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Metabolic syndrome in Canadian adults, 2007 to 2019

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ABSTRACT

Background

Metabolic syndrome (MetS) is a major cause of cardiovascular morbidity and mortality. This study provides an updated prevalence of MetS and its components among Canadian adults aged 18 to 79 years in the period from 2016 to 2019 by age group and sex. It also examines trends in the prevalence of MetS and its components over time in this population from 2007 to 2019.

Data and methods

This study used direct health measures data from cycles 1 to 6 (2007 to 2019) of the Canadian Health Measures Survey. MetS was defined as the presence of at least three of the following components: elevated waist circumference, elevated triglycerides, reduced high-density lipoprotein (HDL) cholesterol, high blood pressure, and elevated fasting blood glucose.

Results

In the period from 2016 to 2019, 26.1% of Canadian adults aged 18 to 79 years had MetS. The prevalence of MetS was similar among females (25.2%) and males (27.0%) and increased with age, from 11.1% for those aged 18 to 39 years to 44.3% for those aged 60 to 79 years. The prevalence of MetS remained stable from the 2007-to-2011 period to the 2016-to-2019 period. Among individuals with MetS in the period from 2016 to 2019, high waist circumference was the most common component (90.0%), followed by high fasting blood glucose (70.6%) and low HDL cholesterol (65.8%). The prevalence of all components of MetS increased with age, except for low HDL cholesterol, which significantly decreased with age.

Interpretation

The prevalence of MetS among adults has remained stable over time in Canada. Low HDL cholesterol seems to be the leading component of MetS among young adults.

Keywords

Obesity, diabetes, hypertension, blood pressure, cholesterol, triglycerides

AUTHORS

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What is already known on this subject?

- Metabolic syndrome (MetS) occurs when a person has at least three of the following conditions: high waist circumference, high triglycerides, reduced high-density lipoprotein cholesterol level, high blood pressure, and high fasting glucose. MetS greatly increases the risk of cardiovascular disease and type 2 diabetes.
- The global prevalence of MetS in the general population of adults varied from 12.5% to 31.4%, according to the definition considered, and is increasing, posing an important global public health concern.
- The data from the Canadian Health Measures Survey used in studies examining the prevalence of MetS among Canadian adults are outdated (2007 to 2011), highlighting the need to investigate the updated prevalence of MetS in the most recent available data from this survey (2016 to 2019).

What does this study add?

- In the period from 2016 to 2019, just over one in four Canadian adults aged 18 to 79 years had MetS based on the criteria from the 2009 joint interim statement.
- The prevalence of MetS increases with age and is similar among females and males.
- The prevalence of MetS among adults has remained stable over time in Canada.
- High waist circumference and high fasting blood glucose remain the most prevalent components among individuals with MetS.

Metabolic syndrome (MetS) is a clustering of multiple risk factors, including abdominal obesity (or high waist circumference), elevated triglycerides, low high-density lipoprotein (HDL) cholesterol, high fasting blood glucose, and high blood pressure. MetS is an important contributor to cardiovascular disease and type 2 diabetes. Research indicates that MetS doubles the risk of cardiovascular disease and increases the risk of diabetes fivefold.[1,2] The prevalence of MetS has been on the rise among adults, posing a global public health concern.[3,4] A recent meta-analysis in the general population of adults has indicated that the global prevalence of MetS varied from 12.5% (95% confidence interval [CI]: 10.2% to 15.0%) to 31.4% (95% CI: 29.8% to 33.0%) according to the definition considered.[5]

Several definitions of MetS have been proposed by different organizations over time,[6] including the World Health Organization (WHO) in 1998;[7] the European Group for the Study of Insulin Resistance in 1999;[8] the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) in 2001;[9] the American Heart Association and the National Heart, Lung, and Blood Institute (AHA/NHLBI) in 2004;[10] the International Diabetes Federation (IDF) in 2005;[10] and the joint interim statement by the AHA/NHLBI and IDF in 2009.[11]

These variations make it difficult to compare the prevalence of MetS across studies. For example, among previous studies using the Canadian Health Measures Survey (CHMS), Riediger et al. (2011) applied the NCEP ATP III and the 2009 joint interim statement, using two sets of waist circumference cut-off points because they found limited evidence supporting either cut-off.[12] In contrast, Clarke and Janssen (2013) used the 2009 joint interim statement with waist circumference cut-offs aligned with Health Canada's recommendations.[13] Finally, Rao et al. (2014) applied three definitions: the revised NCEP ATP III (which uses revised waist circumference criteria), the IDF, and the 2009 joint interim statement.[14] Regardless of the definition used, evidence has shown that individuals with MetS had an increased risk of cardiovascular disease and diabetes.[15,16] Ongoing surveillance efforts are necessary to contribute to better prevention and management of MetS in Canada.

Apart from the challenges of defining MetS, WHO has recommended using ethno-specific waist measurement cut-off points. For adults with a predominant South Asian, Southeast Asian, or East Asian ethnicity, lower thresholds are advised—90 centimetres or more for men and 80 centimetres or more for women—as indicators of an increased risk of having visceral adiposity and developing cardiometabolic comorbidities. For adults from other ethnic backgrounds, higher thresholds are used: 102 centimetres or more for men and 88 centimetres or more for women.[11,17] This is particularly important because Canada is a multicultural country, with 5.7 million people reporting South Asian, East Asian, or Southeast Asian ethnicity in the 2021 Census.[18]

The CHMS is an ongoing, nationally representative survey that collects self-reported health information and direct physical measures, including blood samples and waist circumference. Previous studies have used data from Cycle 1 (2007 to 2009) or Cycle 2 (2009 to 2011) of the CHMS to examine the prevalence of MetS in relation to different outcomes in Canadian adults.[12-14] With six cycles of CHMS data spanning 12 years (2007 to 2019) now available, it is worthwhile to investigate the updated prevalence of MetS in adults based on the most recent MetS

definition criteria—the 2009 joint interim statement, which accounts for ethno-specific abdominal obesity—in a representative sample of Canadian adults.[11] This approach facilitates comparisons across recent studies and enhances understanding of the population burden of MetS in Canada.

