With great inequality comes great responsibility: the role of government spending on population health in the presence of changing income distributions

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Abstract

Objectives To determine the association between provincial government health and social spending and population health outcomes in Canada, separately for men and women, and account for the potential role of income inequality in modifying the association.

Methods We used data for nine Canadian provinces, 1981 to 2017. Health outcomes and demographic data are from Statistics Canada; provincial spending data are from provincial public accounts. We model the ratio of social-to-health spending (“the ratio”) on potentially avoidable mortality (PAM), life expectancy (LE), potential years of life lost (PYLL), infant mortality, and low birth weight baby incidence. We interact the ratio with the Gini coefficient to allow for income inequality modification.

Results When the Gini coefficient is equal to its average (0.294), the ratio is associated with desirable health outcomes for adult men and women. For example, among women, a 1% increase in the ratio is associated with a 0.04% decrease in PAM, a 0.05% decrease in PYLL, and a 0.002% increase in LE. When the Gini coefficient is 0.02 higher than average, the relationship between the ratio and outcomes is twice as strong as when the Gini is at its average, other than for PAM for women. Infant-related outcomes do not have a statistically significant association with the ratio.

Conclusion Overall, outcomes for men and women have similar associations with the ratio. Inequality increases the return to social spending, implying that those who benefit the most from social spending reap higher benefits during periods of higher inequality.

Résumé

Objectifs Déterminer l’association entre les dépenses sociales et de santé du gouvernement provincial et les conditions de santé de la population du Canada, séparément pour hommes et femmes, et expliquer le rôle que l’inégalité salariale pourrait jouer dans la modification de cette association.

Méthodes Nous avons utilisé les données pour neuf provinces canadiennes, de 1981 à 2017. Les conditions de santé et les données démographiques parviennent de Statistiques Canada, les données sur les dépenses provinciales parviennent de comptes publics provinciaux. Nous avons modélisé le rapport de dépenses social-à-santé (« le rapport ») sur la mortalité potentiellement évitable (MPE), l’espérance de vie (EV), les années de vie potentielles perdues (AVPP), la mortalité d’enfant et l’incidence d’un poids à la naissance faible. Nous interagissons le rapport avec le coefficient de Gini pour permettre la modification d’inégalité salariale.

Résultats Quand le coefficient de Gini est égal à sa moyenne (0,294), le rapport est associé avec des conditions de santé désirables pour hommes et femmes adultes. Par exemple, en femmes, une augmentation de 1 % dans le rapport est associé avec une réduction de 0,04 % en MPE, une réduction de 0,05 % en AVPP, et une augmentation de 0,002 % en EV. Quand le coefficient de Gini est 0,02 plus haut que la moyenne, la relation entre le rapport et les résultats est deux fois plus fort que quand le Gini est à sa moyenne, à part la MPE en femmes. Les résultats liés aux nouveau-nés n’ont pas une association statistique significative avec le rapport.

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Conclusion Globalement, les résultats pour hommes et femmes ont des associations semblables avec le rapport. L'inégalité augmente le retour aux dépenses sociales, insinuant que ceux et celles qui profitent le plus de dépenses sociales récoltent plus de bénéfices pendant des périodes de plus grande inégalité.

Keywords Health expenditures · Population health · Social determinants of health · Canada

Mots-clés Dépenses de santé · santé de la population · déterminants sociaux de la santé · Canada

Introduction

International comparisons of the performance of health care systems have shown that Canada is average in terms of health care system efficiency and health outcomes (Schneider et al. 2017; Tchouaket et al. 2012). The link between spending and outcomes is sometimes underlined to emphasize a gradient of efficiency across health care systems (Evans et al. 2001). The argument that spending on health care in some countries returns more value in terms of health outcomes, and those outcomes are attributable to some form of effective system management, is seemingly intuitive (Cylus et al. 2016). There is also a large and overwhelming body of evidence showing the importance of the social determinants of health (generally understood as the circumstances within which people lead their lives) (Lucyk and McLaren 2017), and that a potentially large, important, and malleable set of population health determinants are outside of the health care system (Bambra et al. 2010). Thus, government spending that achieves population health improvement could come from multiple sources, and attributing all gains in health to health care spending is committing an error known as “the wrong pocket problem” (McCullough 2019; Taylor et al. 2016).

