# Multimorbidity in Canadians living in the community

## Results from the Canadian Longitudinal Study of Aging

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## Abstract

**Objective** To determine the mean number of chronic diseases in Canadians aged 45 to 85 years who are living in the community, and to characterize the association of multimorbidity with age, sex, and social position.

**Design** An analysis of data from the Canadian Longitudinal Study on Aging. The number of self-reported chronic diseases was summed, and then the mean number of chronic health problems was standardized to the 2011 Canadian population. Analyses were conducted stratified on sex, age, individual income, household income, and education level.

**Setting** Canada.

**Participants** A total of 21241 community-living Canadians aged 45 to 85 years.

**Main outcome measures** Overall, 31 chronic diseases (self-reported from a list) were considered, as were risk factors that were not mental health conditions or acute in nature. Age, sex, education, and household and individual incomes were also self-reported.

**Results** Multimorbidity was common, and the mean number of chronic illnesses was 3.1. Women had a higher number of chronic illnesses than men. Those with lower income and less education had more chronic conditions. The number of chronic conditions was strongly associated with age. The mean number of conditions was 2.1 in those aged 45 to 54; 2.9 in those 55 to 64; 3.8 in those aged 65 to 74, and 4.8 in those aged 75 and older ($P<.05$, ANOVA [analysis of variance]).

**Conclusion** Multimorbidity is common in the Canadian population and is strongly related to age.

## Editor's key points

- Chronic diseases co-occur and this co-occurrence carries a high risk of death and increased health care use. It also complicates clinical care and can lead to polypharmacy. There are studies of multimorbidity (MM) in clinical settings and using administrative data. However, there are few population-based epidemiologic studies of MM.
- This study found that MM was common in those aged 45 to 85, and increased with age. The study also found that women have more chronic conditions than men do.
- An association was observed between social position and MM—those with lower levels of education, lower household incomes, and lower individual incomes had higher rates of MM. However, this association diminished with advancing age. Some of this effect might be owing to the extremely strong association between age and MM, which might overwhelm the effect of other factors. Although the relative risk of social position declines with age, the absolute risk might remain relevant because of the higher baseline risk in older adults.

## Points de repère du rédacteur

- Les maladies chroniques coexistent, et cette coexistence entraîne un risque élevé de mortalité et un recours accru aux soins de santé. Les soins cliniques en sont d'autant plus compliqués et peuvent entraîner la polypharmacie. Il existe des études sur la multimorbidité (MM) en milieux cliniques, qui utilisent des données administratives. Par ailleurs, les études épidémiologiques sur la MM dans la population sont plutôt rares.
- Cette étude a révélé que la MM était commune chez les personnes de 45 à 85 ans, et qu'elle augmentait avec l'âge. L'étude a aussi fait valoir que les femmes souffraient de problèmes chroniques davantage que les hommes.
- Une association entre la situation sociale et la MM a été observée; les personnes moins éduquées, de même que les ménages et les individus à plus faible revenu avaient des taux plus élevés de MM. Par contre, cette association s'atténuait avec l'avancement en âge. Cet effet pourrait s'expliquer en partie par le lien extrêmement étroit entre l'âge et la MM, qui pourrait atténuer les effets d'autres facteurs. Même si le risque relatif lié à la situation sociale diminue avec l'âge, le risque absolu pourrait demeurer pertinent en raison du risque de base plus élevé chez les adultes plus âgés.

# La multimorbidité chez les Canadiens vivant dans la communauté

## Résultats tirés de l'Étude longitudinale canadienne sur le vieillissement

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## Résumé

**Objectif** Déterminer le nombre moyen de maladies chroniques dont souffrent les Canadiens âgés de 45 à 85 ans qui vivent dans la communauté, et caractériser l'association entre la multimorbidité et l'âge, le sexe et la situation sociale.

**Type d'étude** Une analyse des données tirées de l'Étude longitudinale canadienne sur le vieillissement. Le nombre de maladies chroniques signalées par les participants a été additionné, et le nombre moyen de problèmes de santé chroniques a ensuite été normalisé pour la population canadienne en 2011. Des analyses ont été effectuées pour stratifier les données en fonction du sexe, de l'âge, du revenu individuel, du revenu du ménage et du niveau d'éducation.

**Contexte** Le Canada.

**Participants** Au total, 21 241 Canadiens de 45 à 85 ans vivant dans la communauté.

**Principaux paramètres à l'étude** Dans l'ensemble, 31 maladies chroniques (signalées par les participants à partir d'une liste) ont été prises en compte, de même que les facteurs de risque qui n'étaient pas liés à des problèmes de santé mentale ou de nature aiguë. L'âge, le sexe, le niveau d'éducation, le revenu du ménage et le revenu individuel étaient aussi indiqués par les participants.

**Résultats** La multimorbidité était fréquente, et le nombre moyen de maladies chroniques se situait à 3,1. Les femmes souffraient d'un plus grand nombre de maladies chroniques que les hommes. Les personnes dont le revenu était plus faible et dont le niveau d'éducation était moins élevé souffraient de plus de problèmes chroniques. Le nombre de problèmes chroniques était fortement associé à l'âge. Le nombre moyen de problèmes se situait à 2,1 chez les personnes de 45 à 54 ans, à 2,9 chez les 55 à 64 ans, à 3,8 chez les 65 à 74 ans, et à 4,8 chez les 75 ans et plus ($p < ,05$, ANOVA [analyse de variance]).