Using the most recent nationally representative data from the CHMS (2016 to 2019), this study provides an updated prevalence of MetS and its components among Canadian adults aged 18 to 79 years by age group and sex. It also examines trends in the prevalence of MetS and its components over time in this population from 2007 to 2019.

Methods

Data source

Data are from Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019) of the CHMS, a cross-sectional survey of Canadians aged 3 to 79 years (except in Cycle 1, where participants were aged 6 to 79 years) that is conducted by Statistics Canada in partnership with Health Canada and the Public Health Agency of Canada.[19] Data from cycles 1 to 6 remain relevant, as data collection for Cycle 7 (2022 to 2024) has been completed but results are not yet available. Additionally, combining cycles enhances statistical power. The CHMS is designed to provide representative data of the Canadian population living in private dwellings across the 10 provinces over two-year cycles. The survey excludes people living in the territories, on First Nations reserves, or in institutional facilities, as well as full-time members of the Canadian Forces and residents of certain remote regions or areas with a low population. Sociodemographic data and information about health-related risk factors, health conditions, and medication use are collected at home via general health interviews, followed by a visit to a mobile examination centre, where blood and urine samples are collected and other direct physical measurements, such as height, weight, and blood pressure, are taken. Respondents provide a list of all prescription and over-the-counter products taken in the past month. All recorded medications were coded using the Anatomical Therapeutic Chemical (ATC) classification system. Additional information on survey methodology and data collection is described elsewhere.[19,20]

To increase statistical power, produce estimates by sex and age group, and compare data over time, the six cycles were combined into three pairs as follows: Cycle 1 (2007 to 2009) and Cycle 2 (2009 to 2011), Cycle 3 (2012 to 2013) and Cycle 4 (2014 to 2015), and Cycle 5 (2016 to 2017) and Cycle 6 (2018 to 2019). The most recent data from 2016 to 2019 were treated as the reference period. Analyses were restricted to respondents aged 18 to 79 years who fasted before the tests at the mobile examination clinic and were not pregnant at the time of data collection: n=3,734 for cycles 1 and 2, n=3,404 for cycles 3 and 4, and n=3,334 for cycles 5 and 6. Those with incomplete data on waist circumference, plasma triglycerides, blood glucose, HDL cholesterol, and blood pressure were excluded from the analysis. The final analytical sample sizes were as follows: cycles 1 and 2 (2007 to 2011), n=3,694; cycles 3 and 4 (2012 to 2015), n=3,366; and cycles 5 and 6 (2016 to 2019), n=3,296.

Measures and definitions

Detailed information on the measurement procedures for the MetS components is available online.[21,22] Briefly, waist circumference was measured to the nearest 0.1 centimetre at the midpoint between the last floating rib and the top of the iliac crest, at the end of a normal expiration, using a Gulick tape measure. Abdominal obesity, as defined by a high waist circumference, indicates an increased risk of having visceral adiposity and developing cardiometabolic comorbidities. Resting blood pressure was measured electronically using a BpTRU BPM-200 device (BpTRU Medical Devices Ltd., Coquitlam, British Columbia). After resting quietly for five minutes, a minimum of six measurements were taken automatically, one minute apart, and the average systolic blood pressure and diastolic blood pressure were determined using the

Table 1
Definition of metabolic syndrome

Criterion	Cut-off for men	Cut-off for women
Abdominal obesity (low thresholds for waist circumference)[1]	Waist circumference of 90 cm or more	Waist circumference of 80 cm or more
Abdominal obesity (high thresholds for waist circumference)[2]	Waist circumference of 102 cm or more	Waist circumference of 88 cm or more
High plasma triglycerides	1.7 mmol/L or more	1.7 mmol/L or more
High fasting blood glucose	5.6 mmol/L or more	5.6 mmol/L or more
Low HDL cholesterol	Less than 1.03 mmol/L	Less than 1.30 mmol/L
High blood pressure	130/85 mmHg or more	130/85 mmHg or more

1. High waist circumference for respondents who reported being South Asian, Chinese, Filipino, Southeast Asian, Korean, or Japanese.
2. High waist circumference for the remaining respondents.

Notes: HDL = high-density lipoprotein, mmol/L = millimoles per litre, and mmHg = millimetres of mercury. The use of medication for any of the above criteria is considered as meeting the specific criterion. Participants who reported taking medication to control blood pressure or blood glucose were considered positive for meeting the high blood pressure and the high fasting blood glucose criteria, respectively, because biological markers would not accurately reflect the risks. There was no question specific to lipid-lowering medications, but the Anatomical Therapeutic Chemical classification codes were used for triglycerides, HDL cholesterol, blood pressure, and blood glucose.

Source: Alberti KG, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: A joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation. 2009;120(16):1640-1645.

last five of the six measurements. High blood pressure was defined using the cut-off points presented in Table 1 or if respondents had been taking an antihypertensive medication in the month before the measurement. This included medications with ATC codes beginning with C02, C03, C07, C08, C09, C04AA02, or C04AB01, or a "yes" response to the question: "In the past month, did you take any medication for high blood pressure?"

