive, (11) lymphatic, and (12) activities of daily living. The commission further recommended that BMI-based obesity measures, when not supported by assessment of obesity-related impairment, should be used only for screening purposes or as proxies of health risk in population-level epidemiological research.

Canadian clinical guidelines recommend using BMI along with WC to classify individuals as having obesity;[6] however, national estimates of obesity prevalence have typically been based solely on BMI.[4,7,8] Aligned with the commission's recommendations and diagnostic criteria, the objective of this study is to use population-level measures of BMI and WC together with indicators of organ or tissue dysfunction and limitations in daily activities to examine obesity prevalence among adults in Canada. With data from the Canadian Health Measures Survey (CHMS) for individuals aged 18 to 79 years, this study (1) estimates obesity using BMI only and BMI

together with elevated WC to identify excess adiposity, (2) identifies and explores the prevalence of CHMS-based measured and self-reported indicators of the diagnostic criteria for obesity-related impairment, and (3) uses these indicators combined with excess adiposity to characterize and estimate the prevalence of clinical and preclinical obesity in the adult population.

Data and methods

Data

Data were combined from Cycle 5 (January 2016 to December 2017) and Cycle 6 (January 2018 to December 2019) of the CHMS. The CHMS is a cross-sectional survey that collects questionnaire-based and directly measured health information from community-dwelling individuals aged 3 to 79 living in the 10 provinces. People living in the three territories or on reserves and settlements in the provinces, the institutionalized population, residents of certain remote regions, and full-time members of the Canadian Armed Forces are excluded (about 4% of the Canadian population). The CHMS involves visiting a mobile examination centre (MEC) following an in-person household interview. Prior to the household interview, some dwellings are randomly flagged to indicate that a respondent should fast for at least 10 hours before the MEC appointment. The household interview gathers detailed information on health, nutrition, and lifestyle. At the MEC, there is an interview, and direct physical measurements are taken—such as blood pressure (BP), height, and weight—and samples of blood and urine are collected. Current medications are recorded during the household and MEC interviews and are assigned to codes from the Anatomical Therapeutic Chemical classification system. Ethics approval for the CHMS was received from Health Canada's Research Ethics Board.[9] Further information about the CHMS is available online.[10]

Those aged 18 to 79 years who fasted prior to their visit to the MEC and were not pregnant at the time were eligible for this analysis: n=1,651 (Cycle 5) and n=1,670 (Cycle 6). Eligible respondents were excluded from the analysis if their BMI or WC was missing (n=13 [Cycle 5] and n=15 [Cycle 6]). The final analytical sample sizes were n=1,638 (Cycle 5) and n=1,655 (Cycle 6), for a total analytical sample size of 3,293.

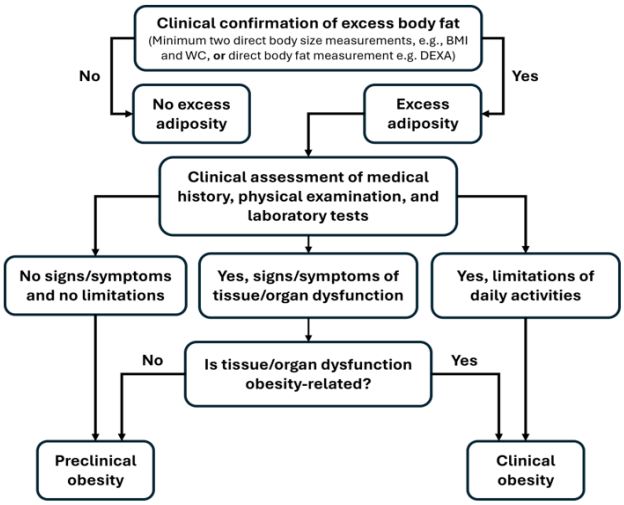
Measures and definitions

Blood pressure: Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured with the BpTRU™ BPM-300 automated oscillometric device (BpTRU Medical Devices Ltd., Coquitlam, British Columbia) at the MEC. Six BpTRU™ readings were taken for each CHMS participant, with the last five averaged to determine the SBP and DBP levels.[11]

Waist circumference: WC was measured to the nearest 0.1 cm, directly on the landmarked skin, with a flexible, inelastic measuring tape with an attached tension metre. The measure was taken at the highest point of the iliac crest.[12]

Elevated waist circumference: As per the commission's recommendations,[5] elevated WC for respondents who reported being South Asian, Chinese, Filipino, Southeast Asian, Korean, or Japanese (n=352) was defined as ≥90 cm for males and ≥80 cm for females. Elevated WC for the remaining respondents (n=2,941) was defined as ≥102 cm for males and ≥88 cm for females.

Figure 1
Diagnostic model of clinical obesity



Notes: BMI = body mass index, WC = waist circumference, DEXA = dual-energy X-ray absorptiometry.
Source: Adapted from the infographic (https://www.thelancet.com/infographics-do/clinical-obesity-25) produced for Rubino F, Cummings DE, Eckel RH, et al. Definition and diagnostic criteria of clinical obesity. *Lancet Diabetes Endocrinol* 2025. doi:10.1016/S2213-8587(24)00316-4.

Height: Height was measured to the nearest 0.1 cm using a ProScale M150 digital stadiometer (Accurate Technology Incorporated, Fletcher, United States).

Weight: Weight was measured to the nearest 0.1 kg with a Mettler Toledo VLC with Panther Plus terminal scale (Mettler Toledo Canada, Mississauga, Canada).

Body mass index: BMI was calculated as measured weight in kilograms divided by measured height in metres squared. As per the commission's recommendations,[5] BMI categories for respondents who reported being South Asian, Chinese, Filipino, Southeast Asian, Korean, or Japanese (n=352) were defined as normal weight (BMI<23 kg/m^2), overweight (23≤BMI<25 kg/m^2), or obesity (BMI≥25 kg/m^2). BMI categories for the remaining respondents (n=2,941) were defined as normal weight (BMI<25 kg/m^2), overweight (25≤BMI<30 kg/m^2), or obesity (BMI≥30 kg/m^2).

Excess adiposity: Excess adiposity was defined as BMI in the obese range (BMI≥30 kg/m^2) plus elevated WC.

