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Research Article

Absence of a Socioeconomic Gradient in Older Adults' Survival with Multiple Chronic Conditions

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ABSTRACT

Background: Individuals of low socioeconomic status experience a disproportionate burden of chronic conditions; however it is unclear whether chronic condition burden affects survival differently across socioeconomic strata.
Methods: This retrospective cohort study used health administrative data from all residents of Ontario, Canada aged 65 to 105 with at least one of 16 chronic conditions on April 1, 2009 (n = 1,518,939). Chronic condition burden and unadjusted mortality were compared across neighborhood income quintiles. Multivariable Cox proportional hazards models were used to examine the effect of number of chronic conditions on two-year survival across income quintiles.
Findings: Prevalence of five or more chronic conditions was significantly higher among older adults in the poorest neighborhoods (18.2%) than the wealthiest (14.3%) (Standardized difference > 0·1). There was also a socioeconomic gradient in unadjusted mortality over two years: 10.1% of people in the poorest neighborhoods died compared with 7.6% of people in the wealthiest neighborhoods. In adjusted analyses, having more chronic conditions was associated with a statistically significant increase in hazard of death over two years, however the magnitude of this effect was comparable across income quintiles. Individuals in the poorest neighborhoods with four chronic conditions had 2.07 times higher hazard of death (95% CI: 1.97–2.19) than those with one chronic condition, but this was comparable to the hazard associated with four chronic conditions in the wealthiest neighborhoods (HR: 2.29, 95% CI: 2.16–2.43).
Interpretation: Among older adults with universal access to health care, the deleterious effect of increasing chronic condition burden on two-year hazard of death was consistent across neighborhood income quintiles once baseline differences in condition burden were accounted for. This may be partly attributable to equal access to, and utilization of, health care. Alternate explanations for these findings, including study limitations, are also discussed.

1. Introduction

The burden of multiple chronic conditions is felt disproportionately among people living in low-socioeconomic status (SES) neighborhoods (Freedman et al., 2011; Barnett et al., 2012). This inverse relationship between SES and chronic condition burden is robust: it persists across studies done in different countries, and using both individual and neighborhood measures of SES (Mackenbach et al., 2008; Freedman et al., 2011; Barnett et al., 2012; Payne et al., 2013; Violan et al., 2014a). According to the Inverse Care Law, the availability of good medical care tends to vary inversely with the need for it in the population served (Hart, 1971). In countries where the Inverse Care Law has been demonstrated, people of lower SES are less likely to receive adequate health care, despite their greater need (van Doorslaer et al., 2006; Pruitt et al., 2009). When health care is not universally accessible to young people, this disparity in health care access can establish SES gaps in early health that persist into old age, even if universal health care is available for senior citizens (Currie and Rossin-Slater, 2015).

Socioeconomic characteristics in peoples'neighborhoods – such as median level of income and material deprivation – affect individual health through a number of avenues (Riva et al., 2007; Yen et al., 2009; Meijer et al., 2012; Jonker et al., 2015; Schule and Bolte, 2015). Low-SES neighborhoods are less likely to have healthy built environments, including access to healthy food or safe spaces for physical

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recreation (Yen et al., 2009; Schule and Bolte, 2015). Low-SES individuals are also more likely to live in low-SES neighborhoods and their relatively high rates of smoking, physical inactivity, and obesity account for approximately a third of the increased cardiovascular mortality seen in these areas (Jonker et al., 2015). In addition to their higher rates of unhealthy behaviors (Jonker et al., 2015; Schule and Bolte, 2015), inhabitants of low-SES neighborhoods are less likely to self-manage appropriately (Coventry et al., 2014) or be adherent with medical therapy and recommendations (Gerber et al., 2011). Reduced mobility and increased vulnerability render older adults especially susceptible to the unhealthy effects of low-SES neighborhoods (Yen et al., 2009; Rosso et al., 2011).

