

# Estimating multimorbidity prevalence with the Canadian Chronic Disease Surveillance System

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## Abstract

**Introduction:** The Public Health Agency of Canada's Canadian Chronic Disease Surveillance System (CCDSS) uses a validated, standardized methodology to estimate prevalence of individual chronic diseases, such as diabetes. Expansion of the CCDSS for surveillance of multimorbidity, the co-occurrence of two or more chronic diseases, could better inform health promotion and disease prevention. The objective of this study was to assess the feasibility of using the CCDSS to estimate multimorbidity prevalence.

**Methods:** We used administrative health data from seven provinces and three territories and five validated chronic conditions (i.e. cardiovascular disease, respiratory disease, mental illness, hypertension and diabetes) to estimate multimorbidity prevalence. We produced age-standardized (using Canada's 1991 population) and age-specific estimates for two multimorbidity definitions: (1) two or more conditions, and (2) three or more conditions from the five validated conditions, by sex, fiscal year and geography.

**Results:** Among Canadians aged 40 years and over in the fiscal year 2011/12, the prevalence of two or more and three or more chronic conditions was 26.5% and 10.2%, respectively, which is comparable to other estimates based on administrative health data. The increase in multimorbidity prevalence with increasing age was similar across provinces. The difference in prevalence for males and females varied by province and territory. We observed substantial variation in estimates over time. Results were consistent for the two definitions of multimorbidity.

**Conclusion:** The CCDSS methodology can produce comparative estimates of multimorbidity prevalence across provinces and territories, but there are challenges in using it to estimate temporal trends. Further expansion of the CCDSS in the number and breadth of validated case definitions will improve the accuracy of multimorbidity surveillance for the Canadian population.

**Keywords:** *chronic disease, surveillance, prevalence, CCDSS*

## Introduction

Multimorbidity, the co-existence of two or more chronic diseases where one is not necessarily more central than the others,<sup>1</sup> is becoming increasingly common, particularly among older adults.<sup>2-7</sup> Multimorbidity prevalence is expected to rise, in Canada as in other countries, due to an aging population and an increasing prevalence of such chronic diseases as diabetes

and hypertension.<sup>8</sup> Multimorbidity is an important issue for health care providers and policy makers to monitor because it has been linked with potentially negative health outcomes, including decreased health-related quality of life<sup>9</sup> and increased health care utilization and costs.<sup>10,11</sup>

The Canadian Chronic Disease Surveillance System (CCDSS) is a collaborative effort

between the Public Health Agency of Canada (PHAC) and provincial and territorial governments. The goal of the CCDSS is to produce accurate estimates of chronic disease prevalence and incidence for such conditions as diabetes and hypertension. This information can be used in a number of ways, such as for assessing the impact of chronic disease on the health care system. The CCDSS produces comparative data using a population-based methodology that has been validated and standardized

## Highlights

- The Canadian Chronic Disease Surveillance System (CCDSS) uses a standardized methodology based on administrative data to estimate the prevalence of chronic conditions, such as diabetes, for provinces and territories. We examined the feasibility of using the CCDSS for surveillance of multimorbidity, commonly defined as the co-occurrence of two or more chronic conditions.
- The overall prevalence of multimorbidity using this definition was 26.5% in 2011/12, based on data for five conditions (cardiovascular disease, respiratory disease, mental illness, hypertension, diabetes) from seven provinces and three territories. Age-specific trends were similar across jurisdictions, but changes over time showed substantial variation.
- The CCDSS will be increasingly useful for national multimorbidity surveillance as more chronic disease case definitions are added.

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across provinces and territories. Currently, however, the CCDSS focusses on individual chronic diseases; it has not yet been investigated for multimorbidity surveillance.

At present, there is limited population-based information about multimorbidity in Canada. Roberts et al.<sup>7</sup> used data from the Canadian Community Health Survey (CCHS) to estimate multimorbidity prevalence for a single year and demonstrate its association with determinants of health such as age and income. Kuwornu et al.<sup>12</sup> used CCHS data to compare the prevalence and characteristics of multimorbidity in Canadian Aboriginal and non-Aboriginal Caucasian populations. However, no population-based studies have provided comparative estimates for all of Canada's provinces and territories. A few population-based studies have been conducted for individual provinces or territories,<sup>6,13,14</sup> but only one<sup>6</sup> of these has examined changes in multimorbidity over time, and none have examined variations across population subgroups. Given this background, the purpose of this study was to assess the feasibility of using the CCDSS to estimate multimorbidity prevalence across population groups defined by age, sex and geography, and over time.