**Conclusion** La multimorbidité est commune dans la population canadienne, et elle est fortement liée à l'âge.

Chronic conditions accumulate during the life course and this cumulative disease burden might be more important than the effect of any disease in particular. Multimorbidity (MM) has long been recognized[1] but remains relatively understudied,[2] with attention often focusing on single-system disease. This focus on single diseases leads to public health and clinical programming targeting single diseases in isolation, rather than addressing the complexity of multiple issues in multiple health domains.[3,4]

Describing the epidemiology of MM is important for laying the foundation for further study to identify and address risk factors, and to design prevention and care models for those with MM. The epidemiology of MM has long attracted intermittent attention. In a community survey of patients attending GPs in Scotland, Williamson et al noted that the most striking finding was the presence of multiple disabilities (ie, diseases), with a mean of 3.26 diseases per patient.[1] Subsequent surveys in primary care[5-9] and hospitals[10,11] have also noted the very high prevalence of MM in clinical populations. Studies of general populations have noted a high prevalence of MM, with an increasing prevalence with age and a higher prevalence among those living in lower-income areas.[12-14]

There are numerous measures of MM.[15-17] Measures of MM might include risk factors, overt disease states, or symptoms of disease.[18-21] Studies also differ in data sources. Some studies have used self-reported diseases,[17,22] some have used data gathered for administrative reasons,[14] while others have used direct biological measures. Another difference in methodology is the study sampling frame, with some reports focusing on clinical populations,[5-11] some on small regions,[22] and others on whole populations.[17] Using administrative data reports on the epidemiology of MM in Scotland,[14] Barnett et al noted the very high prevalence of MM and the strong social gradient in the risk of MM across local income groups. They "challenge the single-disease framework by which most health care, medical research, and medical education is configured" and recommend "a complementary strategy … supporting generalist clinicians to provide personalised, comprehensive continuity of care."[14] While there has been a great deal of clinical research on MM in Canada, there are few recent population-based studies of MM. One study reported on the prevalence of MM using 9 chronic diseases, and found a strong association with age, sex, and measures of social position.[17]

To supplement these studies, we therefore report on the epidemiology of MM in the Canadian Longitudinal Study on Aging (CLSA), which is a population-based cohort study intended to be as representative of the Canadian population as possible. Specifically, our objectives are to determine the prevalence of MM in Canada and to investigate factors associated with MM: in particular, how age, sex, and social position are associated with MM.

# Methods

## Design, setting, and sample

We conducted an analysis of CLSA data.[23,24] The CLSA is a large, national, prospective cohort study that will follow more than 50 000 men and women, who were between 45 and 85 years of age when recruited, for at least 20 years. We used data from the baseline wave of the tracking cohort (Baseline Tracking, version 3.0, accessed September 10, 2016). This is a sample of 21 241 participants who provided questionnaire information through telephone interviews. The sampling frame and strategy are described elsewhere.[24,25] The sample is intended to provide estimates that are generalizable to the Canadian population. People were excluded if they lived on federal First Nations reserves, were full-time members of the Canadian Armed Forces, lived in institutions, were unable to respond in English or French, or were cognitively impaired. As such, it is comparable to adults living in the community in Canada. Baseline data were collected between September 2011 and May 2014. The sample was restricted to those between the ages of 45 and 85 years. Owing to the time frames involved in the sampling period, a small number of participants were younger than 45 or older than 85. We included these participants in the analyses, but excluded them from graphical representations. We also excluded participants if they did not answer any of the items used to elicit the presence of a disease included in our measure of MM. The CLSA received ethical approval from the appropriate institutional bodies of each participating site. These analyses received approval from the Research Ethics Board of the Bannatyne Campus of the University of Manitoba in Winnipeg.

## Measure of MM

Participants self-reported chronic conditions that lasted or were expected to last at least 6 months and were diagnosed by a health professional. We excluded acute issues, infectious diseases, and cognitive and mental health diagnoses. We also did not include subjective symptoms (except low back pain). We included osteoarthritis (OA), rheumatoid arthritis, other arthritis, chronic obstructive pulmonary disease, asthma, hypertension, diabetes, heart disease, angina, myocardial infarction, peripheral vascular disease, cerebrovascular accident, transient ischemic attack, Parkinson disease, multiple sclerosis, epilepsy, migraines, gastrointestinal ulcer, bowel disease (which included Crohn disease, ulcerative colitis, and irritable bowel syndrome), allergies, bowel incontinence, urinary incontinence, cataracts, glaucoma, macular degeneration, cancer, osteoporosis, back problems, hypothyroidism, hyperthyroidism, and kidney disease. Participants were asked about OA of different joints. We collapsed these responses into OA of any joint. Similarly, we collapsed responses of the presence of cancer into any type or site

of cancer. We then simply summed the positive responses for each participant, who could then be placed on a scale from 0 to 31 chronic conditions. We considered a dichotomy of 3 or more chronic conditions as the cut point for MM, as suggested by the American Geriatrics Society.[26,27] By happenstance, this is a median split for the sample. For some analyses, we also considered the number of conditions as a continuous variable.