The commission's diagnostic model of clinical obesity

To distinguish clinical obesity from preclinical obesity, the commission described the diagnostic process as confirming excess body fat through anthropometric or direct measures; assessing associated illness via medical history, examination, and laboratory tests; and determining whether any observed organ dysfunction or activity limitation is attributable to obesity (Figure 1).[5]

Table 1
Prevalence of different characterizations of obesity by sex and age group, adults aged 18 to 79 years, Canada, excluding territories, 2016 to 2019

Obesity characterization	Both sexes	95% CI		Males	95% CI		Females	95% CI	
	%	from	to	%	from	to	%	from	to
Ages 18 to 79 years									
BMI in obese range	29.4	26.1	32.9	29.1	23.9	35.0	29.6	26.2	33.3
Excess adiposity	27.2	24.3	30.4	25.0	20.5	30.0	29.5	26.1	33.2
Tier 1									
Clinical obesity	18.8	16.5	21.5	19.9	16.6	23.5	17.8	14.6	21.5
Preclinical obesity	8.4	6.6	10.6	5.1	3.1	7.9	11.7 †	8.9	15.1
Tier 2									
Clinical obesity	11.8	9.8	14.2	12.7	9.9	16.2	10.9	8.3	14.3
Preclinical obesity	15.4	13.0	18.2	12.2	9.0	16.4	18.5 †	15.2	22.4
Tier 3									
Clinical obesity	6.6	5.2	8.4	6.6	4.7	9.0	6.7	4.3	9.8
Preclinical obesity	20.6	17.9	23.6	18.4	14.5	22.9	22.8	19.4	26.7
Ages 18 to 39 years									
BMI in obese range	25.7	19.7	32.9	24.1	15.5	35.5	27.4	19.6	36.8
Excess adiposity	23.1	17.7	29.6	18.9	12.4	27.8	27.3	19.5	36.8
Tier 1									
Clinical obesity	9.4	6.2	13.4	12.0	7.6	18.4	6.7	4.0	10.4
Preclinical obesity	13.7	9.4	19.7	7.0	3.2	12.8	20.6 †	13.6	30.0
Tier 2									
Clinical obesity	2.2	1.0	4.2	2.8	0.9	6.5	1.6	0.5	3.7
Preclinical obesity	20.9	15.2	28.1	16.2	10.3	24.5	25.7	17.6	36.0
Tier 3									
Clinical obesity	0.6	0.0	2.3	0.6	0.0	4.0	0.6	0.1	1.7
Preclinical obesity	22.5	17.1	29.1	18.4	12.2	26.7	26.7	18.8	36.6
Ages 40 to 59 years									
BMI in obese range	30.6	24.0	38.1	30.4	22.4	39.9	30.7	22.0	41.1
Excess adiposity	28.0	21.5	35.6	25.5	18.5	34.1	30.5	21.7	41.0
Tier 1									
Clinical obesity	21.6	16.6	27.6	22.2	15.2	31.1	21.0	14.5	29.4
Preclinical obesity	6.4	3.8	9.9	3.4	1.0	7.9	9.5 †	5.3	15.4
Tier 2									
Clinical obesity	14.1	9.9	19.8	15.7	8.8	26.4	12.6	7.3	20.8
Preclinical obesity	13.9	9.7	19.4	9.9	5.2	16.6	17.9 †	12.4	25.1
Tier 3									
Clinical obesity	8.5	5.2	13.0	8.2	4.0	14.4	8.9	3.9	17.0
Preclinical obesity	19.4	13.9	26.5	17.4	12.2	24.0	21.5	14.1	31.4
Ages 60 to 79 years									
BMI in obese range	33.3	28.6	38.3	35.2 ‡	29.5	41.4	31.4	24.7	39.1
Excess adiposity	32.5 ‡	27.7	37.7	33.8 ‡‡	28.1	40.0	31.3	24.6	38.9
Tier 1									
Clinical obesity	29.4 ‡‡	24.9	34.5	29.1 ‡‡	23.8	35.0	29.8 ‡‡	23.3	37.1
Preclinical obesity	3.1 ‡‡	1.7	5.0	4.7	2.3	8.4	1.5 †‡‡	0.6	3.1
Tier 2									
Clinical obesity	23.4 ‡‡	19.4	28.0	24.4 ‡‡	18.4	31.6	22.4 ‡‡	18.6	26.8
Preclinical obesity	9.1 ‡	7.0	11.6	9.4	5.6	14.7	8.9 ‡	4.7	14.9
Tier 3									
Clinical obesity	13.3 ‡‡	10.8	16.1	14.0 ‡‡	9.9	19.5	12.5 ‡‡	9.5	16.3
Preclinical obesity	19.2	15.9	23.2	19.8	15.2	25.3	18.8	12.3	27.7

† indicates that the difference between females and males was statistically different from zero at p < 0.05 (t-test)
‡ indicates that the linear tests for trends across age groups were statistically significant (p < 0.05)
‡‡ indicates that the linear tests for trends across age groups were statistically significant (p < 0.01)
Notes: BMI = body mass index, excess adiposity = BMI in the obese range with elevated waist circumference, CI = confidence interval. Tier 1: clinical obesity = excess adiposity plus one or more indicators of impairment in at least one domain, preclinical obesity = excess adiposity plus zero indicators; Tier 2: clinical obesity = excess adiposity plus indicators of impairment in two or more domains, preclinical obesity = excess adiposity plus indicators in only one domain; Tier 3: clinical obesity = excess adiposity plus indicators of impairment in three or more domains, preclinical obesity = excess adiposity plus indicators in only one or two domains.
Source: Statistics Canada, Canadian Health Measures Survey, 2016 to 2019, combined.

The commission outlined diagnostic criteria for obesity-related impairment in 12 domains: (1) central nervous system, (2) upper airways, (3) respiratory system, (4) cardiovascular system, (5) metabolism, (6) renal, (7) urinary system, (8) liver, (9) musculoskeletal, (10) reproductive, (11) lymphatic, and (12) activities of daily living.[5] Appendix 1 summarizes the signs, symptoms, or diagnostics for each domain and identifies the corresponding indicators—where available—in the CHMS. Eight out of 12 domains had at least one corresponding CHMS indicator; domains 1, 7, 10, and 11 did not. See Appendix 2.7 in Supplementary Appendix 2 of Rubino et al. for a copy of the complete assessment form for clinical obesity in adults proposed by the commission.[5]

Characterization of clinical and preclinical obesity using population health data

Clinical assessment was not available to confirm that the indicators of impairment measured in the CHMS were attributable to obesity. Therefore, a tiered classification system was used to define clinical and preclinical obesity, applying progressively stricter criteria across three tiers. Higher tiers required indicators of impairment in multiple domains to minimize misclassification of clinical obesity by ensuring more comprehensive evidence of obesity-related health issues.

Tier 1

- **Clinical obesity:** Excess adiposity plus one or more indicators of impairment in at least **one** domain.
- **Preclinical obesity:** Excess adiposity plus **zero** indicators.

Tier 2

- **Clinical obesity:** Excess adiposity plus indicators of impairment in **two or more** domains.
- **Preclinical obesity:** Excess adiposity plus indicators in only **one** domain.

Tier 3

- **Clinical obesity:** Excess adiposity plus indicators of impairment in **three or more** domains.
- **Preclinical obesity:** Excess adiposity plus indicators in only **one or two** domains.