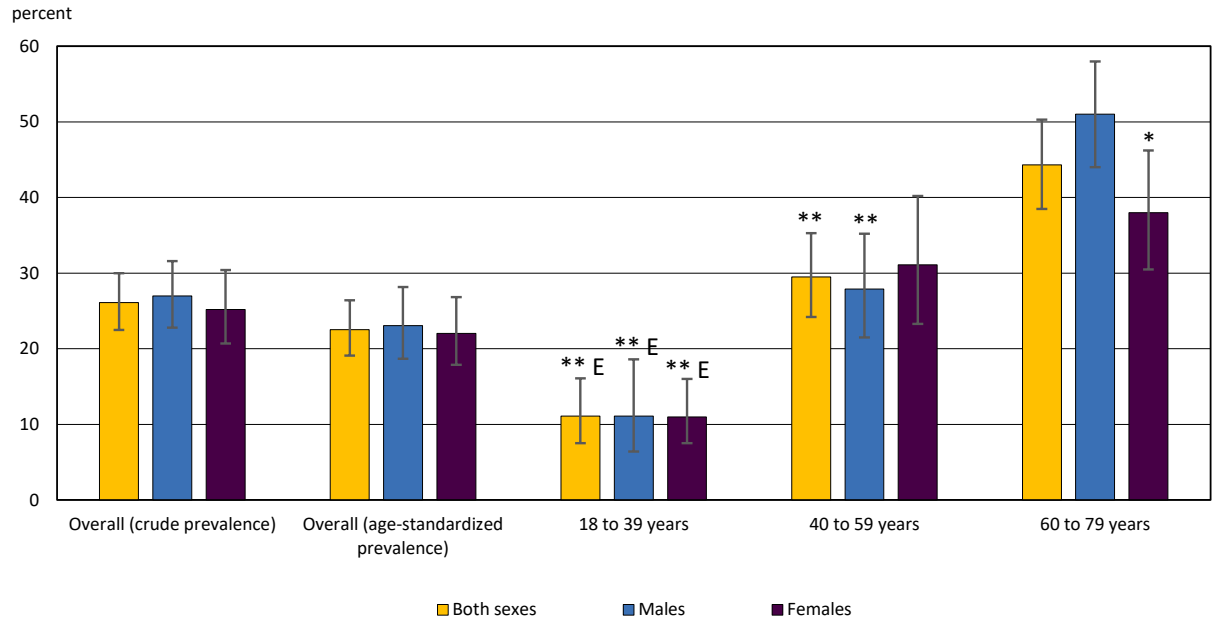
Venous blood samples were collected after a 10-hour fasting period. Glucose, triglycerides, and HDL cholesterol were measured in serum. Starting in Cycle 5, the reference laboratory for glucose, HDL cholesterol, and triglycerides changed, and glucose is now measured using the hexokinase ultraviolet assay on a Roche Cobas C501 analyzer. High fasting blood glucose was defined using the cut-off points outlined in Table 1, or if respondents used diabetes medications in the past month (ATC codes beginning with A10). HDL cholesterol and triglycerides are measured using the homogenous enzymatic colorimetric method on a Roche Cobas C501 analyzer.[22] High triglycerides and low HDL cholesterol were defined using the cut-off points outlined in Table 1. There is no question specific to lipid-lowering medications, but the following ATC codes were used to identify medication related to triglycerides: C04AC01, C04AC03, C10AB01, C10AB02, C10AB04, C10AB05, C10AC01, C10AC02, C10AX02, and C10AX06. For HDL, the following codes were used: C04AC01, C04AC03, C10AB01, C10AB02, C10AB04, C10AB05, C10AC01, C10AC02, and C10AX02.

MetS was defined based on the criteria and definition published in the 2009 joint interim statement, as outlined in Table 1.[11] MetS was considered present if any three of the following five criteria were met: abdominal obesity (defined by high waist circumference), high plasma triglycerides, high fasting blood glucose, low HDL cholesterol, and high blood pressure.

Statistical analyses

All statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, North Carolina) and SUDAAN 11.0.3 (RTI International, Durham, North Carolina). The crude and age-standardized prevalence of MetS and all its components, including high waist circumference, high plasma triglycerides, high plasma triglycerides, high fasting blood glucose, low HDL cholesterol, and high blood pressure, were calculated. Estimates were age standardized to WHO's world standard population using the direct method.[23] Age-standardization represent the potential prevalence of an outcome if the study population had

Chart 1
Prevalence of metabolic syndrome by sex and age group, household population aged 18 to 79 years, Canada, combined 2016 to 2019



[E] use with caution
* significantly different from reference category ($p < 0.05$)
** significantly different from estimate for 60- to 79-year-olds ($p < 0.05$)
Notes: The total sample for both sexes was 3,296 participants, with 1,690 males and 1,606 females. Vertical error bars represent the 95% confidence interval.
Source: Statistics Canada, Canadian Health Measures Survey, 2016 to 2019 (combined).

the same age distribution as a given standard population. Cross-tabulation was used to assess the relationship of MetS with all its components by age group (18 to 39 years, 40 to 59 years, and 60 to 79 years), sex (males and females), and survey year (2007 to 2011, 2012 to 2015, and 2016 to 2019). A chi-square adjusted for the survey design was used to test for significant differences. Survey weights for the fasting subsample calculated by Statistics Canada were used to ensure that analyses for this restricted subpopulation remained representative of the Canadian population. Weights for the combined cycles and the appropriate denominator degrees of freedom were integrated into the analysis. To account for survey design effects, 500 bootstrap replicate weights were used to calculate variance estimation (95% CI) and conduct significance testing. The statistical threshold was set at $p < 0.05$.