We hypothesized that these neighborhood effects would create a socioeconomic gradient in the burden of chronic conditions in older (aged 65 to 105) adults. We further hypothesized that low neighborhood SES would exacerbate the effects of increasing chronic condition burden on older adults and worsen their survival prognosis relative to those in high-SES neighborhoods, even with universal access to health care. To test these hypotheses, we described differences in chronic condition burden and health care utilization across neighborhood income quintiles in Ontario, Canada. Then we examined the impact of increasing number of chronic conditions on hazard of death over two years in the same sample, controlling for confounders and stratified by neighborhood income quintile.

2. Methods

2.1. Setting

This retrospective cohort study was conducted using linked provincial health administrative databases in Ontario, Canada. In Ontario, government-funded universal health insurance pays for all medically necessary hospital and physician services for all residents of all ages – without user fees at the point of service – as well as prescription drugs for individuals over 65 years old.

2.2. Data Sources

The provincial health insurance claims database allows for identification of all individuals who use the health care system and retrieval of information about their medical conditions, utilization, and outcomes. These data are housed and secured at the Institute for Clinical Evaluative Sciences (ICES) under data security and privacy policies approved by the Offices of the Information and Privacy Commissioner of Ontario. This study was approved by the Research Ethics Board and Privacy Office at ICES.

The following datasets were linked using unique encoded identifiers and analyzed at ICES: (1) the Ontario Registered Persons Database was used to identify individuals' age, sex, postal code, and date of death (if death occurred during the study period); (2) the 2011 Canadian Census data were linked to individuals' postal codes and used to identify the median income of the neighborhoods in which they lived as well as whether they were urban or non-urban according to the Rurality Index of Ontario (RIO) (Kralj, 2008); (3) the Discharge Abstract Database contains data on all hospital discharges and was used to determine individuals' inpatient chronic condition diagnoses; (4) the Ontario Health Insurance Plan (OHIP) claims database contains data on all physician billing and was used to examine health care utilization and individuals' outpatient chronic condition diagnoses; (5) OHIP data and Client Agency Program Enrolment data were combined to determine whether individuals had a usual provider of care (UPC).

2.3. Study Cohort

All Ontario residents who met the following criteria were eligible for the study sample: (1) aged 65 to 105 on the study index date, April 1, 2009; (2) eligible for OHIP from April 1, 2009 to March 31st 2011 (or death); and (3) had at least one of the following 16 conditions on April 1, 2009: acute myocardial infarction, asthma, cancer, cardiac arrhythmia, chronic coronary syndrome, chronic obstructive pulmonary disorder (COPD), congestive heart failure (CHF), mood disorders (depression or bipolar disorder), dementia, diabetes, hypertension, osteoarthritis, osteoporosis, renal failure, rheumatoid arthritis and stroke. We examined individuals 65 and over as representing a cohort particularly vulnerable to chronic disease burden and associated adverse health outcomes (including death) and also susceptible to neighborhood SES effects (Yen et al., 2009). Of the 1,528,437 eligible study participants, 9498 (0.62%) had missing data on income quintile and were excluded from all multivariable analyses.

2.4. Exposure

The primary exposure was chronic condition burden, defined as the number of selected chronic conditions at the index date. Number of conditions was coded as one (referent group), two, three, four, or five-plus. Five of the sixteen chronic conditions (asthma, CHF, COPD, hypertension, and diabetes) were defined based on previously validated population-derived ICES cohorts. These definitions are based on diagnostic criteria of one inpatient or two outpatient diagnoses within two years of claims data. All algorithms have high specificity and sensitivity, as detailed elsewhere (Koné Pefoyo et al., 2015). For the remaining 11 conditions where a derived ICES cohort did not exist, we adopted a similar approach to the derivation algorithms (i.e. at least one inpatient or two outpatient diagnoses recorded in physician records within a two-year period) (Koné Pefoyo et al., 2015). These 16 conditions were selected based on their population burden, both in terms of cost and prevalence (Koné Pefoyo et al., 2015). The full set of diagnostic codes used to define the conditions is listed in Supplementary Table A.