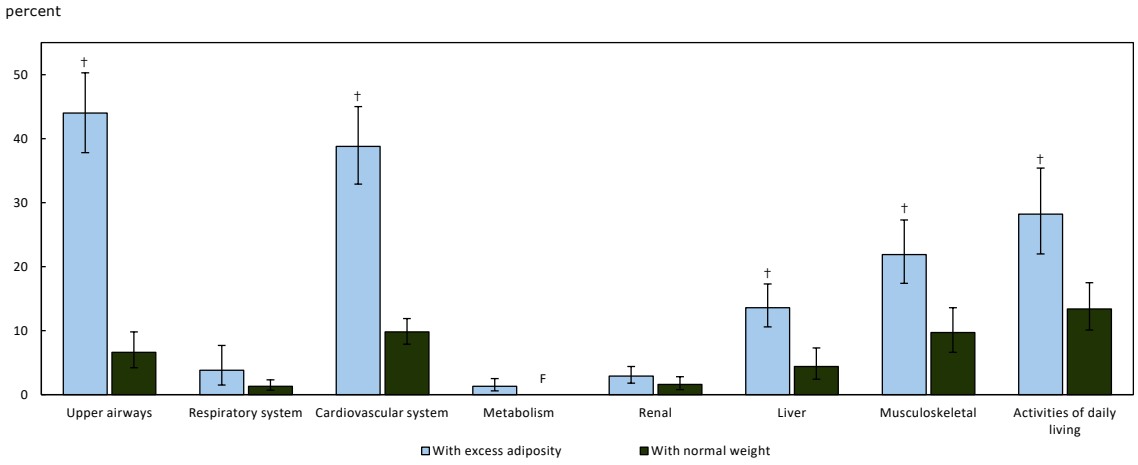
Covariates

Sex at birth (male or female) and age in years were reported at the visit to the MEC. Age groups were 18 to 39 years, 40 to 59 years, and 60 to 79 years.

Statistical analysis

All analyses were done using cycles 5 and 6 combined. The prevalence of BMI categories, elevated WC, and the CHMS indicators of the diagnostic criteria for obesity-related impairment was estimated for the adult population. Domain-level prevalence was defined as the presence of at least one indicator of impairment within that body system domain. The prevalence of impairment in the eight domains was compared between adults with excess adiposity and adults with normal weight. The prevalence of the characterizations of obesity was estimated by sex and age group. The prevalence of the CHMS indicators of impairment was estimated for adults with excess

Chart 1
Prevalence of impairment by domain, adults with excess adiposity versus adults with normal weight, adults aged 18 to 79 years, Canada, excluding territories, 2016 to 2019



F too unreliable to be published
† indicates that the prevalence of impairment for adults with excess adiposity compared with normal weight was statistically different from zero at $p < 0.01$ (t-test)
Source: Statistics Canada, Canadian Health Measures Survey, 2016 to 2019, combined.

adiposity by sex. The proportion of adults with excess adiposity with indicators in zero, one or more, two or more, three or more, four or more, or five or more domains, by sex and age group, was estimated. The average number of domains with indicators of impairment present among adults with excess adiposity was estimated by sex and 10-year age group. The prevalence of the three tiers of clinical and preclinical obesity in the adult population was estimated by sex and age group.

All estimates were weighted by using the combined survey weights for cycles 5 and 6, and the sampling variance was calculated by using the combined bootstrap weights for these cycles. For proportion estimates that fell below 10% or above 90%, the modified Clopper-Pearson method was used to estimate 95% confidence intervals (CIs). T-tests were conducted, corresponding to the null hypothesis that proportion differences were zero between those with excess adiposity versus normal weight or between males and females. Linear orthogonal polynomial contrasts were conducted to test for linear trends across age groups. The statistical significance of t-tests and linear tests for trends was assessed at $p < 0.05$ unless otherwise indicated. All analyses were conducted in SAS 9.4 and SAS-callable SUDAAN 11.0.3.

Results

The study population was evenly split between males and females, and 39% were aged 18 to 39 years, 36% were aged 40 to 59 years, and 25% were aged 60 to 79 years (Appendix 2). The prevalence of the CHMS indicators of obesity-related impairment in the population ranged from 1% (95% CI: 0.5%, 2%) for metabolic dysfunction to 24% (95% CI: 22%, 26%) for cardiovascular system dysfunction.

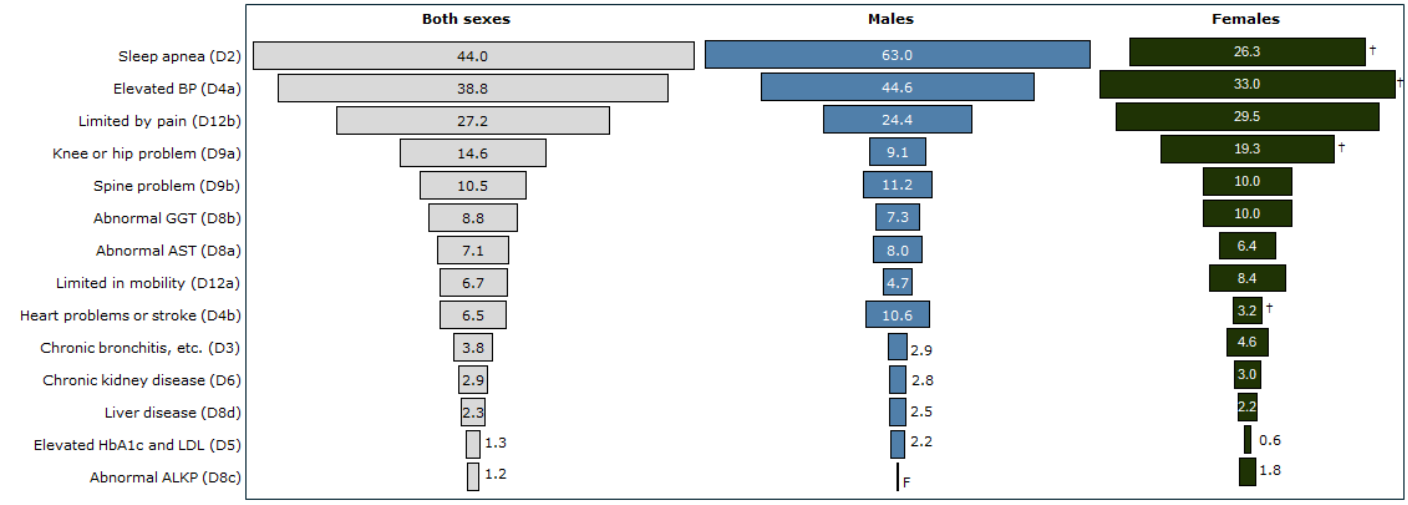
Obesity prevalence according to different characterizations

Among adults, 29% (95% CI: 26%, 33%) had BMI in the obese range and 27% (95% CI: 24%, 30%) had excess adiposity (BMI in the obese range with elevated WC) (Table 1). According to the Tier 1 classification, 19% (95% CI: 17%, 22%) of adults had clinical obesity and 8% (95% CI: 7%, 11%) had preclinical obesity. Clinical obesity prevalence was 12% (95% CI: 10%, 14%) under the Tier 2 classification and 7% (95% CI: 5%, 8%) under Tier 3. Though the proportion of males and females with clinical obesity was similar at all tiers, a higher proportion of females than males were categorized as having preclinical obesity at tiers 1 and 2, primarily among those younger than 60 years (Table 1). For both sexes, clinical obesity prevalence was higher at older age groups regardless of tier.

