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ABSTRACT

Background

Multimorbidity is a significant challenge for health care systems worldwide. There are limited data, particularly in a Canadian context, on multimorbidity prevalence and incidence, and how these differ by multimorbidity complexity, sex, age, and neighbourhood income quintile.

Methods

This study included administrative data from residents of British Columbia, Canada, from 2001/2002 to 2019/2020. This study analyzed trends in the prevalence and incidence of multimorbidity (two or more conditions) and complex multimorbidity (five or more conditions) by sex, age, and neighbourhood income quintile. This study also identified the most prevalent disease combinations.

Results

More than 25% of adults and 60% of seniors met criteria for multimorbidity in 2019/2020. From 2001/2002 to 2019/2020, age-standardized multimorbidity prevalence increased annually by an average of 1.5% in females and 2.9% in males, and incidence decreased by 3.3% in females and 1.1% in males. Complex multimorbidity prevalence increased annually by an average of 4.8% in females and 5.7% in males, and incidence increased by 1.1% in females and 2.2% in males. Younger age groups had higher average annual increases in multimorbidity prevalence and incidence. Multimorbidity risk was higher in lower income quintiles, relative to higher income quintiles, and these disparities were larger for complex, relative to standard, multimorbidity. Highly prevalent single diseases tended to form the most prevalent disease combinations, and the most prevalent disease combinations varied by income quintile.

Interpretation

These findings suggest that the burden and complexity of multimorbidity continue to rise in British Columbia. Population trends in multimorbidity have important implications for projecting future disease burden and health care planning.

Keywords

multimorbidity; comorbidity; multiple conditions; epidemiology; socioeconomic status; administrative data

AUTHORS

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What is already known on this subject?

- Individuals with multimorbidity experience increased treatment burden and health care fragmentation, as well as higher rates of dependence and mortality.
- Multimorbidity prevalence is on the rise in Canada and worldwide, but estimates of incidence, a more timely measure of changing disease epidemiology, are rare, and none have been published in Canada.

What does this study add?

- This study provides a comprehensive assessment of long-term trends in the burden of multimorbidity in a Canadian jurisdiction, including measures of incidence, differences by neighbourhood income quintile, and the most common disease combinations.
- More than 25% of adults and 60% of seniors met criteria for multimorbidity in 2019/2020, with the largest relative increases over the past two decades occurring among younger adults.
- The prevalence of complex multimorbidity (five or more conditions) doubled from 2001/2002 to 2019/2020, affecting about 4% of adults and approximately 20% of seniors in 2019/2020.
- Multimorbidity risk was higher in lower income quintiles, relative to higher income quintiles, and these disparities were larger for complex multimorbidity, relative to standard multimorbidity (two or more conditions).
- Future research should aim to develop consensus on approaches to measure multimorbidity and further expand assessment of the burden in priority populations.

Multimorbidity is the co-occurrence of two or more chronic diseases—a common reality for many patients.[1] Co-occurring chronic diseases are associated with an outsized negative impact on patient mortality,[2] complexity of patient management,[3,4] and health care costs.[5,6] Multimorbidity is highly prevalent and is projected to rise with aging population demographics and the increasing prevalence of single chronic diseases across high-income nations.[7,8] Canadian multimorbidity prevalence estimates range from 25% to 45% of adults, with variations by data source and the number of diseases included in the analyses.[9-14] However, it is consistently reported that more than 50% of the Canadian population aged 65 and older have multimorbidity.[9-12]

Tracking multimorbidity incidence, in addition to prevalence, is needed to better understand multimorbidity disease progression and to improve multimorbidity projections for population health and health care systems.[1] Annual incidence provides a timely measure of change in the epidemiology of disease because it represents new cases only (over the course of a year). Few studies have assessed multimorbidity incidence.[1,15] In the United Kingdom, age-standardized multimorbidity incidence remained stable from 2004 to 2019 but increased in individuals younger than 60 years, and this may have contributed to rising multimorbidity prevalence in older populations.[16] To date, there are no published data on multimorbidity incidence in Canada.

While age is a principal risk factor for multimorbidity, neighbourhood income is increasingly recognized as an important contributor.[17,18] Younger individuals living in economically deprived regions have multimorbidity prevalence rates that are similar to those of older individuals in more affluent areas.[19-21] Analyses from the United Kingdom have reported higher multimorbidity incidence in more economically deprived areas, a disparity that widened from 2004 to 2019.[16] Individuals in more economically deprived areas in the United Kingdom also had a more rapid accumulation of chronic conditions from 2005 to 2020.[22] There is a need for analyses that characterize disparities in multimorbidity prevalence and incidence by neighbourhood income in a Canadian context.

Multimorbidity represents a spectrum of complexity, where the number and type of co-occurring conditions will significantly modulate individual experiences and outcomes. Measuring multimorbidity by the binary criteria of two or more chronic conditions is a useful, but relatively non-specific, index. This study defined complex multimorbidity as individuals with five or more co-occurring conditions,[23] representing a subset of the population likely to have high associated health care needs and costs.[24,25] Furthermore, identifying which diseases co-occur most frequently in multimorbidity will improve understanding of typical multimorbid patient profiles[10,11] and provide more disease-relevant information to improve multimorbidity management.

A comprehensive analysis of multimorbidity was performed over a 19-year period in British Columbia, Canada, using linked administrative data from a universal health care system. This study assessed temporal trends in the prevalence and incidence of multimorbidity and complex multimorbidity in adults aged

20 and older from 2001/2002 to 2019/2020. This study investigated how multimorbidity prevalence and incidence vary by complexity, sex, age, and neighbourhood income quintile. Finally, disease profiles were assessed by identifying the most prevalent co-occurring diseases in individuals with multimorbidity.

Methods

Study population and data

This study is a retrospective cohort analysis using linked administrative data. The study population was all British Columbia residents aged 20 and older who were registered for universal health insurance coverage from fiscal year 2001/2002 to fiscal year 2019/2020 (April 1, 2001, through March 31, 2020). The age range of 20 and older was chosen because many British Columbia Chronic Disease Registry (BCCDR) case algorithms do not cover ages below this range. Population denominators were obtained from the Client Roster for British Columbia's universal health insurance program, the British Columbia Medical Services Plan (MSP). Neighbourhood income was quantified as quintiles of average neighbourhood income using census data by postal code.