### Other measures

Age, sex, and educational attainment were self-reported. We considered the categories of incomplete high school, no postsecondary school, non-university certificate (trade or vocational school), bachelor's degree, and post-bachelor's degree. Individual income was also self-reported, and categorized as less than $20 000, $20 000 to less than $50 000, $50 000 to less than $100 000, $100 000 to less than $150 000, and $150 000 or more per year. Similarly, household income was self-reported in the same categories. As there were very few individuals reporting individual or household incomes of $150 000 or more per year in some age categories, we collapsed the highest 2 categories into incomes of $100 000 or more per year.

### Analyses

To account for the complex sampling design, weights were calculated to create prevalence estimates that represented the Canadian population (inflation weights) and to estimate associations (analytic weights). Analytic weights are inflation weights that have been rescaled to sum to the sample size within each province. These were provided in the CLSA data set. Analyses considered the analytic weights. For the primary analyses, we excluded individuals with missing variables for any of the chronic conditions. As a secondary analysis, we imputed missing values. As there were few individuals with missing values, the analyses gave similar results (available on request).

We conducted a direct standardization of the mean number of chronic conditions to match the population structure of the nearest Canadian census (2011) according to age (ie, age standardized). We did this for the population of Canada 45 to 85 years of age overall. We also stratified on 10-year age increments. These analyses were done in Microsoft Excel. We then determined the percentage of the sample in each group that had 3 or more chronic conditions. Graphs and analyses were not age standardized. All other analyses were not standardized; rather, analytic survey weights were used.

We conducted analyses stratified on sex, age, individual income group, household income group, and education level. We used $\chi^2$ tests for categorical variables. These were not directly standardized. To determine the effects of social position, age, and sex on the risk of MM, we constructed weighted logistic regression models. The independent variable was the presence of 3 or more chronic conditions. We included age and sex in each model. To account for weighting, we also included province of residence (data not presented) per analysis guidelines for CLSA data. As individual income, household income, and education were strongly correlated, as are all surrogate measures of social position, we included these predictors separately. To test for interactions, we constructed logistic regression models with the main effects term and 1-way interaction terms. We noted an interaction between age and all measures of social position on MM. We therefore constructed logistic models for those younger than 65 and for those aged 65 and older. We also noted an interaction between sex and education on MM. Analyses were conducted in both SPSS, version 24, and SAS, and graphs were created in SPSS, version 24.

## Results

Baseline characteristics are shown in **Table 1**. These characteristics are presented to describe the sample population and are not weighted and do not reflect the general population prevalence. **Figure 1** shows the percentage of participants with each chronic condition. Hypertension, OA, allergies, back problems, and cataracts were all common. **Figure 1** represents the percentage of people with chronic conditions within the CLSA sample, and is not necessarily representative of the Canadian population.

Multimorbidity was common. When we age standardized the results to the Canadian population of 2011, the mean number of chronic illnesses was 3.1. The standardized number of chronic conditions was strongly associated with age: the mean number of conditions was 2.1 in those aged 45 to 54, 2.9 in those aged 55 to 64, 3.8 in those aged 65 to 74, and 4.8 in those aged 75 and older ($P<.05$, ANOVA [analysis of variance]). Similar associations were seen when we categorized the number of chronic conditions. Those with lower income and less education had more chronic conditions.

Women had a higher number of chronic illnesses compared with men: **Figure 2** shows the association between age, sex, and mean number of chronic conditions. We also noted an association between all measures of social position and MM. This effect was a gradient effect noted for educational level, household income, and individual income. We investigated the presence of interactions both by stratifying analyses and by constructing weighted logistic regression models with main-effect terms and interaction terms. As we noted an interaction between age and all measures of social position, and as this interaction has been previously reported,[14] we stratified analyses on age. In younger adults, there was an association between mean number of chronic conditions and education level ($P<.05$, $\chi^2$ test; **Figure 3A**), individual income ($P<.05$, $\chi^2$ test; **Figure 3B**), and household income ($P<.05$, $\chi^2$ test; **Figure 3C**). However, these associations were weaker in those aged 65 and older.

**Table 1. Baseline characteristics of the sample:** ***These results are not standardized to the Canadian population; some variables do not sum to the column value owing to missing data.***