Indicators of impairment among adults with excess adiposity

The prevalence of impairment in five of eight domains was substantively and significantly higher among adults with excess adiposity versus adults with normal weight (Chart 1), a pattern that was evident within age groups particularly among those aged 40 to 79 (data not shown). Sleep apnea, elevated BP, activities prevented by pain, and knee or hip problems were the most prevalent CHMS indicators of impairment among adults with excess adiposity (Chart 2). Sleep apnea, elevated BP, and a diagnosis of heart disease, heart attack or stroke were more prevalent among males than females, while a diagnosis of knee

Chart 2
Prevalence of individual indicators of impairment by sex, adults with excess adiposity aged 18 to 79 years, Canada, excluding territories, 2016 to 2019



F too unreliable to be published
† indicates that the prevalence for females compared with males was statistically different from zero at $p < 0.05$ (t-test)
Notes: BP = blood pressure, GGT = gamma-glutamyltransferase, AST = aspartate aminotransferase, HbA1c = glycated hemoglobin A1c, LDL = low-density lipoprotein, ALKP = alkaline phosphatase. The prevalence of elevated HbA1c was 1.3% and abnormal ALKP was 1.2% for both sexes combined. The prevalence of liver disease was 2.5% and elevated HbA1c and LDL was 2.2% for males. The prevalence of elevated HbA1c and LDL was 0.6% for females.
Source: Statistics Canada, Canadian Health Measures Survey, 2016 to 2019, combined.

or hip problems was less prevalent. The proportion of males with excess adiposity and sleep apnea was more than double that of females (63% [95% CI: 53%, 72%] versus 26% [95% CI: 17%, 39%]), and the proportion of males with excess adiposity and a diagnosis of heart disease, heart attack or stroke was three times higher (11% [95% CI: 7%, 16%] versus 3% [95% CI: 2%, 6%]). The proportion of females with excess adiposity and knee or hip problems was double that of males (19% [95% CI: 14%, 26%] versus 9% [95% CI: 5%, 15%]).

Among adults with excess adiposity, 31% (95% CI: 25%, 37%) did not have any indicators of impairment (Table 2), with a higher proportion for females (40% [95% CI: 31%, 49%]) than males (21% [95% CI: 15%, 28%]). About 44% of both sexes together (95% CI: 37%, 50%) had indicators in two or more domains, and 24% (95% CI: 19%, 30%) had indicators in three or more domains. Among those aged 18 to 39 years, 60% (95% CI: 45%, 73%) did not have any indicators of impairment, versus 9% (95% CI: 6%, 15%) of those aged 60 to 79 years. The proportion of adults with indicators of impairment regardless of domain threshold was higher at older ages (linear test for age trend $p < 0.01$). When examined across 10-year age groups, the average number of domains with indicators present among adults with excess adiposity was lowest among those aged 18 to 29 years, with 0.4 domains (95% CI: 0.3, 0.6), and highest among those aged 70 to 79 years, with 2.7 domains (95% CI: 2.4, 2.9) (linear test for age trend $p < 0.01$) (data not shown).

Clinical versus preclinical obesity status among adults with excess adiposity

According to the Tier 1 classification, 69% of adults with excess adiposity had clinical obesity and 31% had preclinical obesity (Chart 3). Under Tier 2, 44% were classified with clinical obesity versus 56% with preclinical obesity; under Tier 3, the proportion was 24% with clinical obesity versus 76% with preclinical obesity. The proportion of adults with excess adiposity classified with clinical obesity was higher at older ages, regardless of tier (linear test for age trend $p < 0.01$). At ages 60 to 79, 91% (Tier 1), 72% (Tier 2), and 41% (Tier 3) were classified with clinical obesity. Being classified with preclinical obesity was more common at ages 18 to 39. A higher proportion of males than females with excess adiposity were classified with clinical obesity at Tier 1, and this difference was driven primarily by the higher prevalence among males (63% [95% CI: 46%, 78%]) than females (25% [95% CI: 14%, 39%]) at ages 18 to 39 (Table 3). However, at ages 60 to 79, a higher proportion of females (95% [95% CI: 90%, 98%]) than males (86% [95% CI: 76%, 92%]) were classified with clinical obesity at Tier 1.

Discussion

Following the *Lancet Diabetes & Endocrinology* Commission's framework,[5] this study used a tiered classification of measured and self-reported indicators of obesity-related impairment to characterize clinical and preclinical obesity in Canadian adults. Of the 27% of adults with excess adiposity, 4 in 10 had indicators of impairment in two or more domains and 2 in 10 had indicators in three or more domains. The least restrictive characterization of clinical obesity (Tier 1), which required excess adiposity plus one indicator of impairment, produced a clinical obesity population prevalence of 19% and a preclinical obesity prevalence of 8%. Tier 2, which required impairment in two or more domains, yielded a clinical obesity prevalence of 12% and a preclinical obesity prevalence of 15%. Tier 3 was the most stringent classification, which required impairment in three or more domains, and produced a prevalence of 7% for clinical obesity and 20% for preclinical obesity. The study also found that preclinical obesity—especially at tiers 1 and 2—was more commonly identified among younger adults and females, highlighting age and sex differences in obesity-related impairment.

Distinct patterns emerged across sex and age groups. Though the higher prevalence of excess adiposity among females than among males was not statistically significant, a higher proportion of females than males with excess adiposity were classified as having preclinical rather than clinical obesity at tiers 1 and 2. This is because a higher proportion of females than males with excess adiposity had either zero indicators of impairment or had indicators in a single domain only.