## Methods

### Data sources

A total of 10 provinces and territories provided data for the analyses reported in this study: British Columbia (BC), Manitoba (MB), Ontario (ON), Quebec (QC), New Brunswick (NB), Nova Scotia (NS), Newfoundland and Labrador (NL), Yukon (YT), Northwest Territories (NT) and Nunavut (NU). These jurisdictions responded to the v2015 CCDSS data call as of April 2015. These provinces and territories represent about 86% of the entire Canadian population, including all of Canada's northern population.<sup>15</sup>

The administrative health databases we used to estimate multimorbidity prevalence included hospital records, physician billing claims and population registry files. Hospital records and physician billing claims provide information about diagnosed disease cases that are recorded with the International Classification of Diseases, Ninth Revision (ICD-9),<sup>16</sup> International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)<sup>17</sup> and International Statistical

Classification of Diseases and Related Health Problems, Tenth Revision, Canada (ICD-10-CA).<sup>18</sup> Population registry files capture all residents of the provinces and territories with valid health insurance coverage, and also provide demographic information (i.e. age and sex). These three data sources can be anonymously linked via a resident's unique lifetime identifier (i.e. health insurance number).

### Definitions of selected chronic conditions

Five chronic conditions were included in this study: (1) cardiovascular disease, which includes ischemic heart disease and heart failure; (2) respiratory disease, which includes asthma and chronic obstructive pulmonary disease (COPD); (3) mental illness, a CCDSS omnibus category (including ICD-9 290–319) that encompasses psychosis, neurotic disorders, personality disorders, other nonpsychotic mental disorders and mental retardation; (4) hypertension; and (5) diabetes. We chose these chronic conditions because validated case definitions had been developed by the CCDSS.<sup>19–25</sup> Additional chronic conditions that are prevalent in adults aged 40 years and over, such as arthritis and osteoporosis, are included in other multimorbidity definitions, but did not have validated CCDSS case definitions at the time of this study. All of the selected chronic conditions have been included in previous research about the measurement of multimorbidity.<sup>26</sup>

The selected chronic conditions were defined using case rules (Table 1) applied to administrative data for fiscal years 1995/96 and onward (a fiscal year extends from April 1 to March 31); prevalence estimates were produced for 2001/02 and 2011/12. Each case rule, which was developed by a CCDSS working group, describes the number and types of diagnosis codes that must be recorded in an administrative database in a specified period of time for an individual to be classified as a disease case. Fiscal year 2011/12 was the most current year for which data was available at the time the call for data was distributed to the provinces and territories.

We evaluated two definitions of multimorbidity. The first was the most common definition, which is the co-occurrence of two or more (2+) chronic conditions. The second definition was the co-occurrence of three or more (3+) conditions. This

definition has also been investigated in previous research.<sup>7</sup>

### Statistical analysis

We estimated the prevalence of multimorbidity for people aged 40 years and over by sex, five-year age group, province and territory, definition and fiscal year. We selected 40 years as the minimum age because it represents the common lower age limit among the chronic disease case definitions included in this research. We calculated age-standardized, age-specific and crude prevalence rates for each province and territory, and for all 10 provinces and territories combined. The age-standardized rates were calculated using Canada's 1991 population as the standard population. We calculated crude prevalence rates by dividing the number of people with multimorbidity by the total population as defined by the provincial or territorial population registry. We conventionally rounded prevalence counts to adjacent multiples of five (rounded to multiples of 10 for Ontario and overall data).