Canadian and international research have shown that social spending has a higher return to population health outcomes than health spending (i.e., spending on the health care system) when considered jointly (Bradley et al. 2011, 2016; Dutton et al. 2018; Rubin et al. 2016). These publications operationalize the relative returns to health and social spending as the social-to-health spending ratio (“the ratio”), showing higher levels of the ratio are associated with better measures of mortality (e.g., life expectancy, infant mortality in the United States, cause-specific mortality) and morbidity (e.g., prevalence of obesity, asthma, self-reported activity limitation) across and within countries. Insights like this are used as justification for a Health in All Policies (HiaP) approach to policymaking, intended to circumvent the wrong pockets problem by explicitly valuing the contribution of social spending. HiaP approaches are considered critical by Canadian public health organizations and authorities (Canadian Public Health Association 2017; Canadian Public Health Association 2019; Government of Canada 2013). Research indicates that despite greater emphasis on HiaP, in Canada,

social spending has not kept pace with growth in health spending (Dutton et al. 2018).

Additionally, there are potentially important distributional considerations as spending benefits are not shared evenly across the population. An analysis of the trends in Canadian social and health spending over different age groups indicates older Canadians have disproportionately benefitted from both types of spending, such that each Canadian under age 45 would need an additional \$947 in social spending (in 2016) to equalize the ratio across age groups (Kershaw 2020). Thus, important equity differences might be concealed if the ratio is treated as homogeneous across groups.

Gender is one important axis that could play a role in the relationship between population health and public spending. For example, in the event of family dissolution, children are more likely to live with their mother, meaning health outcomes for women might have a stronger association with spending that benefits families with children (Sinha 2014). The people who would benefit most from increased social spending are those at the lowest end of the income distribution; they are the ones who use services that provinces in Canada denote as social spending, and it is not clear whether men or women benefit differentially.

Finally, the environment within which the spending occurs is likely important when determining what scenarios would call for additional spending on social services. One factor widely considered important for population health is income inequality; there have been hundreds of studies cataloging the relationship between measures of health and income inequality, complete with debate over mechanisms and relevant policy targets (Chung and Muntaner 2006; Kondo 2012; Lynch et al. 2004; Lynch et al. 2000). Generally accepted in this vast literature is that increases in income inequality are at least associated with poorer population health, such that income inequality is potentially a marker of mechanisms at play that imperil health (Coburn 2000, 2004) if not the causal agent responsible for poor health by acting on psycho-social health pathways (Wilkinson 1999). In Canada, income inequality has been increasing nationally since at least the 1990s and that has come with an expansion of the share of people working in the lowest-earning jobs (Beach 2016). Social spending is designed to mitigate the bad outcomes associated with a poor distribution of the social determinants of health, so it stands to

reason that social spending's return on investment in terms of health outcomes might be higher in the presence of relatively higher income inequality.

Our study explores the issue of gender-stratified health outcomes and their relationship with government spending, and how that relationship changes in the presence of different levels of income inequality. Our objective was to build on previous scholarship on this topic in Canada with a longer time period and gender-disaggregated models and to determine the role of income inequality in potentially modifying the relationship between public spending and health outcomes.

Methods

Data

The data for nine Canadian provinces are available for most variables below from 1981 to 2017 (a 37-year time period). Prince Edward Island and the northern territories were excluded because of insufficient data. Our data come from two main sources. Health and demographic data are from Statistics Canada; provincial spending data are from a routinely updated dataset maintained at the University of Calgary's School of Public Policy that gathers expenditure data from provincial government public accounts (Kneebone and Wilkins 2016).

Dependent variables—health outcomes

In this study, we used five dependent variables as health outcomes. These are potentially avoidable mortality (age-standardized rate per 100,000), potential years of life lost (age-standardized rate per 100,000), life expectancy at birth (in years), infant mortality (per 1000 live births), and proportion of low birth weight babies. Potentially avoidable mortality (PAM) refers to premature deaths that could potentially have been avoided through prevention or treatment; potential years of life lost (PYLL) is the difference in the number of years between age at death and expected life expectancy, defined for this indicator as age 75; life expectancy (LE) is the average number of expected years of life at birth; infant mortality (IM) corresponds to the death of a child under 1 year of age; low birth weight (LBW) babies include all births with birth weight less than 2500 g. No data on LBW babies are available for 1981 to 1990 in Newfoundland and Labrador, so we drop Newfoundland and Labrador from our LBW analysis. All of these dependent variables are reported separately for males and females.