2.5. Outcome

The primary outcome was time to death measured in days from the index date. To examine whether this exposure-outcome relationship was moderated by neighborhood SES, we determined median income in individuals' Census-defined neighborhoods and divided neighborhoods into income quintiles, with the first and fifth quintiles having the lowest and highest median incomes, respectively. Neighborhood income quintile has been used extensively in health research as an indicator of neighborhood SES (Yen et al., 2009) and is associated with individuals' health outcomes independent of their personal SES (Southern et al., 2005; Jonker et al., 2015; Schule and Bolte, 2015).

2.6. Covariates

A “burden length” variable described the number of days prior to April 1, 2009 that individuals had lived with their current number of chronic conditions. Whether or not individuals had a UPC – defined as being rostered or virtually rostered to a family physician – was also adjusted for, as were patient age, sex, and urban or non-urban location of dwelling. Frequency of specialist and primary care visits over the two-year follow-up period was also examined.

2.7. Analyses

Demographic characteristics of the study cohort, chronic condition burden, burden length as well as the presence of a UPC were evaluated at the index date within each neighborhood income quintile. Frequency of specialist and primary care visits each individual had over the two-year follow-up period were also examined. Due to the large sample size, standardized differences were calculated to quantify statistical significance of differences across quintiles, independent of sample size (Mamdani et al., 2005). Continuous and categorical variables in the

second to fifth income quintiles were all compared with those in the first (lowest) income quintile using the formulas detailed by Yang and Dalton (Yang and Dalton, 2012).

Univariate Cox proportional hazards models were developed to examine the crude association of each variable with two-year hazard of death. Chronic condition burden, burden length, age, sex, location of dwelling, and presence of a UPC were then simultaneously entered into Cox proportional hazards models stratified by neighborhood income quintile. We did not adjust for the number of physician visits in multivariable models because we hypothesized that they were in the causal pathway between chronic condition burden and survival. The proportionality assumption was verified within each stratum of neighborhood income quintile.

2.8. Sensitivity Analyses

We conducted a supplementary analysis across each income quintile stratum of the multivariable models, wherein the chronic condition burden variable was replaced by dummy-variables for the presence of each chronic condition. This sensitivity analysis tested whether findings attributed to number of conditions were actually due to differential effects of conditions across income quintiles. Sensitivity analyses that included measures of health care utilization or excluded the UPC variable were also done. To examine whether results were due to our cohort age restriction and potential survival biases, we also repeated our analyses among all eligible Ontarians aged 45 to 64 years old. A final sensitivity analysis substituted a measure of material deprivation quintiles – in the place of income quintile – as the neighborhood SES indicator (Matheson et al., 2012). All analyses were done using SAS version 9.3 (SAS Institute, 2012) and reported according to published guidelines (Abraira et al., 2013).

2.9. Role of the Funding Source

The funding sources for this study had no role in study design, collection, analysis, or interpretation of data, or in the writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

3. Results

A sample of 1,518,939 older adults was included in the analysis and is described in Table 1. Older adults living in lower income neighborhoods were significantly more likely to have high chronic condition burden: 18.2% of people in the lowest income neighborhoods had five or more chronic conditions, compared to 14.3% of those in highest income neighborhoods. The prevalence of the 16 chronic conditions by income quintile is presented in Supplementary Figure A.

Table 1
Baseline sample characteristics, according to neighborhood income quintile.