Results

In the period from 2016 to 2019, 26.1% (95% CI: 22.5% to 30.0%) of Canadian adults aged 18 to 79 years had MetS (Chart 1). The crude prevalence of MetS was similar among females (25.2%) and males (27.0%) and increased with age, from 11.1% for those aged 18 to 39 years to 44.3% for those aged 60 to 79 years. The same age patterns were observed among females (from 11.0% for those aged 18 to 39 years to 38.0% for those aged 60 to 79 years) and males (from 11.1% to 51.0%), with significant differences between females and males among the oldest age group (i.e., 60 to 79 years). In this age group, MetS was more prevalent among males (51.0%) than among females (38.0%) (Chart 1).

Table 2

Prevalence of metabolic syndrome risk factors by sex and age group, metabolic syndrome population aged 18 to 79 years, Canada, 2016 to 2019

	Both sexes (N=3,296)				Males (N=1,690)				Females (N=1,606)			
			95% confidence interval				95% confidence interval				95% confidence interval	
	n	%	from	to	n	%	from	to	n	%	from	to
Abdominal obesity												
Overall (crude prevalence)	785	90.0	85.7	93.1	400	82.9	76.0	88.1	385	97.6 †	78.3	92.2
Overall (age-standardized prevalence)	785	91.4	86.5	94.7	400	83.3	75.0	89.2	385	98.8	95.4	99.7
18 to 39 years	131	94.3	88.6	97.2	65	88.9	73.0	96.0	66	99.7	95.3	100.0
40 to 59 years	218	86.2	78.2	91.6	108	75.4	62.3	85.0	110	95.9 †	77.6	99.4
60 to 79 years	436	91.9	87.1	95.1	227	86.7	78.3	92.2	209	98.5 †	94.9	99.6
High plasma triglycerides												
Overall (crude prevalence)	524	59.1	52.4	65.4	316	62.6	54.2	70.3	208	55.4	45.8	64.5
Overall (age-standardized prevalence)	524	63.8	55.7	71.3	316	71.6	59.4	81.4	208	64.5	55.4	72.7
18 to 39 years	110	63.1	50.1	74.5	70	73.1 E	40.8	91.4	40	53.0 E	24.6	79.5
40 to 59 years	173	62.5	48.0	75.1	103	66.4	47.7	81.1	70	59.0	42.4	73.8
60 to 79 years	241	54.3	48.0	60.5	143	55.9	46.0	65.3	98	52.3	39.5	64.9
High fasting blood glucose												
Overall (crude prevalence)	652	70.6	64.3	76.3	376	73.7	64.7	81.2	276	67.3	57.3	76.0
Overall (age-standardized prevalence)	652	61.8	52.2	70.5	376	61.7	46.2	75.2	276	57.7	45.6	69.0
18 to 39 years	80	57.2 ‡	42.3	70.9	44	48.0 E‡	20.8	76.4	36	66.7 E	35.6	87.9
40 to 59 years	181	70.0	61.5	77.4	105	74.9	61.4	84.9	76	65.7	52.5	76.8
60 to 79 years	391	76.3	63.6	85.5	227	81.7	69.8	89.6	164	69.4	48.9	84.4
Low high-density lipoprotein cholesterol												
Overall (crude prevalence)	540	65.8	60.8	70.6	280	62.8	54.9	70.0	260	69.1	58.9	77.8
Overall (age-standardized prevalence)	540	80.4	76.0	84.1	280	78.6	72.5	83.6	260	81.6	72.9	88.0
18 to 39 years	126	90.3 ‡	66.7	97.8	62	91.8 ‡	63.8	98.6	64	88.8 ‡	51.7	98.3
40 to 59 years	183	71.2 ‡	60.7	79.9	99	69.3 ‡	55.5	80.3	84	73.0 ‡	57.9	84.1
60 to 79 years	231	51.4	45.5	57.4	119	47.5	38.7	56.5	112	56.4	43.9	68.1
High blood pressure												
Overall (crude prevalence)	618	66.7	59.2	73.5	345	73.0	64.4	80.2	273	60.1 †	50.8	68.8
Overall (age-standardized prevalence)	618	47.6	37.4	58.1	345	58.3	44.1	71.2	273	37.3	30.1	45.0
18 to 39 years	39	16.0 E‡	7.8	30.1	20	F	F	F	19	F	F	F
40 to 59 years	161	70.0 ‡	60.4	78.1	94	77.4	60.8	88.3	67	63.4	52.2	73.3
60 to 79 years	418	83.0	74.3	89.2	231	86.0	75.6	92.4	187	79.3	64.1	89.1

† significantly different from estimate for males ($p < 0.05$)