Anonymized linked administrative health datasets used in this study were provided by Population Data BC (PopData). Access to data provided by the data stewards is subject to approval but can be requested for research projects through the data stewards or their designated service providers. The following datasets were used in this study: the BCCDR, the BC Cancer Registry, the Consolidation File (MSP Registration and Premium Billing and census data), and Vital Statistics Deaths. You can find further information regarding these datasets by visiting the PopData project web page at https://my.popdata.bc.ca/project_listings/16-218/collection_approval_dates. All inferences, opinions, and conclusions drawn in this publication are those of the authors and do not reflect the opinions or policies of the data stewards.

Disease selection

In total, 25 chronic conditions were included for multimorbidity analyses: 18 conditions from the BCCDR and 7 cancer subtypes from the BC Cancer Registry, based on precedence with previous multimorbidity estimates in British Columbia and consultation with domain experts (see Appendix Table 1 for a list of included diseases). Multimorbidity was defined as the co-occurrence of 2 or more of these 25 conditions, and complex multimorbidity as the co-occurrence of 5 or more of these conditions.[23]

British Columbia Chronic Disease Registry diseases

The BCCDR uses the following administrative health databases to identify chronic conditions: the Discharge Abstract Database, the MSP, and PharmaNet. Chronic disease cases are identified using standard definitions based on validated case algorithms adapted from the Canadian Chronic Disease Surveillance System.[26] More information can be found by visiting the BC Centre for Disease Control Chronic Disease Dashboard Data notes and Case definition sections.[27]

Eighteen diseases were selected for multimorbidity analyses from 25 available conditions in the BCCDR (as of version 2020). Seven conditions were excluded: five conditions were subsets of a primary condition (e.g., acute myocardial infarction is a subset of ischemic heart disease, and haemorrhagic stroke is a subset of stroke), one was a pediatric condition (juvenile idiopathic arthritis), and one was a condition

Table 1
Characteristics of study population

	Multimorbidity (two or more conditions)				Complex multimorbidity (five or more conditions)			
	2001/2002		2019/2020		2001/2002		2019/2020	
	Number of people	%	Number of people	%	Number of people	%	Number of people	%
Total	655,213	100	1,450,059	100	64,022	100	256,264	100
Sex								
Female	376,738	57	786,778	54	36,872	58	141,771	55
Male	278,452	42	663,277	46	27,144	42	114,493	45
Age (average years and SD)	63	16	64	16	76	11	76	12
Age group								
20 to 34	36,339	6	90,517	6	92	0	322	0
35 to 49	100,901	15	174,883	12	1,320	2	4,135	2
50 to 64	184,767	28	423,670	29	8,882	14	37,083	14
65 to 79	216,669	33	517,456	36	27,851	44	110,498	43
80 and older	116,537	18	243,533	17	25,877	40	104,226	41
Income quintile								
1 (lowest)	151,617	23	335,060	23	17,472	27	74,594	29
2	130,937	20	302,576	21	13,269	21	56,895	22
3	120,772	18	283,604	20	11,528	18	48,720	19
4	111,998	17	260,933	18	9,686	15	38,983	15
5 (highest)	110,341	17	256,357	18	8,877	14	35,588	14

Note: SD = standard deviation.
Sources: British Columbia Chronic Disease Registry; BC Cancer Registry; and Statistics Canada, Census of Population, 2001/2002 to 2019/2020.

with unique multidimensional characteristics that is different from many other chronic conditions (substance use disorder). For BCCDR diseases, prevalent cases were defined as lifetime prevalence from the incident case definition. The diseases selected are congruent with diseases included in the existing BC Centre for Disease Control two or more condition multimorbidity indicator,[28] but the BCCDR does not include information about cancer, which is recommended for inclusion in multimorbidity measures.[29] For this analysis, linked data on cancer cases were additionally included from the population-based gold standard cancer registry in British Columbia.

BC Cancer Registry diseases

The BC Cancer Registry is a dataset of all new reportable cancers diagnosed among British Columbia residents. Data sources for cancer records include, but are not limited to, pathology laboratories, vital statistics, abstract summaries of patient hospital stays, and health records from cancer treatment centres. All invasive cancers were included, as well as in-situ bladder cancer, following the inclusion criteria of the Canadian Cancer Statistics publication.[30] Seven cancer groups were created for multimorbidity analyses, reflecting the most common cancers (breast, prostate, lung, colorectal) and those with similar etiology or disease characteristics (melanoma, blood, and all other solid organ cancers; see Appendix Table 1), consistent with the Canadian Cancer Statistics groupings.[30]

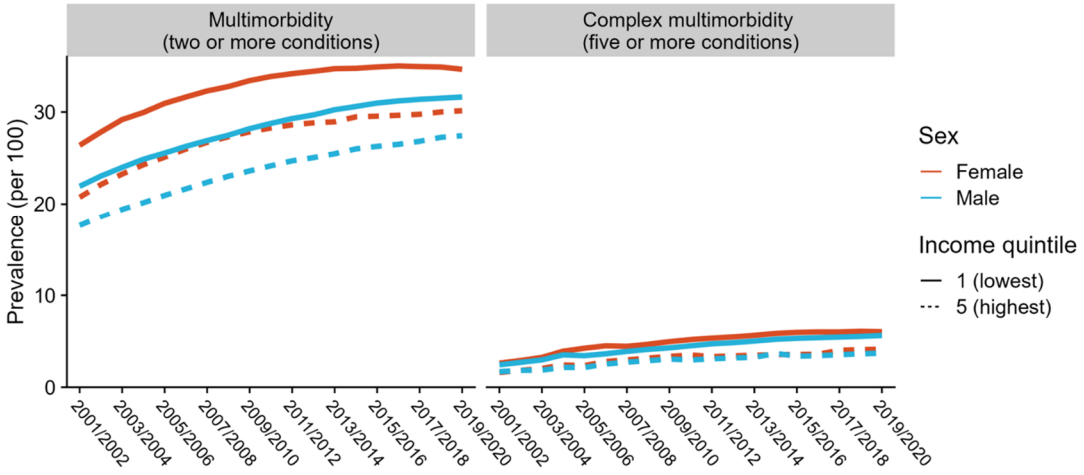
Prevalent cancer cases were defined as five-year period prevalence from the incident case definition to account for possible cancer remission. When determining cases by cancer type, tumours of the same type that did not overlap in five-year case windows were counted as separate cases. When tumours overlapped in five-year case windows, the case window was extended from the first incident tumour case to the end of the five-year window for the most recent tumour case. Only the first occurrence was counted for a cancer of the same type as the incident case for multimorbidity incidence case counts.