Characteristic	Lowest income quintile (n = 292,574)	2nd income quintile (n = 315,401)	3rd income quintile (n = 298,092)	4th income quintile (n = 302,489)	Highest income quintile (n = 310,383)
Mean age in years (SD)	75.5 (7.5)	75.1 (7.3)	74.9 (7.3)	74.7 (7.3)	74.7 (7.3)[a]
Age in years (%)					
65–74	146,683 (50.1)	162,762 (51.6)	157,473 (52.8)	163,507 (54.0)	169,531 (54.6)
75–84	106,352 (36.4)	114,330 (36.3)	105,668 (35.4)	104,910 (34.7)	105,498 (34.0)
85–105	39,539 (13.5)	38,309 (12.2)	34,951 (11.7)	34,072 (11.3)	35,354 (11.4)
Sex (%)					
Female	175,468 (60.0)	182,101 (57.7)	168,522 (56.5)	167,607 (55.4)	168,325 (54.2)
Male	117,106 (40.0)	133,300 (42.3)	129,570 (43.5)	134,882 (44.6)	142,058 (45.8)[a]
Location of dwelling (%)					
Non-urban	82,364 (28.2)	90,868 (28.8)	94,456 (31.7)	100,012 (33.1)[a]	97,014 (31.3)
Urban	205,841 (70.4)	222,744 (70.6)	201,995 (67.8)	201,567 (66.6)	212,571 (68.5)
Missing[b]	4369 (1.5)	1789 (0.6)	1641 (0.6)	910 (0.3)[a]	798 (0.3)[a]
Chronic condition burden (%)					
1 chronic condition	52,682 (18.0)	59,677 (18.9)	58,172 (19.5)	61,450 (20.3)	66,825 (21.5)
2 chronic conditions	73,104 (25.0)	81,656 (25.9)	78,524 (26.3)	80,297 (26.5)	84,160 (27.1)
3 chronic conditions	67,006 (22.9)	72,691 (23.0)	68,434 (23.0)	69,360 (22.9)	70,318 (22.7)
4 chronic conditions	46,557 (15.9)	49,013 (15.5)	45,304 (15.2)	44,879 (14.8)	44,859 (14.4)
5+ chronic conditions	53,225 (18.2)	52,364 (16.6)	47,658 (16.0)	46,503 (15.4)	44,221 (14.3)[a]
Burden length (Days)					
Median (25th, 75th percentiles)	779 (415, 2030)	758 (421, 2030)	749 (419, 2015)	729 (418, 1990)	716 (410, 1953)
Individual has usual provider of care (%)					
No	67,193 (23.0)	66,611 (21.1)	60,295 (20.2)	58,254 (19.3)	58,862 (19.0)
Yes	225,381 (77.0)	248,790 (78.9)	237,797 (79.8)	244,235 (80.7)	251,521 (81.0)

Notes:
Burden length indicates number of days prior to April 1, 2009 that individuals lived with the number of chronic conditions indicated.
[a] Denotes values in second to fifth income quintiles that are significantly different (a standardized difference > 0.1 (Cohen, 1988)) from those in the first income quintile.
[b] The 9498 (0.62%) of individuals with missing data on location of dwelling were retained in the sample by including a category for "missing" in this variable.

Despite the higher morbidity burden in older adults from low-income neighborhoods, the frequency of their visits to primary care and specialist physicians during follow-up did not differ significantly from people in high-income neighborhoods (Table 2). Of the 130,417 (8.6%) individuals who died during follow-up, a higher proportion was from the lowest income neighborhoods (10.1%) than the highest income neighborhoods (7.6%), however this difference was not statistically significant (Table 3). In unadjusted models (Table 4), there was a significantly higher risk of death associated with increasing age, being male, lower neighborhood income quintile, higher chronic condition burden, living in a non-urban setting, and not having a UPC. The results of the un-stratified multivariable Cox regression model are presented in Supplementary Table B.