| CHARACTERISTIC | 0-2 CHRONIC CONDITIONS (n = 9095) | ≥ 3 CHRONIC CONDITIONS (n = 10 876) | TOTAL SAMPLE (n = 19 971) |
|---|---|---|---|
| Mean (SD) age, y* | 58.8 (9.3) | 66.2 (10.5) | 62.8 (10.6) |
| Sex, % female* | 4098 (44.6) | 6172 (56.0) | 10 270 (50.8) |
| Education, n (%)* | | | |
| • Incomplete high school | 566 (6.2) | 1270 (11.7) | 1836 (9.2) |
| • No postsecondary school | 1831 (20.1) | 2424 (22.3) | 4255 (21.3) |
| • Non-university certificate | 3190 (35.1) | 3864 (35.5) | 7054 (35.3) |
| • Bachelor's degree | 2121 (23.3) | 1948 (17.9) | 4069 (20.4) |
| • Postgraduate degree | 1387 (15.3) | 1370 (12.6) | 2757 (13.8) |
| Individual income, n (%)* | | | |
| • < $20 000 | 1240 (14.0) | 2401 (22.9) | 3641 (18.8) |
| • $20 000 to < $50 000 | 3261 (36.8) | 4717 (45.1) | 7978 (41.2) |
| • $50 000 to < $100 000 | 3146 (35.5) | 2644 (25.3) | 5790 (29.9) |
| • ≥ $100 000 | 1225 (13.8) | 707 (6.8) | 1932 (10.0) |
| Household income, n (%)* | | | |
| • < $20 000 | 348 (4.0) | 862 (8.4) | 1210 (6.4) |
| • $20 000 to < $50 000 | 1884 (21.5) | 3629 (35.6) | 5513 (29.1) |
| • $50 000 to < $100 000 | 3311 (37.9) | 3613 (35.4) | 6924 (36.5) |
| • ≥ $100 000 | 3200 (36.6) | 2100 (20.6) | 5300 (28.0) |

*Denotes $P < .05$; $\chi^2$ test.

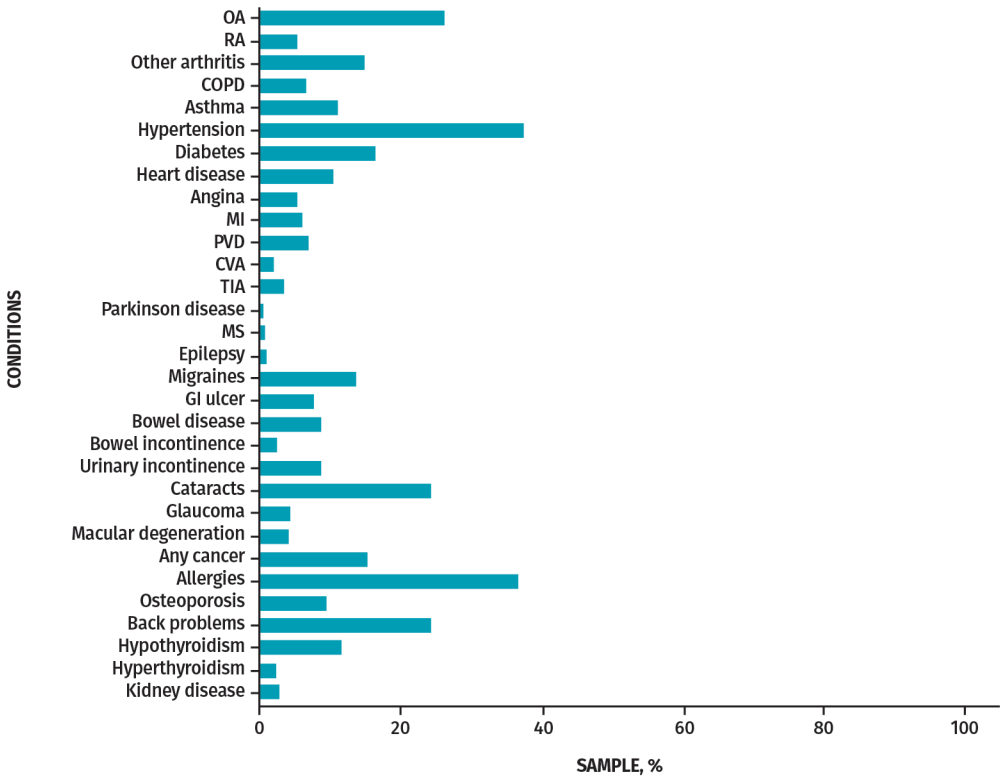
As we noted a significant interaction between sex and some measures of social position on MM, we also stratified analyses on sex. Those with lower education levels were more likely to have MM than those with higher education levels. However, the gradient effect appeared somewhat different in men and in women (**Figure 4A**). In both men and women, we noted an association between individual income (**Figure 4B**) and household income ($P < .05$, $\chi^2$ test; **Figure 4C**) and the presence of MM.

We constructed logistic regression models for the presence of MM. In a logistic regression model adjusting only for age and sex, we noted a strong association between both of these factors on the risk of MM: the adjusted odds ratio for age was 1.08 (95% CI 1.07 to 1.08) per year, and 1.83 (95% CI 1.72 to 1.95) for women versus men. As we noted interactions with age and sex, we have presented models for different age groups and for sex. Models with main effects are only available upon request. **Table 2** shows the results of the logistic regression model for education stratified on age. Lower levels of education were associated with a higher risk of MM in those younger than 65 and in those 65 and older, but the effect was stronger in those younger than 65. **Table 3** shows the logistic regression model of the association between education and MM in women and men. The association between education and MM was present in both sexes, but the gradient in the effect differed somewhat. Those with lower individual incomes (**Table 4**) and household incomes (**Table 5**) had a higher risk of MM, but the effect was stronger in those younger than 65. In all analyses, women had a higher risk of MM. Sex differences were noted particularly for osteoporosis and OA.