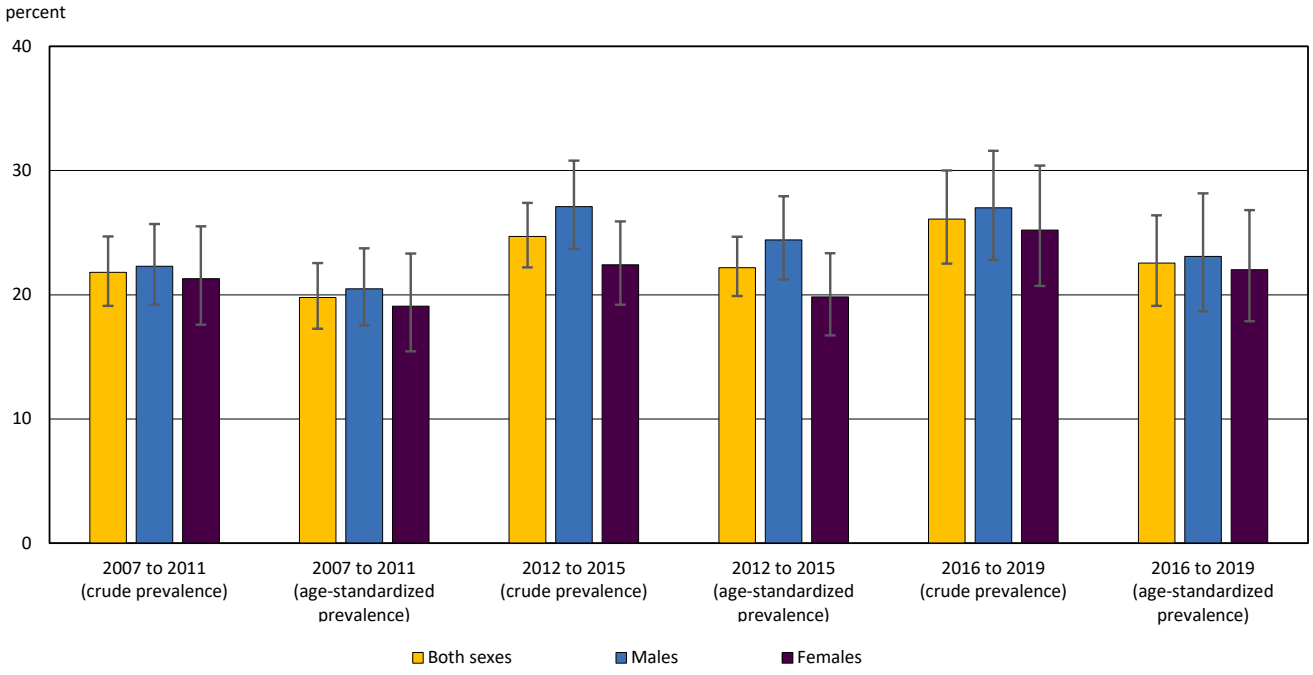
‡ significantly different from estimate for 60- to 79-year-olds ($p < 0.05$)

E use with caution

F too unreliable to be published

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

Chart 2
Prevalence of metabolic syndrome by sex, household population aged 18 to 79 years, Canada, 2007 to 2011, 2012 to 2015, and 2016 to 2019



Notes: From 2007 to 2011, the total sample size for both sexes was 3,694 participants (1,751 males and 1,943 females); from 2012 to 2015, there were 3,366 participants (1689 males and 1677 females); and from 2016 to 2019, there were 3,296 participants (1,690 males and 1,606 females).
Source: Statistics Canada, Canadian Health Measures Survey.

Abdominal obesity (90.0%) was the most common component of MetS in the period from 2016 to 2019, followed by high fasting blood glucose (70.6%), high blood pressure (66.7%), and low HDL cholesterol (65.8%) (Table 2). The prevalence of abdominal obesity was higher among females (97.7%) than males (86.6%) and did not vary across age groups. The prevalence of high blood pressure was higher among males (73.0%) than females (60.1%), while the prevalence of high plasma triglycerides, high fasting blood glucose, and low HDL cholesterol did not differ by sex. The prevalence of high fasting blood glucose significantly increased with age, from 57.2% among those aged 18 to 39 years to 76.3% among those aged 60 to 79 years. In contrast, the prevalence of low HDL cholesterol significantly decreased with age, from 90.3% for those aged 18 to 39 years to 51.4% for those aged 60 to 79 years. The same age patterns were observed among females and males for high fasting blood glucose and low HDL cholesterol. Among individuals aged 60 to 79 years, the three most common components of MetS were abdominal obesity (91.9%), followed by high blood pressure (83.0%) and high fasting blood glucose (76.3%).

Chart 2 displays the crude and age-standardized prevalence of MetS in the Canadian adult population by sex and by paired survey cycle. Both the crude and the age-standardized prevalence of MetS remained fairly stable from the 2007-to-2011 period to the 2016-to-2019 period. For example, the crude prevalence of MetS increased slightly from 21.8% in the 2007-to-2011 period to 26.1% in the 2016-to-2019 period; however, the difference was not statistically significant. The trends among females (from 21.3% in the 2007-to-2011 period to 25.2% the 2016-to-2019 period) and males (from 22.3% to 27.0%) were comparable.

All MetS components remained stable from the 2007-to-2011 period to the 2016-to-2019 period, except for high plasma triglycerides (crude and age-standardized prevalence) and high fasting blood glucose (crude only) (Table 3). The crude prevalence of high plasma triglycerides significantly decreased over time, from 70.1% in the 2007-to-2011 period to 59.1% in the 2016-to-2019 period. In contrast, the prevalence of high fasting blood glucose significantly increased, from 58.6% in the 2007-to-2011 period to 70.6% in the 2016-to-2019 period. Similar patterns were observed among females and males, but the differences were not statistically significant in males. However, values for males and females did not change significantly from the 2007-to-2009 period to the 2012-to-2015 period for the remaining MetS components. Females were more

Table 3
Prevalence of metabolic syndrome risk factors by sex, metabolic syndrome population aged 18 to 79 years, Canada, 2007 to 2011, 2012 to 2015, and 2016 to 2019