Table 5 presents the results of neighborhood income stratified Cox proportional hazards models, adjusted for all of the other variables listed. These data show that there was a stepwise increase in hazard of death during the two-year follow-up period for each additional chronic condition present at baseline. Counter to our a priori hypothesis, the effect of increasing chronic condition burden on two-year survival was comparable for older adults in the poorest versus wealthiest neighborhoods in Ontario. This is indicated by the overlapping 95% confidence intervals for chronic condition burden hazard ratios across all five income quintiles. The minor exception to this finding occurs in the 95% confidence intervals for five-plus chronic conditions; the hazard of death with this high chronic condition burden appears to be slightly higher among those in the highest income quintile than the lowest.

Supplementary Table C shows that the absence of an income gradient exists even when the effect of specific conditions instead of number of conditions is examined. The exceptions to this finding were diabetes and dementia, both of which were associated with marginally higher hazard of death among people in higher-income neighborhoods. In sensitivity analyses, the findings observed for the income-stratified hazard of death with a given chronic condition burden were essentially unchanged following the removal of UPC, or the addition of primary care and specialist visits from the models. Major findings were also consistent when analyses were repeated in a cohort aged 45 to 64 and when material deprivation was used as the neighborhood SES indicator.

4. Discussion

We set out to determine whether the effect of increasing chronic condition burden on two-year survival among older adults differed depending on their neighborhood income quintile. We hypothesized that even with universal health insurance coverage, neighborhood influences on health would cause an SES gradient in older adults' hazard of death. That is, individuals in lower SES neighborhoods would experience a disproportionately high likelihood of death with increasing chronic condition burden, compared to individuals in higher SES neighborhoods.

We found that the unadjusted prevalence of five or more chronic conditions and two-year mortality rate were higher in older adults from the lowest income neighborhoods than those in the wealthiest neighborhoods. However, after adjusting for potential confounders, the effect of increasing chronic condition burden on mortality was similar across neighborhood income strata. This absence of effect modification by neighborhood income quintile was not sensitive to model inclusion or exclusion of variables that measured whether individuals had a usual provider of care, or the frequency of visits they made to primary and specialist physicians during the two-year follow-up period. Main findings from this older adult cohort were consistent when material deprivation was used as the neighborhood SES indicator, and in a cohort aged 45 to 64 at baseline.

Our stratified multivariable models also showed that older age and male sex were associated with a higher hazard of death among people living in wealthy neighborhoods versus poorer ones. This unexpected gradient did not exist in the sensitivity analysis among the cohort aged 45 to 64 years old, and may be attributable to a hearty survivor effect in the lower SES quintiles of our cohort (Glymour and Greenland, 2008). Having five or more chronic conditions was associated with a marginally higher hazard of death among people in the wealthiest neighborhoods than the poorest ones. This may be attributable to the higher hazard of death associated with specific chronic conditions such as dementia (Supplementary Table C) in high-SES individuals (Qiu et al., 2001).

According to the Inverse Care Law, the availability of medical care tends to vary inversely with the need for it in the population served (Hart, 1971). Other studies of multimorbid older adults have supported the existence of this health care utilization gradient, (Alter et al., 1999; Wang et al., 2015) but our study does not. We found that although there was a significantly higher burden of chronic conditions in individuals from the poorest neighborhoods, utilization of primary and specialist care did not differ significantly across income quintiles. This finding aligns with the results of an earlier Ontario study that found no income gradient in likelihood of accessing care or frequency of visits in morbidity-adjusted models (Glazier et al., 2009). Although equal utilization may still be inequitable due to the higher morbidity burden in low-SES individuals, it does not exhibit the *inverse* gradient seen in other high-income countries with universal health care. Future research should build on this finding by studying potential gradients in other health services used in Ontario; SES gradients may still exist in medication use, stage of illness at first medical contact for a diagnosis and supplementation of publically funded services with private health care.