Statistical analyses

Prevalence was defined as the proportion (per 100) of British Columbia residents meeting multimorbidity criteria (two or more and five or more conditions) in each fiscal year of analysis. Incident multimorbidity cases were defined as the number of new cases meeting multimorbidity count criteria (two or more and five or more conditions) during a single fiscal year. Incident multimorbidity cases were recorded as the incident date of the second condition (for two or more multimorbidity criteria) or fifth condition (for five or more multimorbidity criteria). Incidence was defined as the number of new multimorbidity cases per 1,000 of the at-risk population of British Columbia residents during each fiscal year of analysis. The BCCDR data holdings started operating in 1992/1993, allowing for a minimum clearance period of nine years for reporting first (incident) events.[27] We stratified analyses by sex, which is what was available in these administrative datasets. Information on gender is currently not available.

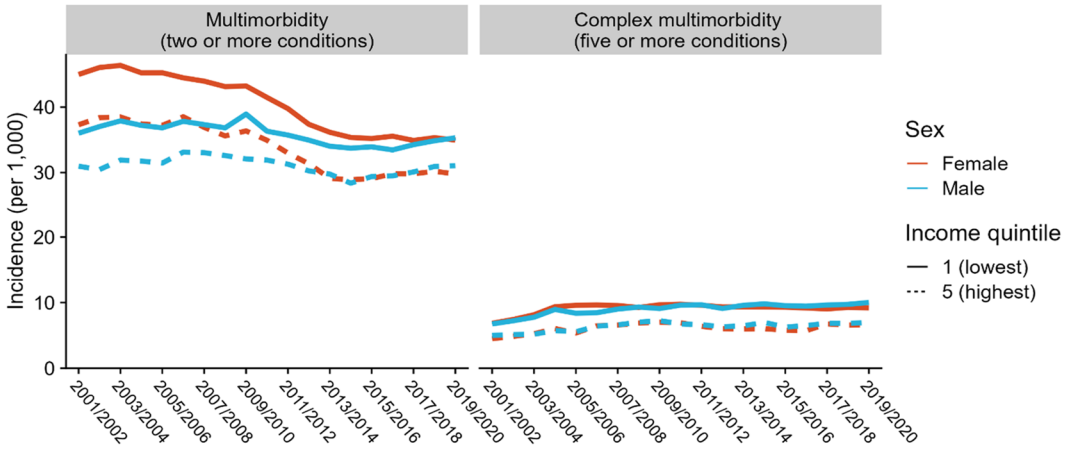
Disease combinations were defined as non-exclusive disease pairs, meaning the co-occurrence of two specific conditions, regardless of any other disease comorbidities. This study assessed the prevalence of all possible two-disease combinations of conditions across the population and in population subgroups stratified by sex, age group and income quintile. Numerators for disease combination prevalence were counted as the number of individuals with both diseases in each disease pair. Denominators were calculated respecting disease-

Figure 1
Annual age-standardized prevalence of multimorbidity and complex multimorbidity by sex and neighbourhood income quintile, 2001/2002 to 2019/2020, British Columbia, Canada



Sources: British Columbia Chronic Disease Registry; BC Cancer Registry; and Statistics Canada, Census of Population, 2001/2002 to 2019/2020.

Figure 2
Annual age-standardized incidence of multimorbidity and complex multimorbidity by sex and neighbourhood income quintile, 2001/2002 to 2019/2020, British Columbia, Canada



Sources: British Columbia Chronic Disease Registry; BC Cancer Registry; and Statistics Canada, Census of Population, 2001/2002 to 2019/2020.

specific case definition age cut-offs (see Appendix Table 1). For example, in the disease pair of osteoporosis and diabetes, the denominator was calculated according to the disease with the highest case definition age cut-off (osteoporosis: age 50 and older; diabetes: age 1 and older; therefore, the denominator for this disease pair was British Columbia residents aged 50 and older).

Annual age-specific prevalence and incidence rates and 95% confidence intervals (CIs) were calculated for the following age groups: 20 to 34, 35 to 49, 50 to 64, 65 to 79, and 80 and older. Annual age-standardized prevalence and incidence and 95% CIs were calculated with a direct standardization method, adjusting estimates to the 2011 standard Canadian population.

Trends in prevalent and incident multimorbidity case counts over time were analyzed with negative binomial regression models, with the year as a continuous independent variable. Negative binomial models were applied instead of Poisson models because of overdispersion in the count data. Age-standardized prevalence and incidence rates were estimated, adjusting for five-year age groups. A preliminary model was used, testing for main effects of sex and sex * year interactions in models. In all cases (multimorbidity and complex multimorbidity prevalence and incidence), females had significantly higher multimorbidity rates than males and sex * year interactions were statistically significant; therefore, for the final analyses, models were stratified by sex. Average annual changes in multimorbidity prevalence and incidence rates were calculated from the β coefficient for the year predictor, using -100 x [1 - exp(β)] as an approximation.

Relative rates (RRs) of prevalent and incident multimorbidity were analyzed with negative binomial regression models, with the year and income quintiles as independent variables and adjusting for five-year age groups. Again, a preliminary model was used, testing for main effects of sex and sex * year interaction, which were statistically significant for all models (multimorbidity and complex multimorbidity prevalence and incidence), with higher multimorbidity RRs in females relative to males. Therefore, final models were stratified by sex. RRs were estimated by exponentiating the model coefficients.