We described the data in both tabular and graphic forms. Comparisons between jurisdictions over time and across population subgroups were conducted using percentages, ranks and the coefficient of variation, a statistical measure of dispersion. We produced 95% confidence intervals (95% CIs) for the estimates of the magnitude of the difference between subgroups using a large-sample chi-square ( $\chi^2$ ) distribution. We used the Spearman rank-order correlation to describe the association between the prevalence estimates obtained from the two multimorbidity definitions at the provincial/territorial level because the distribution of the estimates could not be assumed to follow a normal distribution. The nonparametric Mantel-Haenszel statistic, which asymptotically follows a  $\chi^2$  distribution, was used to test the linear trend over time. All statistical analyses were performed using SAS version 9.3.<sup>27</sup>

## Results

Table 2 reports the estimated age-standardized prevalence of multimorbidity by definition (i.e. 2+ and 3+ conditions) for each province and territory, and for the 10 provinces and territories overall, in the first and last years of the study period. In 2011/12, the overall age-standardized prevalence of 2+ chronic conditions was

**TABLE 1**  
CCDSS case definitions for the chronic conditions selected to estimate multimorbidity prevalence

Chronic condition	Algorithm	Age range (years)	Case date	Hospital & physician codes		Exclusions
				ICD-9-CM	ICD-10-CA	
<b>Cardiovascular</b>						
Ischemic heart disease	One or more hospitalizations or two or more physician codes within one year	20+	Hospital separation or last physician visit (whichever comes first)	410–414	I20–I25	None
Heart failure	One or more hospitalizations or two or more physician codes within one year	40+	Hospital separation or last physician visit (whichever comes first)	428	I50	None
<b>Respiratory</b>						
Asthma	One or more hospitalizations or two or more physician claims within two years	1+	Hospital separation or last physician visit (whichever comes first)	493	J45, J46	None
COPD	One or more hospitalizations or one or more physician claims	35+	Hospital separation or last physician visit (whichever comes first)	491, 492, 496	J41–J44	None
<b>Mental illness</b>						
Omnibus	One or more hospitalizations or one or more physician claims within one year	0+	Hospital separation or last physician visit (whichever comes first)	290–319	F00–F99	None
<b>Hypertension</b>						
	One or more hospitalizations or two or more physician claims within two years	20+	Hospital separation or last physician visit (whichever comes first)	401–405	I10–I13, I15	Pregnancy-induced hypertension in women aged 20 to 54 years
<b>Diabetes</b>						
	One or more hospitalizations or two or more physician claims within two years	1+	Hospital separation or last physician visit (whichever comes first)	250	E10–E14	Gestational diabetes in women aged 10 to 54 years

**Abbreviations:** CCDSS, Canadian Chronic Disease Surveillance System; COPD, chronic obstructive pulmonary disease; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; ICD-10-CA, International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Canada.

26.5%. This was a 29.3% relative increase over the 2001/02 estimate of 20.5%. The overall age-standardized prevalence of 3+ chronic conditions was 10.2% in 2011/12 which was a 50.0% increase over the 2001/02 estimate of 6.8%. The linear trend in the prevalence of 2+ conditions was statistically significant ( $p < .001$ ); the same was true for 3+ conditions ( $p < .001$ ). There was a strong association between the prevalence estimates obtained from the two multimorbidity definitions at the provincial/territorial level using the Spearman correlation coefficient; the estimated correlation was 0.94 in 2001/02 (data not shown).

For the multimorbidity definition of 2+ chronic conditions, the lowest estimate

across the provinces and territories was 6.5% (NU) in 2001/02 and 24.0% (NT) in 2011/12. The highest estimate was 23.5% in 2001/02 and 30.3% in 2011/12, both from NS. For the multimorbidity definition of 3+ conditions, the lowest estimate in 2001/02 was 1.4% (NU) and in 2011/12 it was 9.1% (BC). The highest estimate in 2001/02 was 7.8% (NS) and in 2011/12 it was 12.0% (NU). The ranking of the provinces and territories in terms of the percentage increase between 2001/02 and 2011/12 was similar for both definitions of multimorbidity. NU showed the largest increase, at 326.2% for 2+ conditions and 757.1% for 3+ conditions between the two study years. The smallest increase was in NL: it was 24.9% for 2+ chronic

conditions and 39.7% for 3+ chronic conditions.