Studies that compare SES disparities in health across countries have found that SES gradients in all-cause mortality (Riva et al., 2007; Mackenbach et al., 2008; Meijer et al., 2012) and self-reported health (Riva et al., 2007; Maskileyson, 2014) exist across a range of health systems, and that the steepness of these gradients is largely comparable across countries despite differences in the universality of their publically funded health care (Maskileyson, 2014). The important role of neighborhood and associated behavioral determinants of health in creating "health-wealth" gradients in mortality (Stringhini et al., 2010; Nandi et al., 2014; Jonker et al., 2015) and survival (Southern et al., 2005; Shaw et al., 2014) has also been well-established across a range of settings. Together, these findings from across and within various health systems lead to the commonly held notion that universal health care is necessary but not sufficient to eliminate socioeconomic disparities in health (Berkman and Epstein, 2008).

We posit that the unanticipated absence of a strong SES gradient in our study occurred for several reasons. First, although neighborhood income quintile was associated with higher prevalence of multiple

Table 2
Health care utilization during two-year follow-up, according to neighborhood income quintile.

	Lowest income quintile (n = 292,574)	2nd income quintile (n = 315,401)	3rd income quintile (n = 298,092)	4th income quintile (n = 302,489)	Highest income quintile (n = 310,383)
Mean (SD) # specialist visits per half-year alive	1.6 (9.6)	1.4 (8.5)	1.3 (8.3)	1.3 (8.3)	1.2 (8.2)
Mean (SD) # primary care visits per half-year alive	3.2 (3.0)	3.2 (2.9)	3.2 (2.9)	3.1 (2.8)	3.0 (2.7)

Note:
None of the values in this table for income quintiles two through five are significantly different (a standardized difference > 0.1 (Cohen, 1988)) from those in the first (lowest) income quintile.

Table 3
Unadjusted two-year vital status, according to neighborhood income quintile.

Vital status after two years follow-up (%)	Lowest income quintile (n = 292,574)	2nd income quintile (n = 315,401)	3rd income quintile (n = 298,092)	4th income quintile (n = 302,489)	Highest income quintile (n = 310,383)
Deceased	29,480 (10.1)	27,342 (8.7)	25,272 (8.5)	24,657 (8.2)	23,666 (7.6)
Alive	263,094 (89.9)	288,059 (91.3)	272,820 (91.5)	277,832 (91.8)	286,717 (92.4)

Note:
None of the values in this table for income quintiles two through five were significantly different (a standardized difference > 0.1 (Cohen, 1988) from those in the first (lowest) income quintile.

chronic conditions, the SES gradient in our sample was rather flat compared to other studies of SES gradients in multimorbidity (Violan et al., 2014a). This minimal SES gradient in multimorbidity prevalence is likely attributable to smaller SES disparities in risk factors between older Canadians than are present in other countries (McGrail et al., 2009). This explanation is supported by evidence that the proportion of variance in survival outcomes attributable to socially patterned risk factors is reduced in countries with smaller disparities in social determinants of health (Stringhini et al., 2011). Given that Ontarians have access to universal health care throughout their lifespan, disparities in young adult health are also less likely to carry forward into older adults in this population. Finally, we hypothesize that the ability of low-SES older adults to freely access necessary medical care closed whatever small SES gaps might have existed in survival once people had a given chronic condition burden. This mechanism is supported by Anderson et al.'s work demonstrating the larger absolute effect of universal health care on health among low-SES individuals, and the resulting reduction in the slope of the "health-wealth" gradient (Anderson et al., 2005).