	Both sexes				Males				Females			
			95% confidence interval				95% confidence interval				95% confidence interval	
	n	%	from	to	n	%	from	to	n	%	from	to
High waist circumference (crude prevalence)												
2007 to 2011	769	93.1	90.4	95.1	371	89.1	84.3	92.6	398	97.2 †	95.0	98.5
2012 to 2015	794	90.2	88.1	92.0	370	84.6	79.6	88.5	424	96.9 †	90.5	99.0
2016 to 2019	785	90.0	85.7	93.1	400	82.9	76.0	88.1	385	97.6 †	90.7	99.4
High waist circumference (age-standardized prevalence)												
2007 to 2011	769	94.2	88.8	97.1	371	91.4	83.3	95.8	398	98.1	94.9	99.3
2012 to 2015	794	92.9	88.9	95.6	370	88.8	83.2	92.7	424	98.8	94.6	99.7
2016 to 2019	785	91.4	86.5	94.7	400	83.3	75.0	89.2	385	98.8	95.4	99.7
High plasma triglycerides (crude prevalence)												
2007 to 2011	581	70.1	64.0	75.6	298	72.6	65.5	78.6	283	67.5	59.3	74.8
2012 to 2015	598	72.5	66.0	78.1	320	74.6	64.6	82.6	278	69.9	62.0	76.7
2016 to 2019	524	59.1 ‡	52.4	65.4	316	62.6	54.2	70.3	208	55.4 ‡	45.8	64.5
High plasma triglycerides (age-standardized prevalence)												
2007 to 2011	581	77.8	71.2	83.3	298	76.1	69.6	81.6	283	78.0	68.3	85.3
2012 to 2015	598	83.5	78.9	87.2	320	85.3	75.8	91.5	278	79.6	73.4	84.7
2016 to 2019	524	63.8	55.7	71.3	316	71.6	59.4	81.4	208	64.5	55.4	72.7
High fasting blood glucose (crude prevalence)												
2007 to 2011	524	58.6	53.1	63.9	277	64.2	55.7	71.9	247	52.7 †	46.5	58.9
2012 to 2015	529	60.1	52.3	67.5	295	69.1	60.5	76.5	234	49.4 †	38.1	60.9
2016 to 2019	652	70.6 ‡	64.3	76.3	376	73.7	64.7	81.2	276	67.3 ‡	57.3	76.0
High fasting blood glucose (age-standardized prevalence)												
2007 to 2011	524	50.7	40.6	60.8	277	54.8	41.9	67.2	247	47.6	34.5	61.1
2012 to 2015	529	47.8	37.1	58.7	295	56.7	43.8	68.7	234	35.4	22.4	51.0
2016 to 2019	652	61.8	52.2	70.5	376	61.7	46.2	75.2	276	57.7	45.6	69.0
Low high-density lipoprotein cholesterol (crude prevalence)												
2007 to 2011	541	66.5	60.7	71.8	253	61.0	52.3	69.0	288	72.1 †	65.4	78.0
2012 to 2015	569	63.1	56.3	69.5	268	60.3	49.9	69.8	301	66.5	57.9	74.2
2016 to 2019	540	65.8	60.8	70.6	280	62.8	54.9	70.0	260	69.1	58.9	77.8
Low high-density lipoprotein cholesterol (age-standardized prevalence)												
2007 to 2011	541	76.6	70.2	81.9	253	69.3	59.0	77.9	288	81.6	72.0	88.5
2012 to 2015	569	70.7	59.6	79.9	268	62.2	46.4	75.7	301	81.5	73.5	87.5
2016 to 2019	540	80.4	76.0	84.1	280	78.6	72.5	83.6	260	81.6	72.9	88.0
High blood pressure (crude prevalence)												
2007 to 2011	572	59.9	53.9	65.6	295	62.2	53.1	70.6	277	57.4	48.2	66.1
2012 to 2015	624	64.1	58.0	69.8	319	63.1	55.6	69.9	305	65.4	58.2	72.0
2016 to 2019	618	66.7	59.2	73.5	345	73.0	64.4	80.2	273	60.1 †	50.8	68.8
High blood pressure (age-standardized prevalence)												
2007 to 2011	572	39.6	34.4	44.2	295	46.9	39.3	54.7	277	35.1	26.0	45.4
2012 to 2015	624	42.3	36.6	47.3	319	46.3	36.4	56.5	305	36.7	31.0	42.9
2016 to 2019	618	47.6	36.7	58.7	345	58.3	44.1	71.2	273	37.3	30.1	45.0

† significantly different from estimate for males ($p < 0.05$)
‡ significantly different from estimate for 2007 to 2011 ($p < 0.05$)
Source: Statistics Canada, Canadian Health Measures Survey.

likely than males to have a high waist circumference across all survey cycles and low HDL cholesterol in the period from 2007 to 2011. Males were more likely than females to have high fasting blood glucose in the 2007-to-2011 and the 2012-to-2015 periods, and high blood pressure in the period from 2016 to 2019.

The distribution of the crude and age-standardized prevalence estimates by number of components of MetS among Canadian adults aged 18 to 79 in the period from 2016 to 2019 is summarized in Table 4. Nearly 32% of Canadian adults had none of the MetS components. Females were more likely than males to have none of the components, and the prevalence significantly decreased with age among females and males. In contrast, 10.5% of Canadian adults had four or five of the components. This prevalence significantly increased with age, from 1.7% for individuals aged 18 to 40 years to 19.1% for those aged 60 to 79 years. There were no sex differences in the proportion of participants with four or five of the MetS components.

Results from sensitivity analyses using ethno-specific cut-off points for waist measurement recommended by the 2020 Canadian Adult Obesity Clinical Practice Guideline (i.e., 85 centimetres or more for men and 75 centimetres or more for women with a predominant South Asian, Southeast Asian, or East Asian ethnicity, and 102 centimetres or more for men and 88 centimetres or more for women of other ethnicities)[24] showed very small changes to the estimates (generally less than 1%).