Independent variables

The independent variable of interest is the social-to-health spending ratio. The ratio is provincial government spending on social services divided by spending on health care, as reported in the public accounts, in 2017 dollars. Our demographic controls include the percentage of people over 65 years old, the percentage of people living in a rural area, and the total population of each province. Economic controls included the unemployment rate, the median after-tax income (natural log), the after-tax Gini coefficient (an income distribution summary statistic that indicates earning inequality, the coefficient ranges from 0 to 1, with 0 representing perfect equality and 1 representing perfect inequality), and total real provincial expenditure (in billions of dollars). These variables are in line with previous research on the topic (Dutton et al. 2018). After-tax income was chosen to represent the median level of resources individuals can use to improve health. After-tax Gini coefficients were chosen to represent the distribution of post-tax income. After-tax Gini coefficients capture the distribution of income after transfers like disability and social assistance payments. Thus, after-tax Gini coefficients are related to the level of social spending, along with labour market forces and incomes earned.

A complete list of data sources for each variable is available in Table 1.

Statistical analysis

Our units of analysis are nine provinces over 37 years, 333 total observations. We built a linear regression model for every outcome variable, stratified by men and women, to measure the relationship between the ratio and our health outcomes after controlling the demographic and economic factors. We used a two-way fixed-effect model which includes controls for both (1) time-invariant province-specific factors, accounting for different norms in reporting between provinces, and (2) indicators for province-invariant time-effects, adjusting for secular trends in health. Thus, the covariance between health outcomes and spending which we report has had the impact of time and the impact of province-specific factors partialled out. These models are a standard expansion of the “fixed-effect” or “time-demeaned” models common in panel data analysis.

We are interested in the role income inequality plays in the association between the ratio and health outcomes. To allow for this relationship, we include an interaction term of the Gini coefficient and the ratio in each model to determine if the association between the ratio and health outcomes is modified by economy-wide income inequality. We center the Gini coefficient on its overall average value over our sample (approximately 0.294). In some models, the interaction term was statistically insignificant, in which case we exclude it from the

Table 1 Data sources for each variable, including Statistics Canada table number where appropriate

Variable	Data source
Potentially avoidable mortality	Statistics Canada. Table 13-10-0744-01
Life expectancy	Statistics Canada. Table 13-10-0114-01
Potential years of life lost	Statistics Canada. Table 13-10-0744-01
Infant mortality	Statistics Canada. Table 13-10-0368-01
Low birth weight	Statistics Canada. Table 13-10-0404-01
Total population (provincial)	Statistics Canada. Table 17-10-0005-01
Consumer price index	Statistics Canada. Table 36-10-0223-01
Gini coefficient	Statistics Canada. Table 11-10-0134-01
Percentage of people over 65 years old	Statistics Canada. Table 17-10-0005-01
Percentage of people living in rural area	Statistics Canada. Table 17-10-0118-01
Unemployment rate	Statistics Canada. Table 14-10-0327-01
Median income	Statistics Canada. Table 11-10-0237-01
Health expenditure	Kneebone and Wilkins, Canadian Provincial Government Budget Data. Available here: https://www.policyschool.ca/publication-category/research-data/
Social expenditure	
Total government expenditure	

final adjusted model as no effect measure modification was present. In the presence of a statistically significant interaction term, the association between the ratio and the health outcome is given as:

$$\beta_{\text{Ratio}} + \beta_{\text{Interaction}} \times \text{Gini coefficient}$$

The value β_{Ratio} indicates the relationship between the ratio and the outcome when the Gini coefficient is equal to the average. Since our Gini coefficient variable is multiplied by 100 and is centered on the mean, a value of 1 in the equation above is indicative of a Gini coefficient 0.01 units above the mean.

We report our results for both adjusted and unadjusted models. For all statistical analyses, we used Stata, version 15.

Results

Table 2 displays summary statistics for variables of interest. Health spending exhibits much wider variation than social spending over time with a higher mean value. At no point is social spending (range 0.49 to 1.67 thousand dollars per capita) higher than health spending (range 1.72 to 6.07 thousand dollars per capita), meaning the ratio is always below 1. Figure 1's first panel shows health spending has consistently increased while social spending has remained relatively flat over time, despite provincial variation. Figure 1's second

panel shows the ratio trending down overall with more substantial variation than either health or social spending as denoted by coefficients of variation.

For each health outcome, men have a less desirable mean and greater variation than women, with the sole exception being the proportion of LBW babies. Men have higher PAM than women (387 versus 208 age-standardized rate per 100,000), higher PYLL (6331 versus 3401 age-standardized rate per 100,000), and lower LE (75.9 versus 81.5 years at birth). IM is higher for baby boys (6.9 versus 5.6 per 1000 live births) but LBW baby boys are less prevalent (5.35% versus 6.09%).