Our study is not without some limitations. Our definition of chronic condition burden was limited to the presence of 16 chronic conditions. Although these conditions represent a small number of possible conditions experienced by older adults, together they account for a large proportion of chronic condition burden from a population-based epidemiological perspective (Koné Pefoyo et al., 2015). Due to our use of health administrative data, we were only able to study the relationship between chronic condition burden and survival among those people who had a place of residence and accessed health care. Some of the most vulnerable, low-SES older adults may not have been captured in this sample, leading to underestimation of the chronic condition burden and health disparities in our population as a whole. We were also unable to adjust for the severity of individuals' chronic conditions in our sample. Typically, people of lower SES present to medical care later, with more advanced diseases than their higher SES counterparts, therefore if condition severity was acting as an unmeasured confounder, its effect would be to increase socioeconomic gradients in survival, not create the null effect we report. The neighborhood SES variables available to us for this research at ICES were divided into quintiles, which – due to the inherently greater SES variation of individuals therein – might underestimate SES gradients compared with neighborhood SES deciles used in other studies (Barnett et al., 2012). Despite this limitation, neighborhood SES is commonly measured in quintiles in studies of SES gradients in health outcomes, (Kapral et al., 2012; Payne et al., 2013; Violan et al., 2014b) therefore this measurement increases comparability of our findings with those from other studies. Both our primary (median income) and sensitivity (material deprivation) measures of SES were at the neighborhood level, which may have failed to capture individual-level variations in SES due to personal wealth, education or occupation. However, area-level measures of SES have been shown to predict health outcomes independent of individual SES (Southern et al., 2005; Schule and Bolte, 2015) and are commonly used in studies of SES and health in older adults (Alter et al., 1999; Kapral et al., 2012; Alter et al., 2013).

Despite these limitations, our study makes an important contribution toward understanding the effect of increasing chronic condition burden on survival across neighborhood socioeconomic strata. Our use of health administrative data in a single-payer health care system yielded a representative population sample. We used validated algorithms to identify individuals' chronic condition burden and had access to complete health care utilization and outcome data over the two-year follow-up period. Unlike past studies that have examined SES disparities in survival after a specific acute event (Alter et al., 1999; Kapral et al., 2012; Alter et al., 2013) our study is more broadly relevant to health care providers and policymakers grappling with the growing population of multimorbid older adults. Our sensitivity analyses using an alternate measure of neighborhood SES and a younger cohort of adults strengthen our conclusions by testing for potential misclassification and survival biases. We also demonstrate the insensitivity of our primary null finding to analytic assumptions about inclusion and exclusion of health care utilization variables from our models.

The clinical and health policy implications of this work are significant. We found that in a Canadian province with lifelong universal health care and relatively small socioeconomic disparities in chronic condition burden at baseline, the effect of having three or more chronic conditions on two-year survival was comparable across neighborhood income quintiles. In other words, once older adults in Ontario have two,

Table 4
Unadjusted hazard ratios for death during two-year follow-up, whole sample.

	Univariate model (n = 1,528,437)	
	HR (95% CIs)	p-value
Age in years		
65–74	Reference	–
75–84	2.88 (2.84–2.92)	<.0001
85+	8.93 (8.80–9.06)	<.0001
Sex		
Female	Reference	–
Male	1.12 (1.10–1.13)	<.0001
Neighborhood income quintile		
1st (Lowest)	Reference	–
2nd	0.85 (0.84–0.87)	<.0001
3rd	0.83 (0.82–0.85)	<.0001
4th	0.80 (0.79–0.81)	<.0001
5th (Highest)	0.75 (0.73–0.76)	<.0001
Missing income variable	1.01 (0.92–1.10)	0.8401
Chronic condition burden		
1 chronic condition	Reference	–
2 chronic conditions	1.47 (1.43–1.50)	<.0001
3 chronic conditions	2.16 (2.11–2.21)	<.0001
4 chronic conditions	3.24 (3.16–3.31)	<.0001
5+ chronic conditions	6.48 (6.35–6.62)	<.0001
Burden length	1.00 (1.00–1.00)	<.0001
Location of dwelling (%)		
Non-urban dwelling	Reference	–
Urban dwelling	0.89 (0.88–0.90)	<.0001
Missing urban variable	0.91 (0.86–0.97)	0.0046
Individual has usual provider of care		
No	Reference	–
Yes	0.70 (0.69–0.70)	<.0001

Note:
95% CIs — 95% confidence intervals.

Table 5
Adjusted hazard ratios for death during two-year follow-up, stratified by neighborhood income quintile.