## Discussion

We examined MM in a population-based study that is generalizable to the Canadian population. We found that MM is common in those aged 45 to 85 and increases with age. We also found that women have more chronic conditions than men do. We observed an association between social position and MM—those with lower levels of education, lower household incomes, and lower individual incomes had higher rates of MM. However, this association diminished with advancing age. Some of this effect might be owing to the extremely strong association between age and MM, which might overwhelm the effect of other factors. It should also be noted that although the relative risk of social position declines with age, the absolute risk might remain very relevant because of the higher baseline risk in older adults. Our results are remarkably similar to those of Barnett et al,[14] who used administrative data rather than survey data, and who used a different measure of MM in a different population at a similar time.

**Figure 1. Percentage of the sample with each chronic condition:** *These data are not standardized to the Canadian population.*




COPD—chronic obstructive pulmonary disease, CVA—cerebrovascular accident, GI—gastrointestinal, MI—myocardial infarction, MS—multiple sclerosis, OA—osteoarthritis, PVD—peripheral vascular disease, RA—rheumatoid arthritis, TIA—transient ischemic attack.

**Figure 2. The association between age, sex, and mean number of chronic health conditions**

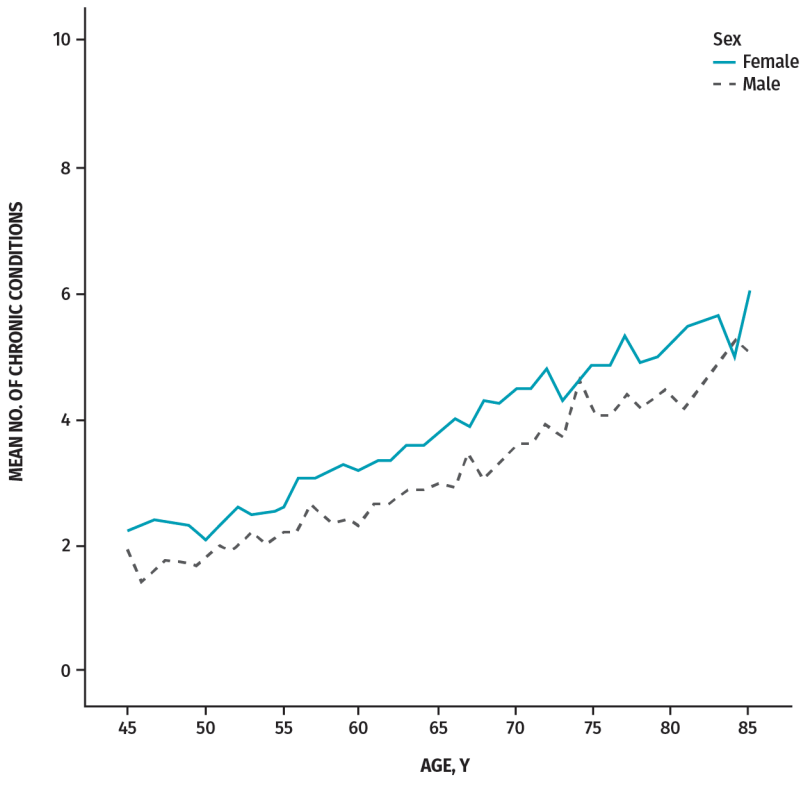
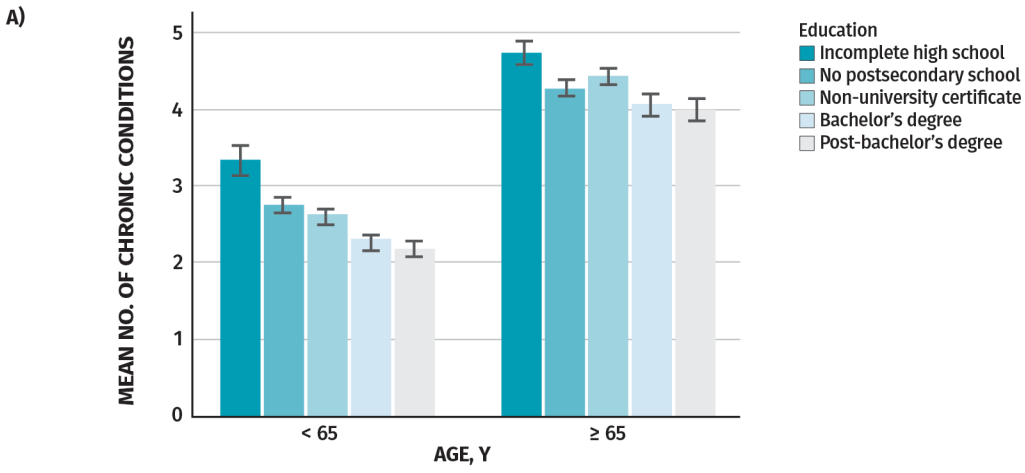
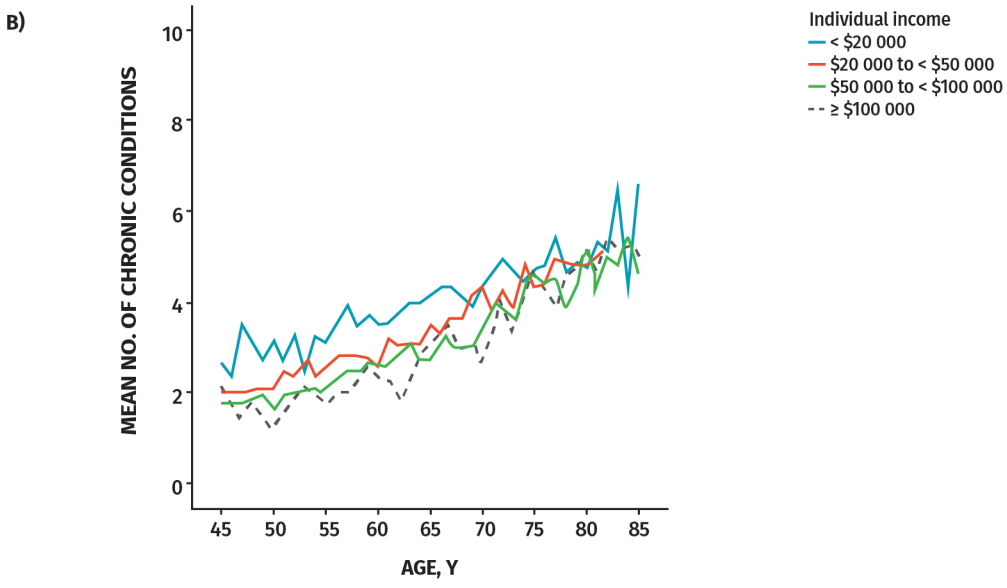