Results

Table 1 shows demographic characteristics of the study population, comparing the first year of analysis (2001/2002) with the final year of analysis (2019/2020). There was a low level of data missingness overall. Sex was not recorded for a total of 288 individuals, who were excluded from sex-stratified analyses. In 2001/2002, the percentage of missing neighbourhood income data was less than 5%, while in 2019/2020, it was less than 0.5%. These missing data were excluded from income-stratified analyses.

Figures 1 and 2 present trends in multimorbidity prevalence and incidence, respectively, by sex and income quintile. Table 2 presents trends in multimorbidity prevalence and incidence. Table 3 presents age-standardized trends in multimorbidity prevalence and incidence by income quintile.

Trends in multimorbidity prevalence

Prevalence of multimorbidity (two or more conditions)

From 2001/2002 to 2019/2020, age-standardized multimorbidity prevalence increased from 23% to 32% of adult females and from 20% to 29% of adult males in British Columbia (Figure 1, Table 2). There was a statistically

Table 2
Trends in multimorbidity prevalence and incidence, 2001/2002 to 2019/2020

	Prevalence (per 100)								Incidence (per 1,000)							
	2001/2002			2019/2020					2001/2002			2019/2020				
Multimorbidity definition	Rate	95% confidence interval from	to	Rate	95% confidence interval from	to	Percent change %	Annual trend %	Rate	95% confidence interval from	to	Rate	95% confidence interval from	to	Percent change %	Annual trend %
Multimorbidity (two or more conditions)																
Age group and sex																
Age-standardized																
Female	23.47	23.39	23.55	32.46	32.38	32.53	38.30	1.51 †	40.75	40.34	41.19	32.52	32.15	32.91	-20.21	-3.29 †
Male	19.70	19.63	19.78	29.41	29.34	29.49	49.31	2.91 †	33.25	32.84	33.68	32.80	32.43	33.19	-1.34	-1.14 †
20 to 34																
Female	6.02	5.94	6.09	9.65	9.57	9.74	60.46	2.41 †	9.30	8.99	9.61	9.56	9.28	9.85	2.86	0.28
Male	3.13	3.08	3.19	8.29	8.21	8.37	164.59	5.65 †	5.02	4.79	5.25	8.20	7.94	8.46	63.51	2.99 †
35 to 49																
Female	11.82	11.72	11.91	19.34	19.22	19.46	63.67	2.52 †	17.78	17.39	18.17	17.41	17.01	17.81	-2.07	-0.67 †
Male	8.41	8.33	8.49	15.34	15.23	15.45	82.44	3.25 †	12.91	12.58	13.24	16.21	15.83	16.59	25.53	0.68 †
50 to 64																
Female	28.11	27.94	28.29	41.19	41.02	41.36	46.51	1.88 †	46.93	46.12	47.75	38.75	38.09	39.43	-17.42	-1.76 †
Male	22.98	22.82	23.13	37.76	37.60	37.93	64.36	2.65 †	34.99	34.31	35.68	39.24	38.58	39.91	12.14	0.06
65 to 79																
Female	54.46	54.15	54.77	67.48	67.22	67.73	23.91	0.96 †	97.76	95.91	99.64	66.38	65.04	67.73	-32.10	-2.89 †
Male	50.07	49.76	50.39	63.80	63.55	64.06	27.42	1.18 †	84.38	82.66	86.13	70.53	69.19	71.89	-16.41	-1.50 †
80 and older																
Female	70.54	70.03	71.05	86.81	86.36	87.27	23.07	1.03 †	134.33	130.57	138.18	95.22	91.34	99.23	-29.12	-2.23 †
Male	67.31	66.67	67.95	83.00	82.49	83.51	23.32	1.08 †	132.77	128.16	137.49	104.45	100.35	108.68	-21.33	-1.66 †
Complex multimorbidity (five or more conditions)																
Age group and sex																
Age-standardized																
Female	2.11	2.08	2.13	4.85	4.82	4.87	130.10	4.80 †	5.68	5.56	5.81	7.54	7.42	7.66	32.78	1.10 †
Male	2.00	1.98	2.03	4.60	4.57	4.63	129.64	5.65 †	5.62	5.49	5.77	8.16	8.03	8.30	45.12	2.22 †
20 to 34																
Female	0.02	0.01	0.02	0.03	0.02	0.03	88.24	3.93 †	0.05	0.03	0.07	0.07	0.05	0.10	51.58	3.37 †
Male	0.01	0.01	0.01	0.03	0.03	0.04	341.77	8.83 †	0.03	0.01	0.05	0.08	0.06	0.11	193.59	7.49 †
35 to 49																
Female	0.14	0.13	0.15	0.42	0.40	0.44	206.46	6.07 †	0.38	0.32	0.43	0.91	0.83	0.99	140.72	3.84 †
Male	0.13	0.12	0.14	0.40	0.38	0.42	212.72	6.54 †	0.36	0.31	0.42	0.91	0.83	1.00	151.40	4.62 †
50 to 64																
Female	1.31	1.27	1.34	3.44	3.39	3.49	163.11	5.13 †	3.60	3.41	3.80	5.78	5.57	5.98	60.49	1.81 †
Male	1.15	1.11	1.18	3.48	3.43	3.53	202.76	6.22 †	3.06	2.88	3.25	6.34	6.13	6.57	107.27	3.62 †
65 to 79																
Female	6.93	6.82	7.04	14.34	14.22	14.46	106.86	3.75 †	18.33	17.75	18.93	20.59	20.12	21.06	12.28	-0.07
Male	6.51	6.40	6.62	13.70	13.58	13.82	110.44	3.85 †	17.81	17.21	18.42	22.65	22.14	23.16	27.18	0.74 †
80 and older																
Female	15.64	15.40	15.88	38.36	38.06	38.67	145.32	4.96 †	41.96	40.65	43.30	58.24	56.80	59.71	38.79	1.62 †
Male	14.99	14.69	15.29	33.92	33.60	34.25	126.33	4.54 †	43.48	41.77	45.24	60.15	58.53	61.81	38.35	1.43 †

† trend significantly different from 0 ($p < 0.001$ - Bonferroni-corrected)

Note: The annual trend (%) is derived from the model coefficients of annual trends in prevalence and incidence.