Table 2
Proportion of adults by number of domains with indicators of impairment present and sex and age group, adults with excess adiposity aged 18 to 79 years, Canada, excluding territories, 2016 to 2019

	No indicators of impairment			Indicators in one or more domains			Indicators in two or more domains			Indicators in three or more domains			Indicators in four or more domains			Indicators in five or more domains		
		95% CI			95% CI			95% CI			95% CI			95% CI			95% CI	
	%	from	to	%	from	to	%	from	to	%	from	to	%	from	to	%	from	to
Total	30.8	25.2	37.2	69.2	62.8	74.8	43.5	36.9	50.3	24.4	19.4	30.2	10.2	7.0	14.7	2.4	1.3	4.0
Sex																		
Males	20.5	14.5	28.1	79.5	71.9	85.5	51.0	40.9	61.1	26.5	19.5	34.9	10.0	6.0	15.4	2.3	0.7	5.4
Females	39.5 ††	30.7	49.1	60.5 ††	50.9	69.3	37.1	28.3	46.8	22.7	15.2	32.4	10.4	6.1	17.0	2.4	1.1	4.6
Age group																		
18 to 39 years	59.5	44.9	72.6	40.5	27.4	55.1	9.5	3.0	21.3	2.5	0.2	10.5	0.7	0.1	2.9	F	...	...
40 to 59 years	22.9	16.1	31.5	77.1	68.5	83.9	50.4	38.5	62.3	30.5	19.9	43.7	15.1	8.5	25.5	1.7	0.3	5.3
60 to 79 years	9.4 ‡	5.5	14.9	90.6 ‡	85.1	94.5	71.9 ‡	65.6	77.4	40.8 ‡	35.2	46.6	14.5 ‡	9.8	20.9	5.5 ‡	2.4	10.7

... not applicable

F too unreliable to be published

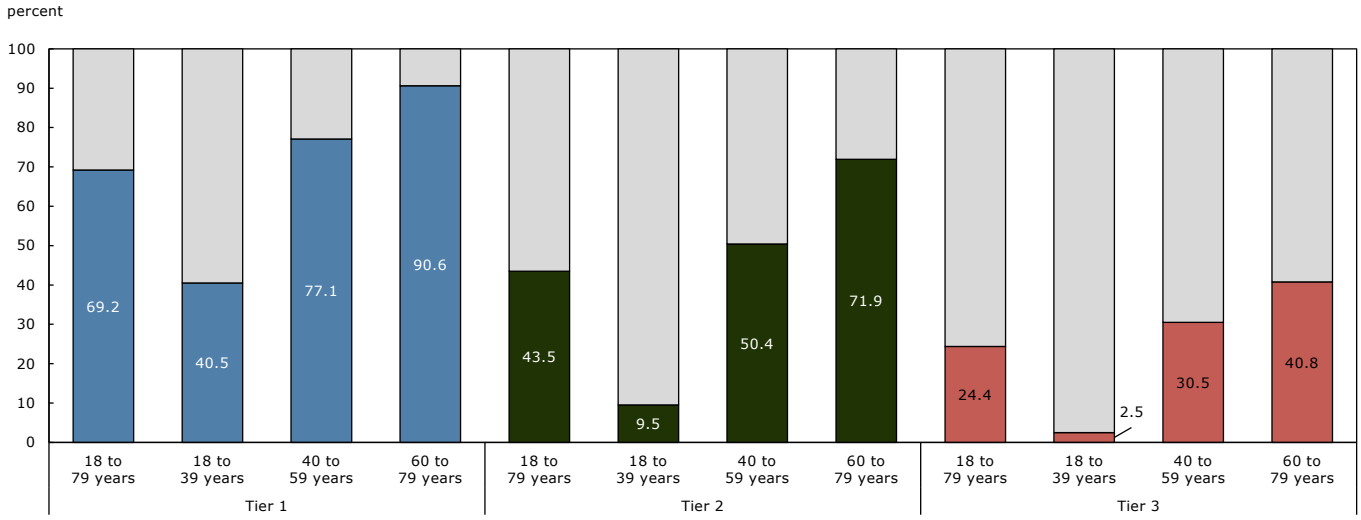
†† indicates that the difference between females and males was statistically different from zero at $p < 0.01$ (t-test)

‡ indicates that the linear tests for trends across age groups were statistically significant ($p < 0.01$)

Notes: CI = confidence interval. Indicators of impairment are out of a maximum of eight domains.

Source: Statistics Canada, Canadian Health Measures Survey, 2016 to 2019, combined.

Chart 3
Proportion classified with clinical obesity under Tier 1, Tier 2 and Tier 3 classifications by age group, adults with excess adiposity aged 18 to 79 years, Canada, excluding territories, 2016 to 2019



Notes: Tier 1: clinical obesity = excess adiposity plus one or more indicators of impairment in at least one domain, preclinical obesity = excess adiposity plus zero indicators; Tier 2: clinical obesity = excess adiposity plus indicators of impairment in two or more domains, preclinical obesity = excess adiposity plus indicators in only one domain; Tier 3: clinical obesity = excess adiposity plus indicators of impairment in three or more domains, preclinical obesity = excess adiposity plus indicators in only one or two domains. The coloured area on the bars distinguishes the classification level of clinical obesity: Tier 1 (blue), Tier 2 (dark green) and Tier 3 (orange). The grey area on the bars denotes the proportion classified with preclinical obesity at each tier. The linear tests for age trends within each tier are statistically significant ($p < 0.01$).
Source: Statistics Canada, Canadian Health Measures Survey, 2016 to 2019, combined.

Moreover, aside from knee or hip problems, the prevalence of all other indicators of impairment was either comparable between females and males or lower in females than in males. In particular, the prevalence of sleep apnea and dysfunction of the cardiovascular system was significantly lower for females; this is consistent with known sex-related differences in the prevalence of these conditions.[13-15] Regarding age, 3 in 5 adults aged 18 to 39 years with excess adiposity had no indicators of impairment, compared with 1 in 10 among those aged 60 to 79. Accordingly, the population prevalence of clinical obesity was higher in higher age groups and lowest in the youngest age group. That additional health impacts had not yet materialized for some groups with excess adiposity suggests an opportunity for risk management and prevention.

For clinicians, the commission recommended assessing obesity-related physiological dysfunction and activity limitation through medical history review, physical examination, and diagnostic assessment across 12 domains. For this population study, directly measured and self-reported indicators of impairment were available in only eight domains. However, individuals with excess adiposity had a significantly higher prevalence of impairment in five of the eight domains, compared with those with normal weight, corroborating the premise that these indicators reflect obesity-related ill health. Moreover, this finding persisted in the oldest age group, despite the increased likelihood of dysfunction and activity limitation independent of obesity that comes with age.[16] In the remaining three domains, population prevalence of impairment was low, especially among those with normal weight, making it difficult to detect differences.