Figure 1 shows the 2011/12 age-standardized prevalence of 2+ chronic conditions by sex and province/territory. The overall prevalence was 1.1 percentage points (95% CI: 1.1–1.2) higher for men than for women. Men had a higher prevalence than women in several of the provinces. However, prevalence was higher for women than men in all of the territories. The smallest absolute difference in estimated prevalence between men and women was observed for NL (0.1%). The largest absolute difference was observed for NU (3.8%). The overall prevalence of 3+ diseases was 1.4 percentage points

**TABLE 2**  
Age-standardized multimorbidity prevalence<sup>a</sup> estimates (%) and 95% CIs, stratified by multimorbidity definition and fiscal year

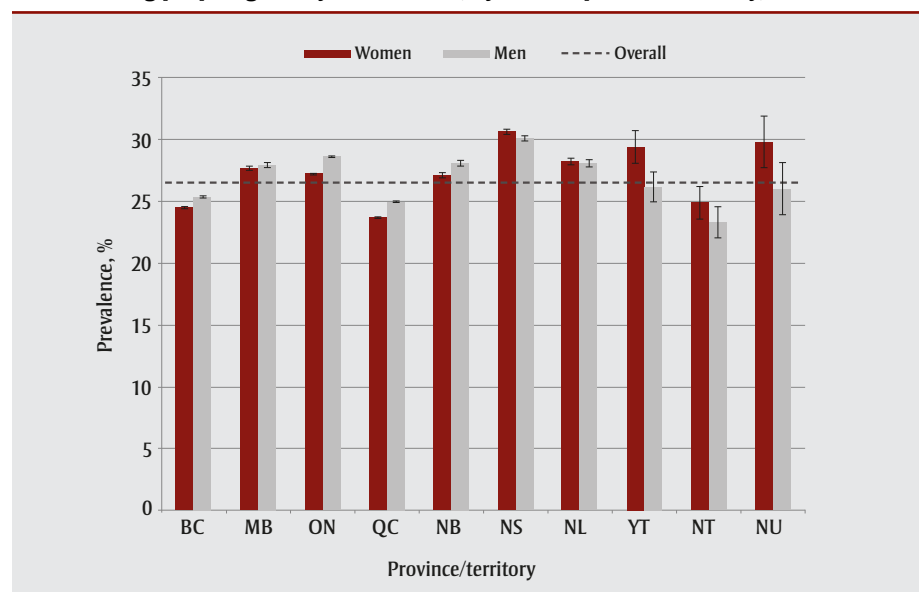
Province or territory	Multimorbidity definition (# of chronic conditions)					
	2+ conditions			3+ conditions		
	2001/02 % (95% CI)	2011/12 % (95% CI)	% Increase (rank)	2001/02 % (95% CI)	2011/12 % (95% CI)	% Increase (rank)
BC	17.4 (17.4–17.5)	24.8 (24.8–24.9)	42.5 (3)	5.2 (5.1–5.2)	9.1 (9.1–9.2)	75.0 (3)
MB	20.4 (20.3–20.5)	27.7 (27.6–27.8)	35.8 (5)	6.4 (6.3–6.4)	10.3 (10.3–10.4)	60.9 (5)
ON	22.2 (22.2–22.2)	27.8 (27.8–27.9)	25.2 (9)	7.6 (7.6–7.6)	10.9 (10.9–10.9)	43.4 (9)
QC	19.0 (18.9–19.0)	24.3 (24.2–24.3)	27.9 (8)	6.3 (6.3–6.3)	9.2 (9.2–9.2)	46.0 (8)
NB	19.6 (19.5–19.8)	27.5 (27.4–27.7)	40.3 (4)	6.5 (6.4–6.5)	10.4 (10.3–10.5)	60.0 (6)
NS	23.5 (23.4–23.6)	30.3 (30.1–30.4)	28.9 (7)	7.8 (7.7–7.8)	11.8 (11.7–11.9)	51.3 (7)
NL	22.5 (22.3–22.7)	28.1 (27.9–28.3)	24.9 (10)	7.3 (7.2–7.5)	10.2 (10.1–10.3)	39.7 (10)
YT	19.3 (18.3–20.2)	27.6 (26.8–28.5)	43.0 (2)	6.1 (5.6–6.7)	10.9 (10.4–11.5)	78.7 (2)
NT	17.7 (16.8–18.6)	24.0 (23.1–24.9)	35.6 (6)	6.3 (5.8–6.9)	10.2 (9.6–10.8)	61.9 (4)
NU	6.5 (5.6–7.5)	27.7 (26.3–29.2)	326.2 (1)	1.4 (1.0–2.0)	12.0 (11.0–13.1)	757.1 (1)
Overall	20.5 (20.5–20.5)	26.5 (26.5–26.5)	29.3	6.8 (6.8–6.8)	10.2 (10.1–10.2)	50.0

**Data source:** Public Health Agency of Canada Canadian Chronic Disease Surveillance System data files contributed by the provinces and territories as of April 2015. Alberta, Saskatchewan and Prince Edward Island data were unavailable.