Sources: British Columbia Chronic Disease Registry and BC Cancer Registry, 2001/2002 to 2019/2020.

significant increasing average annual change in multimorbidity prevalence among females (1.51%, 95% CI: 1.37% to 1.64%) and males (2.91%, 95% CI: 2.72% to 3.11%; see Table 2). Multimorbidity prevalence increased significantly across all age groups, with the greatest average annual change in males aged 20 to 34 (5.65%, 95% CI: 5.32% to 5.98%) and the smallest average annual change in females aged 65 to 79 (0.96%, 95% CI: 0.66% to 1.27%; see Table 2). Individuals in the highest income quintile had significantly lower RRs for multimorbidity prevalence, relative to lower income quintiles, among both females and males (Figure 1, Table 3).

Prevalence of complex multimorbidity (five or more conditions)

From 2001/2002 to 2019/2020, age-standardized complex multimorbidity prevalence doubled from 2% to 5% for both females and males (Figure 1, Table 2). There was a statistically significant increasing average annual change in complex multimorbidity prevalence among females (4.80%, 95% CI: 4.55% to 5.04%) and males (5.65%, 95% CI: 5.44% to 5.86%; see Table 2). Complex multimorbidity prevalence increased significantly in all age groups, with the greatest average annual change among males aged 20 to 34 (8.83%, 95% CI: 7.80% to 9.88%) and the smallest average annual change among females

Table 3
Multimorbidity prevalence and incidence relative rates between sexes and income quintiles

	Prevalence						Incidence					
	Females			Males			Females			Males		
		95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval	
Multimorbidity definition	Relative rate	from	to	Relative rate	from	to	Relative rate	from	to	Relative rate	from	to
Multimorbidity (two or more conditions)												
Year	1.02 †	1.01	1.02	1.03 †	1.03	1.03	0.97 †	0.97	0.97	0.99 †	0.99	0.99
Income quintiles												
1 (lowest)	1.21 †	1.19	1.22	1.15 †	1.13	1.18	1.14 †	1.11	1.17	1.04	1.01	1.06
2	1.14 †	1.13	1.15	1.10 †	1.08	1.12	1.11 †	1.08	1.14	1.02	1.00	1.05
3	1.10 †	1.09	1.11	1.07 †	1.05	1.09	1.08 †	1.06	1.11	1.01	0.98	1.04
4	1.06 †	1.05	1.07	1.05 †	1.03	1.07	1.04 †	1.01	1.07	1.01	0.99	1.04
5 (highest)	1.00	...	...	1.00	...	...	1.00	...	...	1.00	...	...
Complex multimorbidity (five or more conditions)												
Year	1.05 †	1.05	1.05	1.06 †	1.05	1.06	1.01 †	1.01	1.01	1.02 †	1.02	1.02
Income quintiles												
1 (lowest)	1.87 †	1.82	1.92	1.61 †	1.57	1.66	1.69 †	1.64	1.74	1.45 †	1.40	1.50
2	1.49 †	1.44	1.53	1.40 †	1.36	1.44	1.43 †	1.39	1.47	1.27 †	1.23	1.31
3	1.34 †	1.30	1.38	1.27 †	1.24	1.31	1.28 †	1.25	1.32	1.21 †	1.17	1.25
4	1.19 †	1.15	1.22	1.16 †	1.12	1.19	1.16 †	1.13	1.19	1.11 †	1.08	1.15
5 (highest)	1.00	...	...	1.00	...	...	1.00	...	...	1.00	...	...

... not applicable
† significantly different from the higher income quintile ($p < 0.00625$ - Bonferroni-corrected)
Note: Relative rates are based on age-standardized annual trends in prevalence and incidence.
Sources: British Columbia Chronic Disease Registry; BC Cancer Registry; and Statistics Canada, Census of Population, 2001/2002 to 2019/2020.

aged 65 to 79 (3.75%, 95% CI: 3.03% to 4.48%; see Table 2). Individuals in the highest income quintile had significantly lower RRs for complex multimorbidity prevalence, relative to lower income quintiles, among both females and males (Figure 1, Table 3).

Trends in multimorbidity incidence

Incidence of multimorbidity (two or more conditions)

Age-standardized multimorbidity incidence decreased from 41 per 1,000 to 33 per 1,000 among females and remained stable at 33 per 1,000 among males (Figure 2, Table 2). There was a statistically significant decreasing average annual change in multimorbidity incidence among females (-3.29%, 95% CI: -3.62% to -2.96%) and males (-1.14%, 95% CI: -1.46% to -0.83%; see Table 2). Multimorbidity incidence trend effects varied across age groups, with the greatest increasing average annual change among males aged 20 to 34 (2.99%, 95% CI: 2.81% to 3.17%) and the greatest decreasing average annual change among females aged 65 to 79 (-2.89%, 95% CI: -3.29% to -2.49%; see Table 2). Females in the highest income quintile had significantly lower RRs for multimorbidity incidence, and income quintile had no significant effects on multimorbidity incidence among males (Figure 2, Table 3).

Incidence of complex multimorbidity (five or more conditions)

Age-standardized complex multimorbidity incidence increased from 6 per 1,000 to 8 per 1,000 among females and males (Figure 2, Table 2). There was a statistically significant increasing average annual change in complex multimorbidity incidence among females (1.10%, 95% CI: 0.84% to 1.36%) and males (2.22%, 95% CI: 1.99% to 2.46%; see Table 2). Complex multimorbidity incidence significantly increased across all age groups, except for females aged 65 to 79, where the average annual change was non-significant (-0.07%; 95% CI: -0.59% to 0.45%). The largest increase in complex multimorbidity incidence average annual change was seen in males aged 20 to 34 (7.49%, 95% CI: 5.62% to 9.42%; see Table 2). Individuals in the highest income quintile had significantly lower RRs for complex multimorbidity incidence, relative to lower income quintiles, among both females and males (Figure 2, Table 3).