It was not possible to evaluate impairment in 4 of the 12 domains identified by the commission. Consequently, the findings may underestimate the true prevalence of clinical obesity in the population. Of the four missing domains, the absence of indicators of dysfunction in the urinary system—specifically, recurrent or chronic urinary incontinence—likely would contribute most, albeit marginally, to an underestimation of obesity-related impairment, considering its 10% prevalence among adult women.[17] Dysfunction in the other three body systems is even less common. Raised intracranial pressure (central nervous system) has an estimated incidence of 0.9 per 100,000 in the general population.[18] Primary hypogonadism (reproductive system) among males has a reported prevalence of 2%,[19] while primary ovarian insufficiency (reproductive system) affects 2% to 4% of women.[20] Lymphedema (lymphatic system) has a population prevalence of about 3%, and slightly more than half of this proportion is attributed to obesity-related causes.[21]

The commission's diagnostic framework recommends identifying excess adiposity using at least two direct body size measurements—one of which can be BMI—or through a direct body fat assessment, such as a DEXA scan. This study identified excess adiposity by using both BMI and WC, consistent with the Canadian clinical guidelines. Adding the condition of elevated WC to BMI in the obese range produced a population prevalence of excess adiposity that was two percentage points lower than using BMI alone. This finding aligns with a recent study of adults in the United States, which reported less than a one percentage point difference between excess adiposity confirmed by elevated WC and body fat

Table 3
Proportion classified with clinical versus preclinical obesity under Tier 1, Tier 2, and Tier 3 classifications by sex and age group, adults with excess adiposity aged 18 to 79 years, Canada, excluding territories, 2016 to 2019

	Tier 1						Tier 2						Tier 3					
	Clinical obesity			Preclinical obesity			Clinical obesity			Preclinical obesity			Clinical obesity			Preclinical obesity		
		95% CI			95% CI			95% CI			95% CI			95% CI			95% CI	
	%	from	to	%	from	to	%	from	to	%	from	to	%	from	to	%	from	to
18 to 79 years old																		
Males	79.5	71.9	85.5	20.5	14.5	28.1	51.0	40.9	61.1	49.0	38.9	59.1	26.5	19.5	34.9	73.5	65.1	80.5
Females	60.5 †	50.9	69.3	39.5 †	30.7	49.1	37.1	28.3	46.8	62.9	53.2	71.7	22.7	15.2	32.4	77.3	67.6	84.8
18 to 39 years old																		
Males	63.1	45.5	77.8	36.9	22.2	54.5	14.7	5.8	32.3	85.3	67.7	94.2	2.9	0.0	16.5	97.1	83.5	100.0
Females	24.5 †	14.1	39.2	75.5 †	60.8	85.9	5.8	1.0	17.3	94.2	82.7	99.0	2.2	0.2	8.1	97.8	91.9	99.8
40 to 59 years old																		
Males	86.8	68.5	95.2	13.2	4.8	31.5	61.3	36.9	81.1	38.7	18.9	63.1	31.9	18.7	48.9	68.1	51.1	81.3
Females	69.0	56.1	79.5	31.0	20.5	43.9	41.3	27.9	56.1	58.7	43.9	72.1	29.3	15.1	49.2	70.7	50.8	84.9
60 to 79 years old																		
Males	86.1	76.4	92.3	13.9	7.7	23.6	72.2	58.0	83.0	27.8	17.0	42.0	41.6	30.6	53.5	58.4	46.5	69.4
Females	95.1 †	90.4	97.9	4.9 †	2.1	9.6	71.6	61.1	80.2	28.4	19.8	38.9	40.0	28.0	53.3	60.0	46.7	72.0

† indicates that the difference between females and males was statistically different from zero at $p < 0.05$ (t-test)

Notes: CI = confidence interval. Tier 1: clinical obesity = excess adiposity plus one or more indicators of impairment in at least one domain, preclinical obesity = excess adiposity plus zero indicators; Tier 2: clinical obesity = excess adiposity plus indicators of impairment in two or more domains, preclinical obesity = excess adiposity plus indicators in only one domain; Tier 3: clinical obesity = excess adiposity plus indicators of impairment in three or more domains, preclinical obesity = excess adiposity plus indicators in only one or two domains. Sex-specific linear tests for trends in clinical and preclinical obesity across age groups were statistically significant ($p < 0.01$) across all tiers.

Source: Statistics Canada, Canadian Health Measures Survey, 2016 to 2019, combined.

measured by DEXA, compared with BMI.[22] From a surveillance perspective, this suggests that in the absence of additional anthropometric direct measurements of fat mass, BMI based on measured height and weight is an adequate indicator of excess adiposity at the population level. However, because WC offers additional insight into downstream health risks,[23] using both measured BMI and WC to identify excess adiposity—when available—is preferred, as recommended by the commission and Canadian clinical guidelines.

This study has several strengths. It identifies and estimates the prevalence of indicators for obesity-related dysfunction and activity limitation and provides the first population estimates of clinical and preclinical obesity in the adult Canadian population. The results are based on a representative sample of adults that produced robust population estimates. Laboratory tests on blood and urine specimens collected from respondents were conducted, and direct measures of BP and anthropometrics were taken objectively using systematic methodologies. The study applied a tiered classification to enhance specificity for clinical and preclinical obesity, with higher tiers requiring impairment in multiple domains. As a result, the Tier 2 and Tier 3 classifications likely aligned more closely with the commission's diagnostic framework.

There are also some limitations. Some population groups—such as people living in the three territories, on reserves or settlements, or in institutions—are outside the scope of the CHMS, so their clinical obesity status was not characterized or included in the prevalence estimates reported in this study. Self-report bias and misclassification were possible. For example, the CHMS collects self-reported diagnoses of liver and gallbladder disease as a single item, while the commission's criteria refer specifically to liver dysfunction. Self-reported diagnoses of heart disease, heart attack and stroke were included in this study as indicators of cardiovascular system dysfunction because of their association with heart failure, which was not directly assessed. Some of the CHMS indicators may not be the most appropriate for identifying impairment in the corresponding body system. For example, the CHMS measured aspartate aminotransferase (AST) in serum but it did not measure alanine aminotransferase (ALT), and both AST and ALT commonly serve as joint indicators of hepatic damage.[24] For activities of daily living (domain 12), the selected CHMS indicators were based on questions asked as part of the Health Utilities Index Mark 3 on the amount of activity prevented by pain and limits to the ability to walk or be mobile,[25] and not a set of questions asking about limitations in bathing, dressing, toileting, etc., as indicated in the commission's proposed criteria. However, the prevalence of impairment in this domain among all adults with excess adiposity was more than double that among adults with normal weight—almost triple among those aged 60 to 79 years (data not shown). This suggests that the pain and mobility items included in this study captured obesity-related limitations in daily activities.

Conclusion

This study used a tiered approach to characterize clinical and preclinical obesity in Canadian adults, producing the first population-level estimates of obesity to consider tissue and organ dysfunction and reduced capacity for daily activities. Despite some limitations in the available survey indicators and the inability to assess obesity-related dysfunction in 4 of 12 body systems, this study effectively distinguished between clinical and preclinical obesity across age and sex groups. The results suggest that younger adults and females with excess adiposity are less likely to present with obesity-related impairment, highlighting opportunities for targeted prevention. The findings also suggest that, for surveillance at the population level, BMI based on measured height and weight remains an adequate indicator of excess adiposity in the absence of additional body composition data. However, including elevated WC and evaluating excess adiposity alongside obesity-related dysfunction and activity limitation provide an opportunity to enhance public health surveillance and guide more effective intervention strategies.