**Figure 3. Associations between sample characteristics, age, and mean number of chronic conditions:** *A) Association between age, education, and number of chronic conditions (the error bars represent 95% CIs); B) association between individual income, age, and number of chronic conditions; and C) association between household income, age, and number of chronic conditions.*



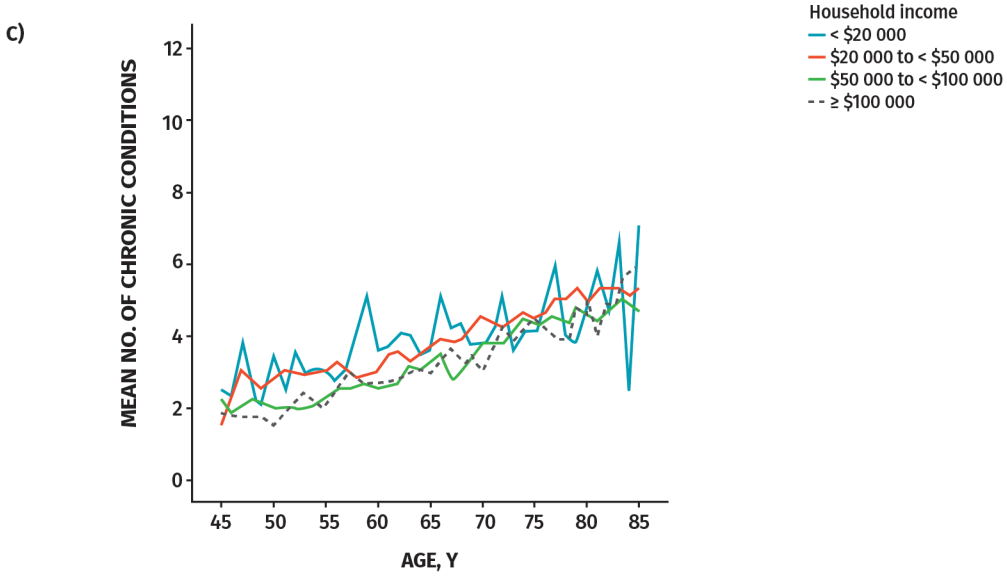



**Figure 4. Associations between sample characteristics, sex, and mean number of chronic conditions:** *A) Association between sex, education, and number of chronic conditions; B) association between sex, individual income, and number of chronic conditions; and C) association between sex, household income, and number of chronic conditions. The error bars represent 95% CIs.*