Multimorbidity disease combinations

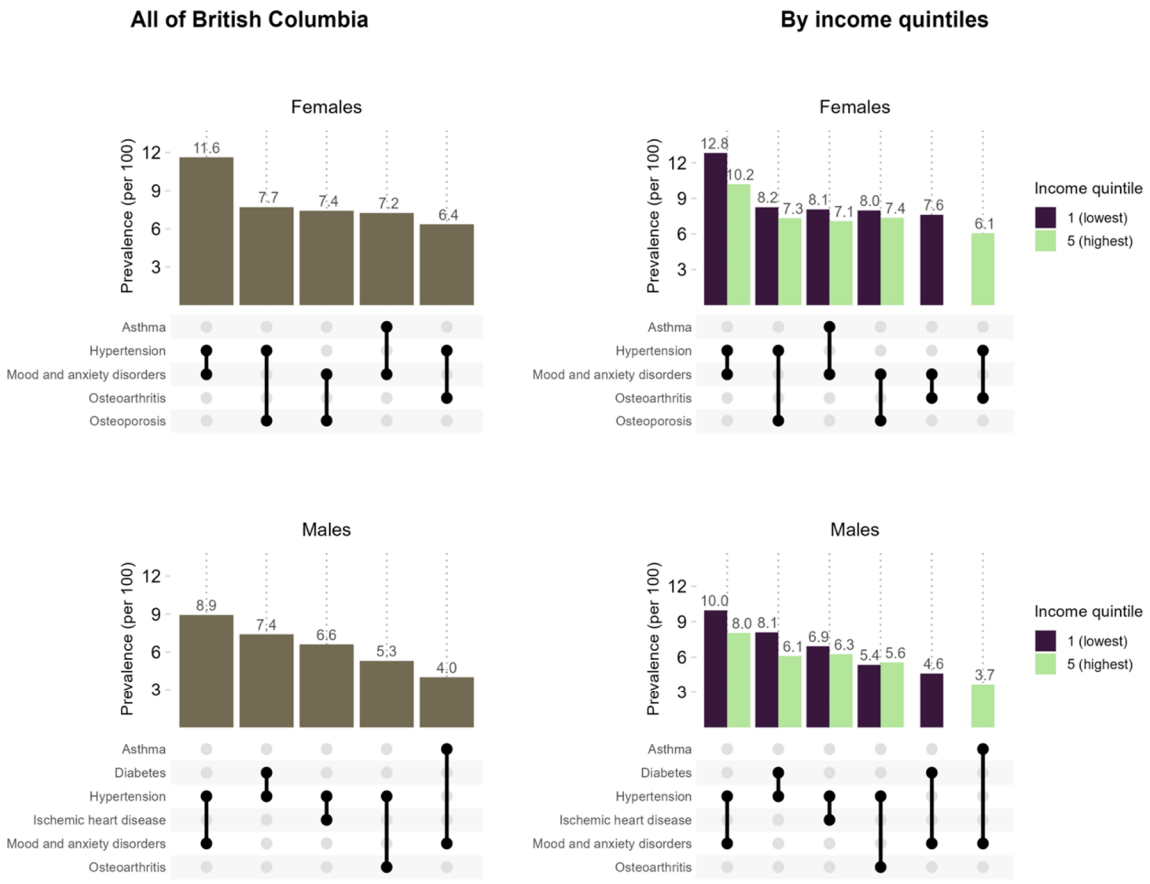
Figure 3 presents the top five disease combinations (pairs) with the highest age-standardized prevalence of multimorbidity (two or more conditions) by sex in the most recent year of analysis (2019/2020) and in subgroups stratified by the highest and lowest income quintiles. Age-specific top disease combinations are presented in Appendix Figure 1.

Hypertension appeared most frequently across disease combinations (three of five combinations in females and four of five combinations in males), and mood and anxiety disorders appeared the second most frequently (three of five combinations in females and two of five combinations in males). Hypertension with mood and anxiety disorders was the most prevalent disease combination for both females and males (11.6% of females and 8.9% of males). The second most prevalent disease combination for females was hypertension with osteoporosis (7.7% of females) and for males was diabetes and hypertension (7.4% of males). When data were stratified by income quintile, the top two disease combinations did not change among females, but the third- to fifth-ranked disease combinations did vary. Among males, the top four disease combinations did not vary when stratified by income quintile; however, the fifth-ranked disease combination did vary. The combination of diabetes with mood and anxiety disorders was more likely in males with the lowest income.

Discussion

This study provides a comprehensive overview of multimorbidity in British Columbia, Canada. In 2019/2020, roughly one-quarter of adults living in British Columbia had multimorbidity (two or more co-occurring conditions), and 5% had complex multimorbidity (five or more co-occurring conditions). In 2019/2020, more than 60% of adults aged 65 and older had multimorbidity, and approximately 20% had complex multimorbidity. Multimorbidity prevalence increased over the study period for both standard and complex multimorbidity. Trends in multimorbidity incidence were more varied. Standard multimorbidity incidence remained stable, decreased, or increased, depending on the population subgroup considered. Complex multimorbidity incidence increased over the study period, indicating growing patient complexity in the British Columbia population, especially among younger adults. There were significant economic disparities in multimorbidity prevalence and incidence, based on analyses by neighbourhood income quintile. These findings have implications for managing the growing population burden of multimorbidity.

Figure 3
Upset plots of the five most prevalent (age-standardized) multimorbidity disease combinations by sex, 2019/2020, British Columbia, Canada



Sources: British Columbia Chronic Disease Registry; BC Cancer Registry; and Statistics Canada, Census of Population, 2001/2002 to 2019/2020.

These results are consistent with recent Canadian reports of increasing multimorbidity prevalence.[9,25] While multimorbidity prevalence was higher in females, this study found that males showed a steeper rate of increase in prevalence over time. A similar trend has been observed in previous studies, suggesting that multimorbidity prevalence is rising faster in males than in females.[25,31,32] Sex differences in multimorbidity may be driven by sex differences in individual chronic disease prevalence. Preliminary internal analyses from the authors suggest that sex differences in multimorbidity prevalence are partly explained by the higher prevalence of diagnosed mood and anxiety disorders in females relative to males (see BC Centre for Disease Control Chronic Disease Dashboard).[27] Complex multimorbidity prevalence (five or more conditions) is increasing at higher rates than multimorbidity prevalence (two or more conditions) in British Columbia. The growth in complex multimorbidity prevalence may reflect rising single-disease prevalence[33] or decreasing case fatality for individuals with multimorbidity.[16]

Multimorbidity incidence showed varied trends in the current report. Age-standardized multimorbidity incidence decreased in females over the study period but remained stable in males overall and increased in younger male age groups. There are no previously published Canadian reports on multimorbidity incidence for comparison; however, the stable or increasing rates of multimorbidity in males could explain the steeper rate of increase of multimorbidity prevalence in males in this study and in previous[25,31,32] studies. Complex multimorbidity incidence is rising among both females and males and showed the greatest rate of increase in younger age groups. The growing multimorbidity burden among younger adults, especially males, suggests a potential population subgroup to target for multimorbidity prevention efforts.