**Abbreviations:** BC, British Columbia; CI, confidence interval; MB, Manitoba; NB, New Brunswick; NL, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest Territories; NU, Nunavut; ON, Ontario; QC, Quebec; YT, Yukon.

<sup>a</sup> Prevalence counts were conventionally rounded to an adjacent multiple of 5 (rounded to an adjacent multiple of 10 in ON). Age-standardized rates were calculated with unrounded prevalence counts.

**FIGURE 1**  
Age-standardized prevalence<sup>a</sup> (%) of the co-occurrence of two or more chronic conditions among people aged 40 years and over, by sex and province/territory, 2011/12



**Data source:** Public Health Agency of Canada, using Canadian Chronic Disease Surveillance System data files contributed by the provinces and territories as of April 2015. Alberta, Saskatchewan and Prince Edward Island data were unavailable.

**Abbreviations:** BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest Territories; NU, Nunavut; ON, Ontario; QC, Quebec; YT, Yukon.

**Note:** | signifies a 95% confidence interval.

<sup>a</sup> Prevalence counts were conventionally rounded to an adjacent multiple of 5 (rounded to an adjacent multiple of 10 in ON). Age-standardized rates were calculated with unrounded prevalence counts.

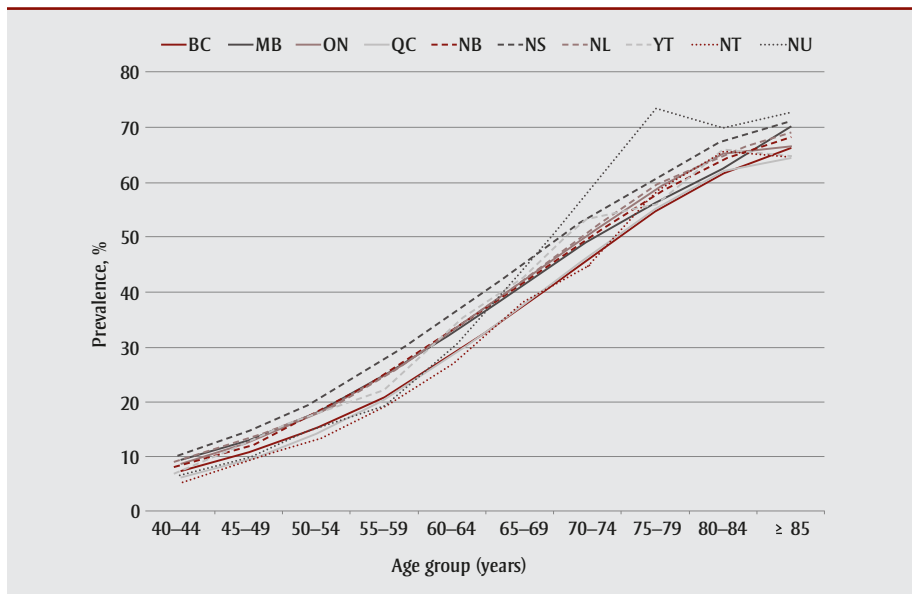
(95% CI: 1.3–1.4) higher for men than for women; prevalence was greater among men than women for all of the provinces, but was greater among women than men in all of the territories (data not shown).

The age-specific prevalence of the co-occurrence of 2+ chronic conditions for each province and territory in 2011/12 is shown in Figure 2. The overall prevalence in the oldest age group ( $\geq 85$  years) was 66.3%. This was 58.6% higher than the overall prevalence in the youngest age group (i.e. 40–44 years; 7.8%). In 2001/02 (data not shown), the overall prevalence was 5.5% in the youngest age group and 52.1% in the oldest age group. In 2011/12, the overall prevalence of 3+ conditions was 1.4% in the youngest age group and 35.6% in the oldest age group (data not shown).