Figure 2's left panel displays the Gini coefficient over time for all provinces. The Gini coefficient was lower at the beginning of our analytical period, with most provinces crossing or above the overall average Gini coefficient (0.294) by the year 2000. After 2003, the Gini coefficients for the provinces diverge from their previously common trend, leading to the S-shaped median spline curve. Some provinces (like New Brunswick and Quebec) returned to earlier levels. Other provinces, like Ontario, Alberta, and British Columbia, maintained their high levels until recently when we observe a general trend back down. Using these data as a guide, we interpret a high Gini coefficient as approximately 0.32, or the 80th percentile of the Gini coefficient after the year 2005. We interpret a low Gini coefficient as 0.28, or the 20th percentile of the Gini coefficient before the year 1999.

The right panel shows a scatter plot of the ratio versus the Gini coefficient. There is a wide variation around the line of best fit, but there is a general downwards trend in the ratio as the Gini coefficient rises in most provinces. New Brunswick and Quebec, provinces that between them exhibit a single observation of the Gini coefficient greater than 0.30, have positive correlations between the ratio and Gini coefficient.

Tables 3 and 4 display our main regression results. We take the natural log of the ratio and our outcome variables, so our coefficients are interpretable as percent changes in the outcome variable given a 1% change in the ratio.

A higher ratio is associated with more desirable outcomes for all three of our non-infant outcomes, and the association between the ratio and outcome becomes stronger at higher levels of inequality. A higher ratio is associated with lower PAM (approximately 0.04% lower for men and women). For women, if the Gini coefficient is 0.01 units higher than average, the ratio is associated with an additional 0.017% decrease in PAM; for men, that additional decrease is 0.033%. Similarly, the ratio is positively associated with LE for both men and women, with that relationship increasing with the Gini coefficient substantially versus the average in both cases. A 1% increase

Table 2 Summary statistics for all variables: mean, standard deviation, and range, including relevant units

Variable	Mean value $\pm$ SD (range)	
Real health spending per capita in 2017 dollars, \$000	3.43 $\pm$ 0.87 (1.72–6.07)	
Real social spending per capita in 2017 dollars, \$000	1.04 $\pm$ 0.23 (0.49–1.67)	
Ratio of social-to-health spending	0.32 $\pm$ 0.09 (0.14–0.61)	
Gini coefficient of after-tax income	0.29 $\pm$ 0.02 (0.26–0.34)	
Percentage of people over 65 years old	0.13 $\pm$ 0.02 (0.07–0.20)	
Percentage of people living in rural area	0.30 $\pm$ 0.12 (0.13–0.51)	
Unemployment rate	9.20 $\pm$ 3.63 (3.50–20.20)	
Median after-tax income, \$	49,297.60 $\pm$ 6916.35 (39300–74,200)	
Real total government spending in 2017 dollars, \$billion	22.03 $\pm$ 27.19 (1.70–154.27)	
Total population, million	3.36 $\pm$ 3.62 (0.51–14.07)	
	Men	Women
Potentially avoidable mortality, age-standardized rate per 100,000	387.47 $\pm$ 102.84 (202.30–642.80)	208.26 $\pm$ 38.15 (132.40–303.90)
Life expectancy at birth, in years	75.91 $\pm$ 2.34 (70.90–80.60)	81.45 $\pm$ 1.40 (78.50–84.70)
Potential years of life lost, age-standardized rate per 100,000	6331.64 $\pm$ 1599.53 (3043.20–10,892.10)	3401.26 $\pm$ 641.85 (2146.00–5322.50)
Infant mortality rate, per 1000 live births	6.94 $\pm$ 2.26 (2.60–15.10)	5.62 $\pm$ 1.70 (1.20–11.40)
Proportion of low birth weight babies, %	5.35 $\pm$ 0.47 (4.10–6.90)	6.09 $\pm$ 0.58 (4.90–7.70)

Health outcomes stratified for men and women

in the ratio has a small association with LE for both men and women (0.006% and 0.002%), but these estimates

increase by approximately 50% each with an additional 0.01 unit increase in the Gini coefficient. PYLL decreases

Note: "CV" denotes Coefficient of Variation.

Fig. 1 Health spending, social spending, and the ratio of social-to-health spending trends in Canada (and by province) over time. Left panel: health (gold lines) and social (blue lines) spending per capita in thousands of

2017 dollars for each province over time, national average in bold. Right panel: the ratio of social-to-health spending for each province over time, national average in bold

Fig. 2 The Gini coefficient over time for each province and its relationship to the social-to-health spending ratio. Left panel: the Gini coefficient by province over time, line of best fit is a median spline.