These findings emphasize the increasing complexity of multimorbid disease burden in British Columbia, which is similar to that of other jurisdictions.[11,16,20,25] A recent British Columbia study reported that hospitalized patients became more complex from 2002 to 2017, with multimorbidity included in the quantification of patient complexity.[34] The current analysis demonstrates that more individuals are managing high numbers of co-occurring conditions, and, in the context of increasing or stable incidence rates, this trend can be expected to continue in coming years. The growing complexity and incidence of multimorbidity, especially in younger age groups, emphasize the importance of risk management and disease prevention efforts across the lifespan.[21,35]

Neighbourhood income quintiles significantly impacted multimorbidity burden. There were larger income disparities in complex multimorbidity risk, relative to standard multimorbidity, and in females, relative to males. The findings of neighbourhood income disparities in multimorbidity are similar in magnitude to those from studies in the United States (50% increased risk of multimorbidity prevalence in the lowest income quintile relative to the highest)[23] and the United Kingdom (14% increased risk of multimorbidity prevalence and 22% increased risk of multimorbidity incidence in the lowest income quintile relative to the highest).[14] However, unlike in the work of Head et al.,[16] the current analysis did not observe significant disparities by income quintile for multimorbidity incidence among British Columbia males. The influence of neighbourhood income quintiles on multimorbidity prevalence and incidence is multifactorial and likely related to broader determinants of health, such as household income, education, discriminatory policies and practices, and social inequities.[36,37]

The severity or complexity of multimorbidity—and thus, prevention and treatment efforts—is impacted not only by the number of co-occurring conditions, but also by the specific diseases that are co-occurring. Disease combinations can help to further characterize multimorbidity across the population[10,11] and may provide more practice-relevant information to mitigate the impact of multimorbidity on the health care system. Unsurprisingly, the most prevalent disease combinations in multimorbidity tended to contain highly prevalent single diseases (e.g., hypertension and mood and anxiety disorders),[27] while relatively less prevalent conditions (such as haematological cancer) were not represented in the most prevalent disease combinations. Age-specific disease combinations also reflect established age-specific trends in single-disease prevalence (such as osteoarthritis appearing in highly prevalent disease pairs for individuals aged 80 and older; see Appendix Figure 1 and the BC Centre for Disease Control Chronic Disease Dashboard).[27] Interestingly, the five most prevalent disease combinations showed some variations by income quintile. For example, in females co-occurring osteoarthritis and mood and anxiety disorders was the fifth most prevalent disease combination in the lowest income quintile, while osteoarthritis and hypertension was the fifth most prevalent disease combination for high income quintiles. These ranking differences may reflect deprivation-related risk factors for single chronic diseases and, therefore, their co-occurrence. Examining disease patterns in multimorbidity will help develop more targeted prevention and management efforts based on typical disease profiles for individuals with multiple chronic conditions.

Here multimorbidity was defined as a count of co-occurring conditions. There is currently no accepted gold standard for multimorbidity measurement,[1] and various measures have been employed in previous research. For instance, multimorbidity measures vary widely in terms of the conditions and the number of conditions included, and whether conditions are counted or weighed against a predefined clinical outcome (for example, the Charlson and Elixhauser comorbidity indexes).[38] A count-based measure (i.e., the presence of two or more conditions) provides a binary classification metric, which is one of the simplest and most widely available. The use of multiple count-based measures, such as in this report, could provide a rough measure of multimorbidity severity. Future research should examine the sensitivity of different multimorbidity counts (e.g., two or more, three or more, four or more, five or more) in predicting health

outcomes and the frequency of health care utilization to inform the development of more standardized multimorbidity measures for application in surveillance settings. Looking at specific combinations of diseases may provide more granular information on specific multimorbidity profiles, which may help refine multimorbidity indexes in the future to incorporate disease-specific impacts on health outcomes. More research is needed to develop consensus on approaches to measure and monitor the population burden of multimorbidity.

The strengths of this study are the near-complete coverage of British Columbia residents, the long time frame, and the use of validated disease case algorithms. This study also has limitations. The analysis was limited to the number of diseases available in the BCCDR and BC Cancer Registry, and, thus, results are not generalizable to diseases beyond those included. However, because the most common chronic conditions were captured, this is not anticipated to impact key insights generated through this work. Furthermore, the diseases included in this analysis largely represent diseases of adulthood and old age. As such, the multimorbidity estimates are not representative of typical diseases in a pediatric population. An inherent limitation to administrative data is the possibility of under-detection or misclassification of disease because detection relies on contact with the health care system. As inclusion in the study population was limited to those registered for universal health insurance, newcomers to British Columbia, including recent immigrants, will be underrepresented. Among newcomers, some diagnoses may be misclassified as incident because prior medical history records may not have been transferred. Further, diagnostic information for newcomers to British Columbia may be incomplete or missing in the administrative data, so disease burden in that population is likely underestimated. For BCCDR conditions, lifetime prevalence estimates were used to count cases, giving higher prevalence estimates than the use of active management prevalence definitions for conditions with relapse-remitting cycles (i.e., mood and anxiety disorders). Therefore, multimorbidity prevalence estimates are to be interpreted as lifetime disease burden for BCCDR conditions. System-level changes in administrative data quality or disease screening or billing practices could also impact the data. The current analysis characterized economic status by neighbourhood income, which is a unidimensional measure of socioeconomic status and does not reflect individual household income. The current study did not investigate differences in multimorbidity trends by rurality, and this is an important area for future research. Finally, it is acknowledged that multimorbidity intersects with several systemic societal forces, such as structural racism, and these intersections may have important implications for health care service availability, access, and delivery. Access to Indigenous identifiers was not possible for the current project, and, therefore, the impact of Indigeneity on multimorbidity trends cannot be analyzed. Future work may involve partnering with Indigenous data stewards to analyze multimorbidity in Indigenous populations.