Appendix table 1
Diagnostic criteria and Canadian Health Measures Survey indicators for assessing impairment

Domain	Signs, symptoms, or diagnostics	CHMS indicator
Domain 1: Central nervous system	Signs of raised intracranial pressure such as vision loss or recurrent headaches	None
Domain 2: Upper airways	Apneas or hypopneas during sleep because of increased upper airway resistance	Diagnosed by a health professional with sleep apnea **or** at high risk of sleep apnea based on the STOP-Bang score
Domain 3: Respiratory system	Hypoventilation, breathlessness, or wheezing because of reduced lung or diaphragmatic compliance	Diagnosed by a health professional with chronic bronchitis, emphysema, or chronic obstructive pulmonary disease
Domain 4: Cardiovascular system	Hypertension and heart failure	a. Elevated blood pressure (BP), defined as systolic BP≥140 mm Hg or diastolic BP≥90 mm Hg or taking medication in the past month corresponding to beta-blockers (Anatomical Therapeutic Chemical [ATC] codes in category C07, excluding C07AA07, C07AA12 and C07AG02), agents acting on the renin-angiotensin system (ATC codes in category C09), thiazide diuretics (ATC codes in category C03, excluding C03BA08 and C03CA01), calcium channel antagonists (ATC codes in category C08), or other antihypertensives (ATC codes in category C02, excluding C02KX01) **or** b. Diagnosed by a health professional with heart disease, heart attack, or stroke
Domain 5: Metabolism	The cluster of hyperglycemia, high triglyceride levels, and low high-density lipoprotein cholesterol levels	a. Elevated blood glucose, defined as fasting glycated hemoglobin A1c ≥6.5% measured in serum or taking medication in the past month to treat elevated glucose (ATC codes in categories A10A, A10B and A10X) **and** b. Elevated low-density lipoprotein (calculated with the Friedewald equation[1] using triglycerides, high-density lipoprotein cholesterol [HDL-C] and total cholesterol measured in serum), defined as ≥3.5 mmol/L (reference #2) **or** taking medication in the past month to treat elevated triglycerides (fibrates: ATC codes in category C10AB) **or** to treat reduced HDL-C (nicotinic acid and derivatives: ATC codes in category C04AC)
Domain 6: Renal	Microalbuminuria with reduced estimated glomerular filtration rate (eGFR)	Chronic kidney disease (CKD), defined as an eGFR of less than 60 mL/min/1.73 m^2 using the CKD-EPI 2021 equations[3]
Domain 7: Urinary system	Recurrent or chronic urinary incontinence	None
Domain 8: Liver	Non-alcoholic fatty liver disease with hepatic fibrosis	a. Abnormal aspartate aminotransferase (AST), defined as AST ≥38 IU/L measured in serum[2] **or** b. Abnormal gamma-glutamyltransferase (GGT), defined as GGT ≥86 IU/L measured in serum for males and GGT ≥56 IU/L measured in serum for females[2] **or** c. Abnormal alkaline phosphatase (ALKP), defined as ALKP ≥137 IU/L measured in serum[2] **or** d. Diagnosed by a health professional with liver or gallbladder disease
Domain 9: Musculoskeletal	Chronic, severe knee or hip pain associated with joint stiffness and reduced range of joint motion, also back pain	a. Leg, knee or hip problem that could be aggravated with physical activity, reported as one of the following conditions: arthritis, a vertebral disorder, a chronic soft tissue condition, or a chronic joint condition **or** b. Back or spine problem that could be aggravated with physical activity, reported as one of the following conditions: arthritis, a vertebral disorder, a chronic soft tissue condition, or a chronic joint condition
Domain 10: Reproductive	Anovulation among females and hypogonadism among males	None
Domain 11: Lymphatic system	Lower limb lymphedema causing chronic pain or reduced range of motion	None
Domain 12: Activities of daily living	Significant, age-adjusted limitations of mobility or other basic activities of daily living, e.g., bathing or dressing	a. Mobility limitation as captured by responses to the Health Utilities Index Mark 3 (HUI3),[4] reported as unable to walk without difficulty or unable to walk at all **or** b. Activity limitation because of pain as captured by responses to the HUI3, reported as pain preventing a few, some, or most activities

1. Friedewald WT, Levy RI and Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem* 1972.
2. Medical Council of Canada. Clinical laboratory tests and adult normal values. https://mcc.ca/examinations-assessments/resources-to-help-with-exam-prep/normal-lab-values/ (2020).
3. Miller WG, Kaufman HW, Levey AS, et al. National Kidney Foundation Laboratory Engagement Working Group Recommendations for Implementing the CKD-EPI 2021 Race-Free Equations for Estimated Glomerular Filtration Rate: Practical Guidance for Clinical Laboratories. *Clin Chem* 2022. DOI: 10.1093/clinchem/hvab278.
4. Horsman J, Furlong W, Feeny D, et al. The Health Utilities Index (HUI): concepts, measurement properties and applications. *Health Qual Life Outcomes* 2003. DOI: 10.1186/1477-7525-1-54.
Note: CHMS = Canadian Health Measures Survey.
Source: Adapted from Table 2 and Appendix 2 in Rubino F, Cummings DE, Eckel RH, et al. Definition and diagnostic criteria of clinical obesity. *Lancet Diabetes Endocrinol* 2025. doi:10.1016/S2213-8587(24)00316-4.

Appendix table 2

Adults aged 18 to 79 years, Canada, excluding territories, 2016 to 2019

	Measured (M) or self-reported (SR) CHMS indicator	Sample size	%	95% CI from	95% CI to
Total	...	3,293	100.0	...	...
Sex					
Male	SR	1,688	49.8	49.4	50.1
Female	SR	1,605	50.2	49.9	50.6
Age group					
18 to 39 years	SR	1,214	38.8	38.3	39.3
40 to 59 years	SR	1,008	35.9	35.5	36.3
60 to 79 years	SR	1,071	25.3	25.0	25.6
Body mass index categories					
Normal weight	M	1,166	37.0	33.3	40.8
Overweight	M	1,108	33.7	30.4	37.1
Obesity	M	1,019	29.4	26.1	32.9
Waist circumference					
Not elevated	M	1,796	55.9	52.2	59.6
Elevated	M	1,497	44.1	40.4	47.8
Domain and indicators of impairment					
Domain 1: Central nervous system	§	...	...	...	...
Domain 2: Upper airways—diagnosed with or at high risk of sleep apnea	SR	660	20.4	17.3	23.9
Domain 3: Respiratory system—diagnosed with chronic bronchitis, emphysema, or COPD	SR	91	2.5	1.7	3.5
Domain 4: Cardiovascular system	M and SR	837	23.9	21.6	26.4
a) Elevated BP	M and SR	784	22.8	20.5	25.1
b) Diagnosed with heart disease, heart attack, or stroke	SR	211	5.2	4.3	6.2
Domain 5: Metabolism—elevated HbA1c and elevated LDL	M and SR	28	1.1	0.5	2.1
Domain 6: Renal—chronic kidney disease	M	103	2.5	1.6	3.7
Domain 7: Urinary system	§	...	...	...	...
Domain 8: Liver	M and SR	306	8.4	5.9	11.5
a) Abnormal AST	M	140	4.4	2.6	7.0
b) Abnormal GGT	M	138	4.6	3.1	6.5
c) Abnormal ALKP	M	26	0.5	0.2	0.9
d) Diagnosed with liver or gallbladder disease	SR	77	1.5	1.1	2.0
Domain 9: Musculoskeletal system	SR	452	13.7	11.1	16.8
a) Knee or hip has bone or joint problem	SR	330	10.2	8.1	12.9
b) Spine has bone or joint problem	SR	180	5.1	3.7	6.9
Domain 10: Reproductive	§	...	...	...	...
Domain 11: Lymphatic system	§	...	...	...	...
Domain 12: Activities of daily living	SR	684	19.3	16.8	22.1
a) Mobility issues	SR	116	2.8	2.0	3.8
b) A few, some or most activities prevented by pain	SR	656	18.9	16.5	21.6