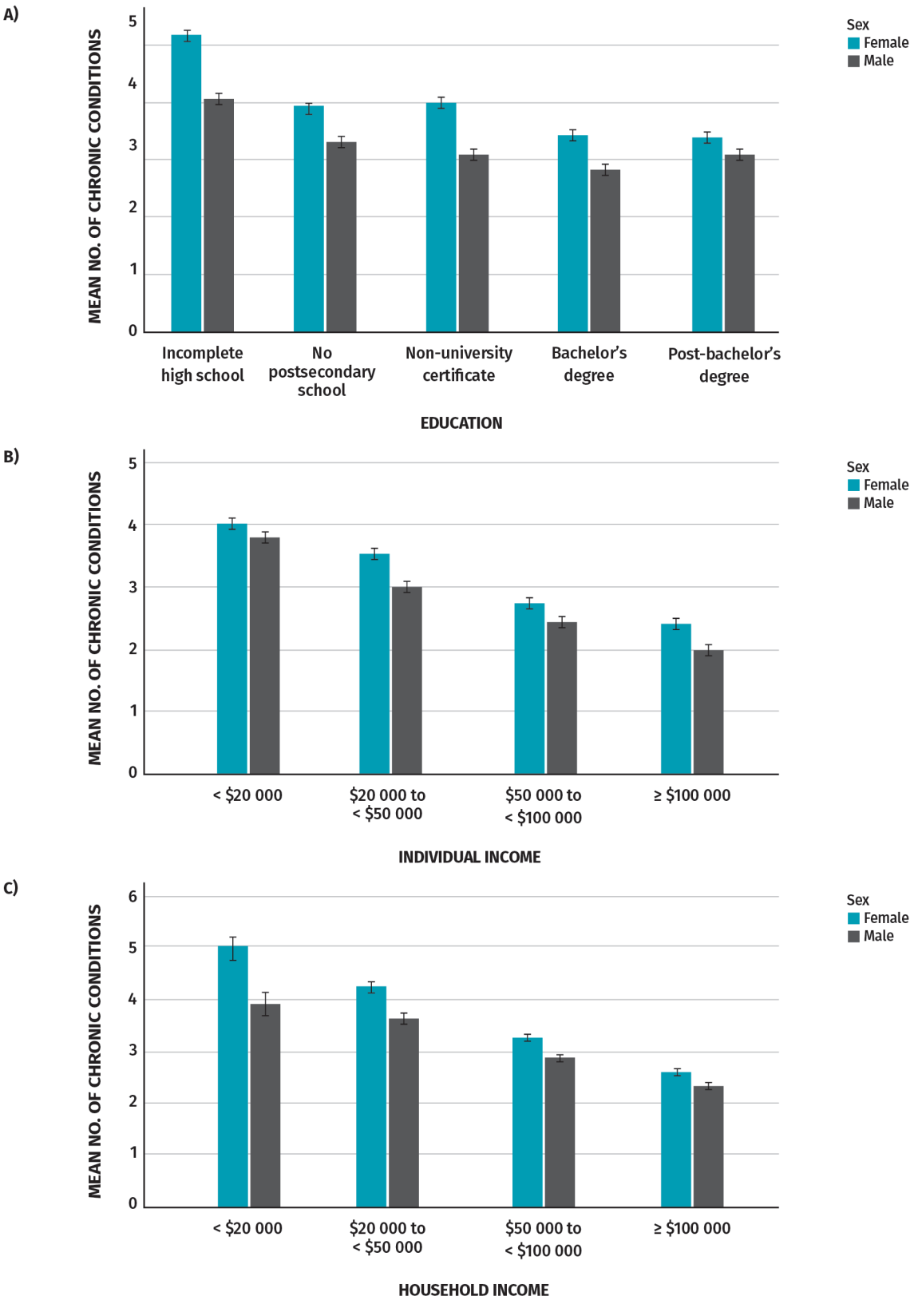


**Table 2.** Results of logistic regression models for the association between education and multimorbidity, stratified on age

| CHARACTERISTIC | AGE < 65 Y, OR (95% CI) | AGE ≥ 65 Y, OR (95% CI) |
|---|---|---|
| Sex (reference: male) | 1.70 (1.58 to 1.82) | 1.69 (1.51 to 1.88) |
| Education (reference: post-bachelor's degree) | | |
| • Incomplete high school | 2.56 (2.13 to 3.08) | 1.43 (1.15 to 1.76) |
| • No postsecondary school | 1.56 (1.39 to 1.77) | 1.07 (0.89 to 1.28) |
| • Non-university certificate | 1.48 (1.33 to 1.65) | 1.10 (0.93 to 1.30) |
| • Bachelor's degree | 1.09 (0.97 to 1.23) | 0.98 (0.81 to 1.18) |

OR—odds ratio.

**Table 3.** Results of logistic regression models for the association between education and multimorbidity, stratified on sex

| CHARACTERISTIC | WOMEN, OR (95% CI) | MEN, OR (95% CI) |
|---|---|---|
| Age, y | 1.08 (1.07 to 1.08) | 1.08 (1.07 to 1.08) |
| Education (reference: post-bachelor's degree) | | |
| • Incomplete high school | 1.99 (1.62 to 2.46) | 1.66 (1.37 to 2.01) |
| • No postsecondary school | 1.24 (1.08 to 1.44) | 1.40 (1.22 to 1.62) |
| • Non-university certificate | 1.38 (1.20 to 1.60) | 1.32 (1.16 to 1.50) |
| • Bachelor's degree | 1.04 (0.90 to 1.20) | 1.05 (0.91 to 1.20) |

OR—odds ratio.

**Table 4.** Results of logistic regression models for the association between individual income and multimorbidity, stratified on age

| CHARACTERISTIC | AGE < 65 Y, OR (95% CI) | AGE ≥ 65 Y, OR (95% CI) |
|---|---|---|
| Sex (reference: male) | 1.46 (1.35 to 1.59) | 1.63 (1.46 to 1.82) |
| Individual income (reference: ≥ $100 000) | | |
| • < $20 000 | 3.76 (3.20 to 4.39) | 1.44 (1.12 to 1.85) |
| • $20 000 to < $50 000 | 2.24 (1.94 to 2.59) | 1.24 (0.98 to 1.57) |
| • $50 000 to < $100 000 | 1.46 (1.27 to 1.70) | 1.01 (0.79 to 1.29) |

OR—odds ratio.