Table 4
Number of metabolic syndrome risk factors by sex and age group, household population aged 18 to 79 years, Canada, 2016 to 2019

	Both sexes (N=3,296)				Males (N=1,690)				Females (N=1,606)			
			95% confidence interval				95% confidence interval				95% confidence interval	
	n	%	from	to	n	%	from	to	n	%	from	to
Zero risk factors												
Overall (crude prevalence)	1,018	32.3	29.2	35.5	504	31.3	27.3	35.6	514	33.2	29.7	36.9
Overall (age-standardized prevalence)	1,018	36.1	32.7	39.7	504	35.5	30.6	40.6	514	36.6	32.4	41.0
18 to 39 years	577	47.2 ‡	40.2	54.3	307	49.7 ‡	40.8	58.6	270	44.7 ‡	35.1	54.7
40 to 59 years	301	29.8 ‡	24.2	36.1	138	26.6 ‡	20.0	34.3	163	33.0 ‡	26.1	40.7
60 to 79 years	140	12.9	9.6	17.0	59	8.8	6.3	12.2	81	16.7 †	12.0	22.7
One risk factor												
Overall (crude prevalence)	774	24.2	21.3	27.3	385	24.2	20.1	28.7	389	24.2	20.4	28.5
Overall (age-standardized prevalence)	774	25.5	22.3	29.1	385	25.4	20.8	30.6	389	25.8	21.4	30.7
18 to 39 years	328	30.6 ‡	25.2	36.6	169	28.5 ‡	21.6	36.6	159	32.8 ‡	24.9	41.9
40 to 59 years	247	21.1	16.8	26.2	125	25.8	18.0	35.5	122	16.5	12.4	21.7
60 to 79 years	199	18.6	15.2	22.5	91	14.8	11.4	19.0	108	22.1	16.3	29.3
Two risk factors												
Overall (crude prevalence)	648	17.5	14.4	21.0	328	17.6	12.9	23.5	320	17.4	14.5	20.6
Overall (age-standardized prevalence)	648	16.1	13.3	19.4	328	16.3	11.4	22.8	320	15.9	13.5	18.7
18 to 39 years	178	11.1	8.0	15.2	82	10.7 E‡	5.6	19.4	96	11.5 E‡	7.8	16.7
40 to 59 years	212	19.6	14.8	25.5	124	19.8 E	13.3	28.4	88	19.4 E	12.9	28.0
60 to 79 years	258	24.3	19.8	29.4	122	25.4	19.0	33.1	136	23.2	18.3	28.9
Three risk factors												
Overall (crude prevalence)	479	15.6	12.8	18.8	254	15.6	12.4	19.5	225	15.5	12.1	19.6
Overall (age-standardized prevalence)	479	13.5	10.8	16.8	254	13.3	10.1	17.5	225	13.6	10.4	17.6
18 to 39 years	98	9.3 E‡	6.0	14.2	48	9.0 E‡	4.9	16.1	50	9.7 E‡	6.2	14.9
40 to 59 years	127	15.5 ‡	12.4	19.3	69	13.5 ‡	9.6	18.8	58	17.5	13.2	22.8
60 to 79 years	254	25.2	20.4	30.6	137	29.3	22.0	37.8	117	21.3	15.7	28.4
Four or five risk factors												
Overall (crude prevalence)	401	10.5	8.8	12.5	231	11.3	9.5	13.5	170	9.7	7.4	12.8
Overall (age-standardized prevalence)	401	8.8	7.2	10.6	231	9.5	7.7	11.7	170	8.1	5.9	10.9
18 to 39 years	49	1.7 E‡	1.0	2.9	31	2.1 E‡	1.1	4.1	18	1.4 E‡	0.7	2.6
40 to 59 years	129	14.0 ‡	10.3	18.8	74	14.3	9.9	20.2	55	13.6 E	8.6	20.9
60 to 79 years	223	19.1	15.4	23.4	126	21.7	16.8	27.6	97	16.7	12.6	21.8

† significantly different from estimate for males ($p < 0.05$)

‡ significantly different from estimate for 60- to 79-year-olds ($p < 0.05$)

E use with caution

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

Discussion

Previous studies have used data from the first two cycles of the CHMS (Cycle 1 [2007 to 2009] and Cycle 2 [2009 to 2011]) to examine the prevalence of MetS in relation to different outcomes.[12-14] With six cycles of CHMS data now available (2007 to 2019), this study provides an updated prevalence of MetS and its components among Canadian adults aged 18 to 79 years in the period from 2016 to 2019 by age group and sex. Results showed that nearly one in four Canadian males and females aged 18 to 79 had MetS. The prevalence of MetS was similar among females and males and increased with age, from 11.1% among those aged 18 to 39 years to 44.4% among those aged 60 to 79 years. Among individuals with MetS in the period from 2016 to 2019, high waist circumference was the most common component, followed by high fasting blood glucose and low HDL cholesterol. The prevalence of all MetS components increased with age, except for low HDL cholesterol, which significantly decreased with age.

Several definitions of MetS have been proposed by different organizations over time,[6] making comparisons across studies difficult. Riediger et al. (2011) used data from Cycle 1 (2007 to 2009) of the CHMS to investigate the prevalence of MetS among Canadian adults aged 18 to 79 years using different criteria.[12] They found that the prevalence of MetS was about 17.7% based on ATP III criteria, 19.1% based on the unified criteria with high thresholds for waist circumference, and 23.2% based on the unified criteria with low thresholds for waist circumference.[12] Rao et al. (2014) also used Cycle 1 data to assess different criteria in adults aged 20 to 79 years.[14] They found that the crude prevalence of MetS was about 15.5% based on ATP III criteria, 23.1% based on the IDF criteria, and 19.6% based on the joint interim statement.[14] In another Canadian study, Clarke and Janssen (2014) combined data from cycles 1 and 2 (2007 to 2012) of the CHMS and documented a prevalence of 16.4% among Canadian adults aged 18 to 64 years, based on the joint interim statement.[13] The estimates reported in this study are different from those reported in previous studies using CHMS data because of differences in study methodology (e.g., age of the study population, combined cycles, exclusions) and definitions of MetS (e.g., the joint interim statement, ethno-specific cut-off points for waist measurement).