	Lowest income quintile	2nd income quintile	3rd income quintile	4th income quintile	Highest income quintile
	(n = 292,574)	(n = 315,401)	(n = 298,092)	(n = 302,489)	(n = 310, 383)
	HR (95% CIs)	HR (95% CIs)	HR (95% CIs)	HR (95% CIs)	HR (95% CIs)
Age in years[a]					
65–74	Reference	Reference	Reference	Reference	Reference
75–84	2.11*** (2.05–2.18)	2.36*** (2.28–2.43)	2.59*** (2.51–2.68)	2.62*** (2.53–2.71)	2.73*** (2.64–2.83)
85 +	5.66*** (5.48–5.84)	6.60*** (6.39–6.82)	7.55*** (7.29–7.82)	7.65*** (7.38–7.92)	8.41*** (8.11–8.73)
Sex[a]					
Female	Reference	Reference	Reference	Reference	Reference
Male	1.39*** (1.36–1.42)	1.38*** (1.35–1.42)	1.32*** (1.28–1.35)	1.29*** (1.26–1.33)	1.22*** (1.19–1.26)
Location of dwelling (%)					
Non-urban	Reference	Reference	Reference	Reference	Reference
Urban	0.85*** (0.83–0.87)	0.84*** (0.82–0.87)	0.81*** (0.79–0.83)	0.81*** (0.79–0.83)	0.81*** (0.79–0.83)
Chronic condition burden					
1 chronic condition	Reference	Reference	Reference	Reference	Reference
2 chronic conditions	1.18*** (1.12–1.24)	1.27*** (1.21–1.34)	1.28*** (1.21–1.35)	1.31*** (1.23–1.38)	1.27*** (1.20–1.35)
3 chronic conditions	1.57*** (1.49–1.65)	1.62*** (1.54–1.71)	1.64*** (1.55–1.73)	1.72*** (1.62–1.82)	1.68*** (1.59–1.78)
4 chronic conditions	2.07*** (1.97–2.19)	2.10*** (1.99–2.22)	2.22*** (2.10–2.36)	2.24*** (2.11–2.38)	2.29*** (2.16–2.43)
5 + chronic conditions[a]	3.45*** (3.28–3.63)	3.70*** (3.51–3.90)	3.75*** (3.54–3.96)	3.93*** (3.72–4.16)	3.90*** (3.69–4.13)
Burden length	1.00*** (1.00–1.00)	1.00*** (1.00–1.00)	1.00*** (1.00–1.00)	1.00*** (1.00–1.00)	1.00** (1.00–1.00)
Individual has usual provider of care[a]					
No	Reference	Reference	Reference	Reference	Reference
Yes	0.75*** (0.73–0.77)	0.73*** (0.71–0.75)	0.74*** (0.72–0.76)	0.70*** (0.68–0.72)	0.69*** (0.67–0.71)

Note:
Hazard ratios adjusted for all other variables in Table 5.
95% CIs: 95% confidence intervals.
[a] Indicates variables for which the 95% confidence intervals do not overlap across all income quintiles.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.0001$.

three, four, or five-plus chronic conditions, their survival trajectories are the same, regardless of their neighborhood socioeconomic status.

5. Conclusions

In Ontario and other regions with comparable health and social systems, reducing socioeconomic disparities in older adults' survival can be achieved by minimizing inequalities in who develops chronic conditions in the first place. Internationally, introduction of universal health care for people of all ages and primary prevention of large disparities in chronic condition burden should be prioritized to achieve similar socioeconomic equality in survival with multiple chronic conditions.

Contributors

NEL, CJM, AG, SEB, and WPW developed the research question and planned the data analysis. NEL conducted the literature search, ran all statistical analyses, led interpretation of the data and wrote the first draft of the manuscript. CJM, AG, SEB, and WPW provided substantive scientific input in interpretation of the results and drafting of the manuscript.

Conflicts of interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ebiom.2015.11.018.

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