**Table 5.** Results of logistic regression models for the association between household income and multimorbidity, stratified on age

| CHARACTERISTIC | AGE < 65 Y, OR (95% CI) | AGE ≥ 65 Y, OR (95% CI) |
|---|---|---|
| Sex (reference: male) | 1.76 (1.62 to 1.91) | 1.67 (1.48 to 1.83) |
| Household income (reference: ≥ $100 000) | | |
| • < $20 000 | 4.21 (3.50 to 5.06) | 1.73 (1.36 to 2.21) |
| • $20 000 to < $50 000 | 2.44 (2.18 to 2.73) | 1.54 (1.30 to 1.82) |
| • $50 000 to < $100 000 | 1.53 (1.38 to 1.68) | 1.17 (0.99 to 1.38) |

OR—odds ratio.

They also noted the strong interactive association between age, social position, and MM, but noted that the absolute number of younger persons with MM was higher than that of older persons. They also noted a lessening of the effect of living in a deprived area among older adults compared with younger adults. Our results are also similar to a Canadian study that considered a different set and number of chronic diseases.[17] Despite different measures and data sources in different populations, the general findings are comparable. Another study, restricted to older adults, also showed similar results[22]; however, this study was limited to 1 province, oversampled very old individuals, and was not intended to produce prevalence estimates for a population.

## Strengths and limitations

There are some limitations to our approach. First, the measure of MM that we used was simply a crude tally of common diseases and risk factors. The prevalence of MM will clearly depend on the number of chronic conditions considered. Risk factors tend to be more prevalent, but have a lower mortality and morbidity[21] than overt disease. Including them might inflate the prevalence of MM in a general population. We also did not consider disease severity—more advanced disease might be more troublesome than less severe disease. We did not consider the differential effect of different diseases. For instance, heart failure generally carries a worse prognosis than OA. This might be important for several reasons—more severe or more advanced disease might be more important and might need to be weighted more prominently. Conversely, more serious diseases might have a higher case fatality rate, thereby reducing the point prevalence in a population. The measurement of MM in a general population is the focus of ongoing study.[17,20,21] We also excluded mental health diagnoses from our measure of MM, which might have influenced some of the associations we noted. It might prove impossible to devise an ideal measure of MM for use in all populations using all data sources, so there will likely continue to be a variety of measures. We also chose to dichotomize the measure of MM at 3 or more conditions, according to the American Geriatrics Society statement. This coincided with a median split. However, there are other cut points—notably, the National Institute for Health and Care Excellence suggests a cut point of 2 or more chronic conditions.[28]

There are also some strengths to the approach we took. First, we used data from the CLSA, which are as representative of the Canadian population as possible. Information on measures was gathered in a standardized manner by trained telephone interviewers. As well, self-report of diseases might be preferable to administrative measures, which rely on patients visiting a health care professional, and therefore partly measure access to and use of health care services.

## Conclusion

In spite of the limitations, our findings are important for several reasons. First, it might be more reasonable to consider MM as a continuous variable rather than dichotomizing it. In other studies, the effect of MM on death and disability is a risk across the measure of MM, and is not limited to those above any arbitrary cut point.[22] Moreover, the number of chronic conditions obviously depends on the number of conditions considered and their individual prevalence. Using the same cut point regardless of the number or prevalence of conditions is therefore problematic. Second, our findings are important because MM—however it is defined—is common. Currently, health care systems are structured to treat individual diseases and organ failure in isolation. As diseases commonly occur together, this approach has limitations, and rigidly adhering to guidelines for each individual condition might be problematic.[29,30] Rather, it might be more appropriate to individualize care and take into consideration all comorbid conditions. This approach might need to be further broadened to consider functional status,[22,31] cognitive status,[32] sociodemographic factors,[33] and patient preferences.[4] The same is true for public health interventions, which might need to be tailored to the specific population. For instance, screening guidelines might need to consider the presence and severity of comorbid conditions. Conversely, if certain diseases share risk factors and cluster together, then perhaps complementary approaches could be taken to prevent these disease clusters. Further study is needed to determine the extent to which diseases co-occur and share common risk factors. A final important finding is the presence of a strong social gradient in the risk of MM. This finding is also consistent with the observation of Barnett et al[14] that those living in areas of Scotland with a higher rate of deprivation had a higher risk of MM. Individual measures of social position are also associated with MM. Moreover, this effect is a gradient across most measures of social position, and is not limited to those living in extreme poverty. While the association between social position and health has long been apparent for mortality, disability, and individual disease states, there is less evidence for MM. Educational attainment has increased considerably over time in Canada, but ensuring access to a high-quality education might be needed. Ensuring an adequate income might also be important in lowering the risk of MM. In addition, it might be important to reduce gradients across the entire range of incomes. Finally, further study is needed into sex and gender interactions. These interactions might be specific to the CLSA, the measures we considered, and our categorizations. Also, the interactions we noted were statistically significant, but might not be relevant to clinical or population health policy. As well, they were attenuated when we considered 3-way interactions with age. Nevertheless, other studies with different measures of MM might want to investigate sex and gender differences in MM.

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**Contributors**

All authors contributed to the concept and design of the study; data analysis and interpretation; and preparing the manuscript for submission.

**Competing interests**
None declared

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