... not applicable

§ no indicators in the CHMS

Notes: Sample size based on unweighted counts and proportion estimates produced using the combined survey weights for cycles 5 and 6. CHMS = Canadian Health Measures Survey, CI = confidence interval, COPD = chronic obstructive pulmonary disease, BP = blood pressure, HbA1c = glycated hemoglobin A1c, LDL = low-density lipoprotein, AST = aspartate aminotransferase, GGT = gamma-glutamyltransferase, ALKP = alkaline phosphatase.

Source: Statistics Canada, Canadian Health Measures Survey, 2016 to 2019, combined.

References

1. Chen F, Sapra T, Natale Z, et al. Modeling the cost of inaction in treating obesity in Canada. *BMC Public Health* 2025. DOI: 10.1186/s12889-025-21905-2.
2. Janssen I. The public health burden of obesity in Canada. *Can J Diabetes* 2013. DOI: 10.1016/j.jcjd.2013.02.059.
3. GBD 2021 Adult BMI Collaborators. Global, regional, and national prevalence of adult overweight and obesity, 1990-2021, with forecasts to 2050: a forecasting study for the Global Burden of Disease Study 2021. *Lancet* 2025. DOI: 10.1016/S0140-6736(25)00355-1.
4. Public Health Agency of Canada. Obesity statistics in Canada, https://www.canada.ca/content/dam/phac-aspc/documents/services/publications/healthy-living/obesity-statistics-canada/obesity-statistics-canada.pdf (2024).
5. Rubino F, Cummings DE, Eckel RH, et al. Definition and diagnostic criteria of clinical obesity. *Lancet Diabetes Endocrinol* 2025. DOI: 10.1016/S2213-8587(24)00316-4.
6. Wharton S, Lau DCW, Vallis M, et al. Obesity in adults: a clinical practice guideline. *CMAJ* 2020. DOI: 10.1503/cmaj.191707.
7. Statistics Canada. Table 13-10-0373-01 Overweight and obesity based on measured body mass index, by age group and sex, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310037301 (2020).
8. Statistics Canada. Table 13-10-0905-01 Health indicator statistics, annual estimates, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310090501 (2024).
9. Day B, Langlois R, Tremblay M, et al. Canadian Health Measures Survey: ethical, legal and social issues. *Health Rep* 2007.
10. Statistics Canada. Canadian Health Measures Survey, https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=1195092 (2019).
11. Bryan S, Saint-Pierre Larose M, Campbell N, et al. Resting blood pressure and heart rate measurement in the Canadian Health Measures Survey, cycle 1. *Health Rep* 2010.
12. National Institutes of Health. The Practical Guide to the Identification, Evaluation and Treatment of Overweight and Obesity in Adults, https://www.nhlbi.nih.gov/files/docs/guidelines/prctgd_c.pdf (2000).
13. Chang JL, Goldberg AN, Alt JA, et al. International Consensus Statement on Obstructive Sleep Apnea. *Int Forum Allergy Rhinol* 2023. DOI: 10.1002/alr.23079.
14. Bozkurt B, Ahmad T, Alexander K, et al. HF STATS 2024: Heart Failure Epidemiology and Outcomes Statistics An Updated 2024 Report from the Heart Failure Society of America. *J Card Fail* 2025. DOI: 10.1016/j.cardfail.2024.07.001.
15. van Riet EES, Hoes AW, Wagenaar KP, et al. Epidemiology of heart failure: the prevalence of heart failure and ventricular dysfunction in older adults over time. A systematic review. *Eur J Heart Fail* 2016. DOI: 10.1002/ejhf.483.
16. World Health Organization. Ageing and health, https://www.who.int/news-room/fact-sheets/detail/ageing-and-health (2025, accessed 21 October 2025).
17. Milsom I and Gyhagen M. The prevalence of urinary incontinence. *Climacteric* 2019. DOI: 10.1080/13697137.2018.1543263.
18. Mirdad RT, Morsy MM, Azzam AY, et al. Comparison of bariatric surgery and community weight management for idiopathic intracranial hypertension in a multicenter retrospective cohort study. *Sci Rep* 2025. DOI: 10.1038/s41598-025-97081-5.
19. Khera M, Broderick GA, Carson CC3, et al. Adult-Onset Hypogonadism. *Mayo Clin Proc* 2016. DOI: 10.1016/j.mayocp.2016.04.022.
20. Jayasena CN, Devine K, Barber K, et al. Society for endocrinology guideline for understanding, diagnosing and treating female hypogonadism. *Clin Endocrinol* (Oxf) 2024. DOI: 10.1111/cen.15097.
21. Keast D, Towers A, Letellier ME, et al. The prevalence of lymphedema in Canada: an update. Accurate determinations of prevalence remain a challenge. *Pathways* 2025. DOI: 10.70472/CDPU5571.
22. Aryee EK, Zhang S, Selvin E, et al. Prevalence of Obesity With and Without Confirmation of Excess Adiposity Among US Adults. *JAMA* 2025. DOI: 10.1001/jama.2025.2704.
23. Ross R, Neeland IJ, Yamashita S, et al. Waist circumference as a vital sign in clinical practice: a Consensus Statement from the IAS and ICCR Working Group on Visceral Obesity. *Nat Rev Endocrinol* 2020. DOI: 10.1038/s41574-019-0310-7.
24. Hadizadeh F, Faghihimani E and Adibi P. Nonalcoholic fatty liver disease: Diagnostic biomarkers. *World J Gastrointest Pathophysiol* 2017. DOI: 10.4291/wjgp.v8.i2.11.
25. Horsman J, Furlong W, Feeny D, et al. The Health Utilities Index (HUI): concepts, measurement properties and applications. *Health Qual Life Outcomes* 2003. DOI: 10.1186/1477-7525-1-54.