The trend across age groups showed an S-shaped pattern for all provinces and territories. The coefficient of variation for the provinces and territories was similar in 2001/02 across age groups; it was 0.28 in the group aged 40 to 44 years and 0.27 in the group aged 85 years and over. In 2011/12, the coefficient of variation was 0.24 in the youngest age group and just slightly lower, at 0.14, in the oldest age



**FIGURE 2**  
Prevalence<sup>a</sup> (%) of the co-occurrence of two or more chronic conditions, by age group and province/territory, 2011/12



**Data source:** Public Health Agency of Canada, using Canadian Chronic Disease Surveillance System data files contributed by the provinces and territories as of April 2015. Alberta, Saskatchewan and Prince Edward Island data were unavailable.

**Abbreviations:** BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest Territories; NU, Nunavut; ON, Ontario; QC, Quebec; YT, Yukon.

<sup>a</sup> Prevalence counts were conventionally rounded to an adjacent multiple of 5 (rounded to an adjacent multiple of 10 in ON). Age-standardized rates were calculated with unrounded prevalence counts.

group. A similar pattern was observed for 3+ conditions, in that the coefficient of variation for 2011/12 was higher in the youngest age group (0.72) and lower in the oldest age group (0.30). In 2001/02, the coefficient of variation was 0.57 in the youngest age group and 0.20 in the oldest age group for 3+ conditions.

## Discussion

Of the population aged 40 years and over from the 10 provinces and territories that submitted study data to the CCDSS, about one-quarter had at least two of the five validated chronic conditions and about 10% had at least three of the five validated conditions for which CCDSS data were collected. Our overall estimate of 26.5% (for 2+ conditions) in 2011/12 is lower than a recent study that estimated Canadian multimorbidity prevalence to be 42.6% for the population aged 18 years and older<sup>28</sup> using national electronic medical record (EMR) data. Fortin et al.<sup>29</sup> observed that multimorbidity prevalence estimates derived for primary care populations tend to be higher than for the general population. As well, that study used a list of 20 chronic conditions to identify patients with multimorbidity compared to

the list of five chronic conditions used in our study. Using 2011/12 CCHS data, Roberts et al.<sup>7</sup> estimated the national prevalence of 2+ conditions to be 12.9%, and the prevalence of 3+ conditions to be 3.9%; these estimates are substantially lower than ours and may reflect the impact of self-report bias on measurement of chronic diseases.<sup>30</sup> The difference in estimates may also be partially explained by the difference in age groups studied; Roberts et al.<sup>7</sup> included people aged 20 years and over, whereas we only estimated multimorbidity prevalence for people aged 40 years and over. A study from Ontario<sup>6</sup> that used administrative health data to estimate multimorbidity prevalence (2+ conditions) reported a value of 24.3% in 2009. However, the Ontario study included a broader range of chronic conditions (16 in total) than the ones included in the CCDSS study, and also included a broader range of ages (0 to 105 years).

Using CCDSS data, we observed no consistent pattern of differences between males and females across the jurisdictions. Previous research has also shown that the magnitude of the difference between males and females will reflect the

choice of health conditions used to measure multimorbidity.<sup>31</sup>

We found that the age-standardized prevalence of multimorbidity increased substantially over time. To date, there have been no longitudinal studies of multimorbidity prevalence in Canada against which we might compare our findings. In fact, there have been few international studies that have focussed on longitudinal trends in multimorbidity prevalence. One exception is the study by Uijen and van de Lisdonk,<sup>32</sup> which used electronic primary care data from the Netherlands and found that multimorbidity prevalence doubled over a 20-year period. Our results show increases between 25.2% and 78.7% in an 11-year period for all provinces and territories studied with the exception of Nunavut; further investigation is needed to determine why these increases have occurred. Wong et al.<sup>33</sup> cautioned that there is the opportunity for an increased number of false positive cases to accrue over time, which may contribute to inflated rates of increasing prevalence across study years. For Nunavut, the large increases in prevalence may reflect the fact that Nunavut officially became a territory in 1999 and therefore its administrative databases may not have had time to sufficiently capture prevalent cases by 2001/02. In other words, the first study year may be more likely to underestimate prevalence than in other provinces where administrative data from fiscal year 1995/96 onward were used for case ascertainment.