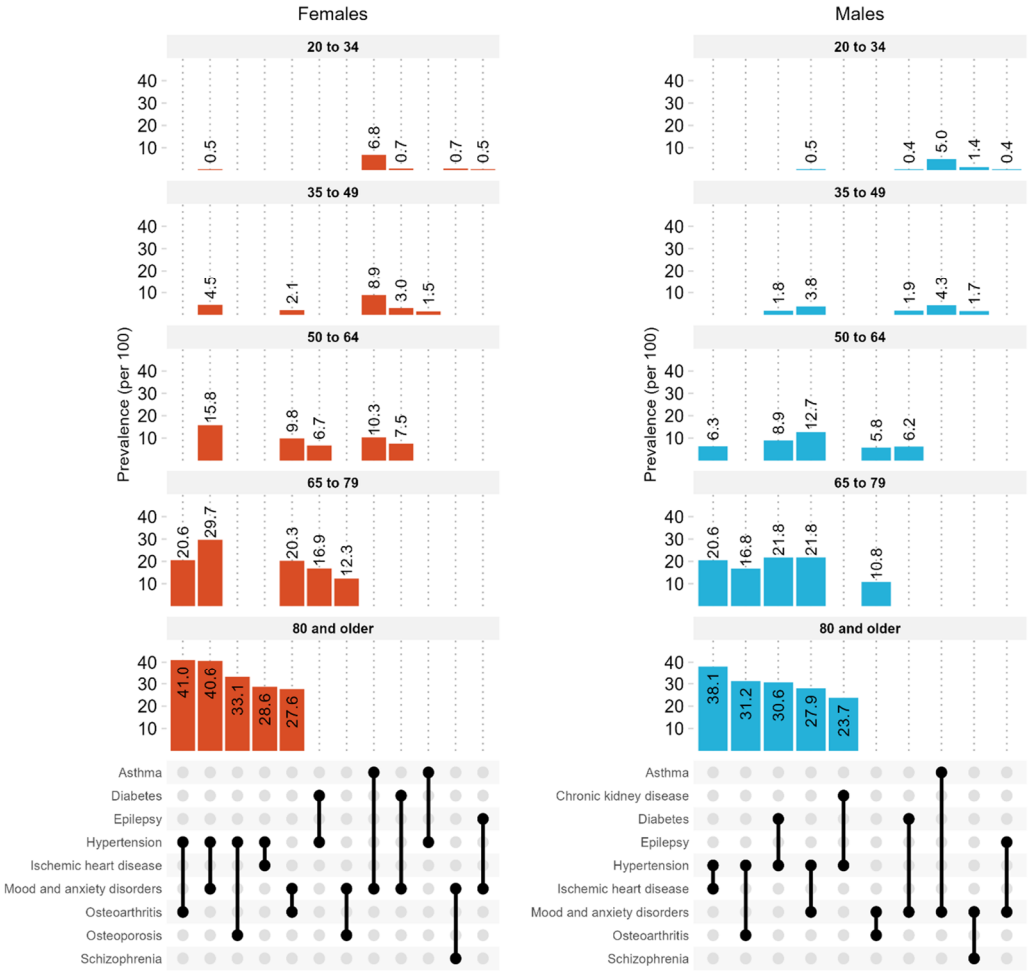
Multimorbidity has been identified as a priority for public health surveillance.[1,39] The BC Centre for Disease Control has begun monitoring multimorbidity prevalence since 2019, as part of ongoing chronic disease surveillance.[28] The Public Health Agency of Canada introduced the monitoring of multimorbidity prevalence as a single count index in 2024 through the Canadian Chronic Disease Surveillance System.[40] This study provides guidance for the development of multimorbidity surveillance tools, including emphasizing the value of monitoring multimorbidity incidence and complexity. This study methodology can be replicated in other Canadian jurisdictions, most of which have similar underlying datasets to those used in the current analysis. In the context of a growing and aging population, these data suggest that the burden and complexity of multimorbidity will likely continue to rise in British Columbia in coming years and indicate avenues for disease prevention and management efforts.

Appendix Table 1
List of included diseases in multimorbidity analyses (and case definition age cut-offs)

Data source: British Columbia Chronic Disease Registry	
1.	Anxiety and mood disorders (age 1 and older)
2.	Asthma (age 1 and older)
3.	Chronic kidney disease (age 1 and older)
4.	Diabetes mellitus (age 1 and older)
5.	Epilepsy (age 1 and older)
6.	Heart failure (age 1 and older)
7.	Osteoarthritis (age 1 and older)
8.	Rheumatoid arthritis (age 1 and older)
9.	Schizophrenia and delusional disorders (age 10 and older)
10.	Gout (age 20 and older)
11.	Hypertension (age 20 and older)
12.	Ischemic heart disease (age 20 and older)
13.	Multiple sclerosis (age 20 and older)
14.	Stroke (age 20 and older)
15.	Chronic obstructive pulmonary disease (age 35 and older)
16.	Alzheimer's and other dementias (age 40 and older)
17.	Parkinson's disease (age 40 and older)
18.	Osteoporosis (age 50 and older)
Data source: BC Cancer Registry	
1.	Breast cancer (no age cut-off)
2.	Colorectal cancer (no age cut-off)
3.	Haematological cancer (no age cut-off)
4.	Lung cancer (no age cut-off)
5.	Melanoma (no age cut-off)
6.	Other solid organ cancer (no age cut-off)
7.	Prostate cancer (no age cut-off)

Sources: British Columbia Chronic Disease Registry and BC Cancer Registry.

Appendix Figure 1
Upset plots of the five most prevalent (age-specific) disease combinations in individuals with multimorbidity by sex, 2019/2020, British Columbia, Canada



Sources: British Columbia Chronic Disease Registry and BC Cancer Registry, 2001/2002 to 2019/2020.

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