Regardless of the diagnostic criteria used, several epidemiological studies have confirmed the increased risk of cardiovascular disease and diabetes for individuals with MetS.[25-27] The overall prevalence of MetS, documented at 26.2% in this study using the joint interim statement definition of MetS, is relatively lower than the prevalence documented among adults in the United States aged 18 and older in the 2007 to 2012 National Health and Nutrition Examination Survey (NHANES) (34.2%) using the same definition,[28] and in the 2011 to 2018 NHANES (37.6%) using the NCEP ATP III definition.[29] Moreover, the lack of sex differences in the prevalence of MetS over time observed in the total study sample is consistent with the findings from the 2011 to 2018 NHANES[29] and suggests that the prevalence of MetS is similar among males and females. However, differences between males and females became more apparent in the oldest age group (i.e., those aged 60 to 79 years), with females more likely to have MetS than males—an interesting observation that warrants further investigation. The findings that the prevalence of MetS increased with age are consistent with results observed in the United States and in other populations around the world.[30-32] It is well known that the prevalence of most chronic diseases and conditions increases with age.[33] As the Canadian population ages, an increase in the prevalence of MetS could be expected, increasing the burden of cardiovascular disease and diabetes.[10,26,27,34] Heightened and ongoing efforts are needed, particularly to address diabetes as defined by high fasting blood glucose, which increased significantly over the study period.

This study also examines trends in the crude and age-standardized prevalence of MetS and its components over time in this population from 2007 to 2019. Results showed that the prevalence of MetS remained relatively stable from the 2007-to-2011 period to the 2016-to-2019 period. These findings contrast with those from the United States that showed an increase over time, from 37.6% in the 2011-to-2012 period to 41.8% in the 2017-to-2018 period.[29] However, the sample size of the present study may be insufficient to detect a significant difference. Trends for all the MetS components were also stable across the same period, except for high plasma triglycerides and high fasting blood glucose. The prevalence of high plasma triglycerides in individuals with MetS significantly decreased over time, while the prevalence of high fasting blood glucose showed an opposite trend. These findings are consistent with those from the United States indicating that among the MetS components, the prevalence of elevated glucose increased from 48.9% in the 2011-to-2012 period to 64.7% in the 2017-to-2018 period, while the prevalence of high plasma triglycerides decreased over time, from 26.7% to 21.1%, although the difference was not statistically significant.[29] The analyses in the present study provide further indication of the rising trend in hyperglycemia as one of the leading causes of MetS, highlighting the pressing need to strengthen ongoing efforts to prevent diabetes in Canada. In contrast, the prevalence of diabetes in the general population of Canadian adults based on the CHMS data remained relatively stable from the 2009-to-2011 period to the 2016-to-2019 period.[35] This finding is consistent with the self-reported data from the Canadian Community Health Survey,[36] indicating that the prevalence of diabetes among Canadian adults was fairly stable from 2015 to 2021. The observed increase in the prevalence of elevated fasting blood glucose over time could be explained by the change in the reference laboratory responsible for glucose test analysis in the CHMS during the period from 2016 to 2019 (i.e., cycles 5 and 6).

The finding that abdominal obesity (90.5%) was the most common component of MetS, followed by high fasting blood glucose (70.6%), was not surprising. Research has shown that the prevalence of MetS rises even more dramatically as body mass index increases. For example, in the 2003 to 2006

NHANES, overweight adult males and females aged 20 years or older were found to be over 6 and 5.5 times, respectively, as likely to meet the criteria for MetS than underweight and normal-weight individuals. However, among those with obesity, these figures spiked to 32 times higher in males and 17 times higher in females, compared with underweight and normal-weight individuals.[37]

The strengths of the present study include the use of a large and nationally representative sample of Canadian adults and the use of direct measures data, which provide unbiased measures of MetS components. Age standardization allows for comparisons of estimates over time by removing the influence of changes in the population's age distribution. The use of ethno-specific abdominal obesity cut-off points may help improve the accuracy of estimates, particularly for Asian participants.[37] Important limitations include the cross-sectional nature of the data, which does not allow for longitudinal follow-up or causal inferences, and the restriction of the present analyses to a smaller fasted subsample of the CHMS. This could be problematic because of reduced statistical power and a likely increased risk of bias.

In conclusion, this study provides an updated prevalence of MetS and its components among Canadian adults aged 18 to 79 years by age group and sex for the period from 2016 to 2019 using the most recent available data. While Cycle 7 data, which were collected from 2022 to 2024, will be available soon, waiting for data from Cycle 8 will allow for a more robust analysis and perhaps a better comparison of the periods before the COVID-19 pandemic and the period following it. In the period from 2016 to 2019, just over one in four Canadian adults had MetS. The prevalence of MetS increases with age and is similar among females and males, except in the oldest age group, where females were more likely than males to have MetS. Abdominal obesity and high fasting blood glucose were the most frequent components among individuals with MetS. The prevalence of MetS and its components remained relatively stable over the period from 2007 to 2011 to the period from 2016 to 2019, except for high plasma triglycerides and high fasting blood glucose, which decreased and increased over time, respectively. The rising trend in high fasting blood glucose highlights the pressing need for heightened efforts to prevent diabetes in Canada. The findings from this study also underscore the need to raise awareness and improve screening among this high-risk group while strengthening ongoing surveillance of obesity and diabetes in Canada to reduce the population burden of MetS.

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