## Strengths and limitations

The key strengths of this study are the use of the CCDSS's standardized and validated methodology, and the production of multimorbidity prevalence estimates for more than 80% of the Canadian population of adults aged 40 years and over. One limitation is that our study is based on validated case definitions for individual chronic conditions rather than an overall validated case definition for multimorbidity, and we were limited to five health conditions that were defined at the time of the provincial/territorial call for data. Fortin et al.<sup>31</sup> have suggested that limiting the conditions to fewer than seven chronic diseases may result in underestimation of the multimorbidity prevalence; these authors recommend including 12 or more chronic diseases. Diederichs et al.<sup>34</sup> identified 11 conditions that they recommend

including in studies about multimorbidity. Diabetes, depression, hypertension, heart disease, and COPD are included in their list, as they were in our study. Additional conditions, such as arthritis, stroke, cancer and osteoporosis, which are found in other definitions, did not have validated CCDSS case definitions at the time of the call for data, but developmental work on case definitions for many of these conditions is underway or has been completed.

Table 3 summarizes the strengths and weaknesses of using the CCDSS to estimate multimorbidity. The CCDSS methodology facilitates comparisons across major determinants of health, including age, sex and region. These comparisons are useful for describing the absolute and relative impact of multimorbidity on different population groups, and can help target health promotion and disease prevention activities. However, the use of the CCDSS and administrative health data to measure multimorbidity presents some challenges. The methodology does not presently allow for comparisons across other important determinants of health, such as socioeconomic status.<sup>7,12,13</sup> There is the potential for misclassification error in diagnoses recorded in administrative data, which can bias prevalence estimates.<sup>35,36</sup> Administrative data do not capture

individuals who have not had contact with the health care system for their chronic condition(s).

In addition, the finding that multimorbidity prevalence increased over time may be at least partially explained by changes in the quality and availability of administrative health data in the provinces and territories. Prevalence rates over time may also be influenced by the presence of individuals who have been incorrectly diagnosed with one or more chronic conditions.<sup>6</sup> Furthermore, provinces and territories that have only a single diagnosis code in physician billing claims may underestimate multimorbidity prevalence, as there is a decreased probability for multiple diagnosis codes to be captured in these data.<sup>37</sup> Finally, we should note that information about the severity of chronic conditions is not available in administrative data.

### Conclusion

We applied validated methods for national surveillance of individual chronic diseases to provide comparative estimates of multimorbidity in selected provinces and territories over more than a decade. Our results showed several patterns that were consistent with previous research, including increases in multimorbidity over the

lifespan.<sup>2-7</sup> While there was no consistent pattern across provinces and territories, higher rates tended to occur in eastern Canada than western Canada, which is not unexpected based on previous research.<sup>38,39</sup> Our findings suggest that the estimates have face validity. In terms of the increases in prevalence over time, there are few studies to which we can compare ours, and none based on Canadian data; trend estimates should be interpreted with caution.

We demonstrated the feasibility of using the CCDSS for individual chronic conditions to produce estimates of multimorbidity prevalence. However, its reach should be expanded with additional validated chronic disease case definitions to provide a more comprehensive profile of multimorbidity in Canada.

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### Conflicts of interest

The authors declare no conflict of interest.

**TABLE 3**  
Key strengths and weaknesses of using the CCDSS to estimate multimorbidity prevalence in Canada

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>The CCDSS uses standardized and validated methodology in all provinces and territories</li> <li>The CCDSS uses routinely collected administrative health data</li> <li>Using CCDSS data allows for comparisons across age, sex, region and time</li> <li>Conducting research using administrative health data is more economical than engaging in primary data collection<sup>36,40</sup></li> <li>CCDSS data is not influenced by recall bias</li> </ul>	<ul style="list-style-type: none"> <li>The methodology does not currently allow for comparisons across some determinants of health, including socioeconomic status and ethnicity</li> <li>There is the potential for misclassification error in diagnoses recorded in administrative health data<sup>34,35</sup></li> <li>CCDSS does not contain information on laboratory results, which may reduce misclassification errors, or chronic disease lifestyle risk factors (i.e. physical activity, smoking, etc.), which may in turn influence multimorbidity risk<sup>36,40</sup></li> <li>CCDSS does not capture individuals who have not received a diagnosis for the chronic condition(s) under investigation</li> <li>A limited number of validated chronic conditions are currently included in the CCDSS methodology</li> </ul>

**Abbreviation:** CCDSS, Canadian Chronic Disease Surveillance System.

## Authors' contributions

AF contributed to the literature review, study design, statistical analyses and manuscript preparation. LL contributed to the study design, statistical analyses and manuscript preparation. KR contributed to the study design and manuscript preparation. All authors have read and approved the final manuscript.

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