Right panel: the social-to-health spending ratio over the Gini coefficient, line of best fit is a simple regression line

with increasing levels of the ratio for both genders, but that relationship is only evident for men with higher than average levels of the Gini. For each 0.01 increase in the Gini coefficient, the ratio is associated with an additional decrease in PYLL of approximately 0.03% for men and women. Figure 3 plots the marginal effect of the relationship between the ratio and these three outcome variables changes for men and women in the presence of previously defined high and low Gini coefficients. As shown by the regression coefficients, the relationship between health outcomes and the ratio is stronger (a steeper slope on the graphs) with a higher Gini coefficient.

The ratio is not associated with infant-related outcomes, either IM or LBW, for baby boys or girls.

Discussion

Overall, the ratio is relevant to changes in our non-infant health outcome variables. Population health outcomes are better when provinces have higher levels of the ratio; mortality outcomes improve further in the presence of higher than average income inequality as measured by the Gini coefficient. The irrelevance of the ratio with respect to infant-specific outcomes is also shown in a previous Canadian study

(Dutton et al. 2018). Some evidence suggests that outcomes like infant mortality are more related to the health care system than to social spending (Chung and Muntaner 2006). This implies our results are driven by mortality outcomes experienced by adults.

Men, on average, exhibit stronger associations between health and the ratio in the face of increasing income inequality (Fig. 3). This implies that, historically, the average man has been more at risk of health outcomes that could be mitigated by social spending. One example of how this gendered difference is realized could be in risk of homelessness. Men make up the majority of people who use emergency shelters (Segaert et al. 2017); it is possible that prevailing societal norms which result in these individuals having little social support to maintain housing in emergency situations can be mitigated by government action (e.g., higher social assistance payments).

The ratio has decreased over time in most provinces, driven by steady increases in health spending. At the same time, Gini coefficients have trended upwards in most provinces. There is a large literature on the weak evidence supporting income inequality itself as the main causal mechanism for health outcome variation (Deaton 2013; Lynch et al. 2004). The issue of cause is relevant to mention here, since if income inequality itself were a health

Table 3 Linear regression results (unadjusted and adjusted) for two-way fixed effect (province and year) models of women's health outcomes

Variables	PAM		LE		PYLL		IM		LBW	
	Unadjusted model	Adjusted model	Unadjusted model	Adjusted model	Unadjusted model	Adjusted model	Unadjusted model	Adjusted model	Unadjusted model	Adjusted model
Ratio of social-to-health spending, real \$	-0.020 (-0.049, 0.008)	-0.040* (-0.062, -0.018)	0.001 (-0.002, 0.003)	-0.017 (-0.053, 0.018)	-0.049* (-0.080, -0.019)	0.012 (-0.088, 0.112)	-0.026 (-0.127, 0.076)	0.009 (-0.026, 0.043)	0.025 (-0.011, 0.061)	
S/H ratio*Gini coefficient										
Gini coefficient of after-tax income	-0.017* (-0.025, -0.010)	-0.033, -0.000 (-0.040, 0.001)	0.002* (0.000, 0.003)	-0.014* (-0.023, -0.004)	-0.029* (-0.056, -0.001)	0.009 (-0.018, 0.036)	0.002 (-0.029, 0.032)	0.007 (-0.000, 0.015)	0.006 (-0.003, 0.015)	
Age > 65 years, %	-0.023* (-0.030, -0.017)	-0.021* (-0.028, -0.015)	0.001* (0.001, 0.002)	-0.026* (-0.034, -0.018)	-0.026* (-0.036, -0.017)	-0.034* (-0.058, -0.010)	-0.036* (-0.068, -0.004)	-0.014* (-0.021, -0.006)	0.001 (-0.010, 0.012)	
Rural residence, %	0.005 (-0.001, 0.011)	0.003 (-0.002, 0.008)	-0.000 (-0.000, 0.000)	0.012* (0.005, 0.020)	0.013* (0.006, 0.020)	0.008 (-0.013, 0.030)	0.027* (0.002, 0.052)	-0.008* (-0.015, -0.002)	-0.006 (-0.013, 0.001)	
Unemployment rate, percentage points	0.005 (-0.001, 0.011)	0.007* (0.002, 0.012)	-0.000 (-0.000, 0.000)	0.008* (0.001, 0.016)	0.008* (0.001, 0.015)	0.028* (0.006, 0.049)	0.017 (-0.009, 0.042)	0.010* (0.004, 0.017)	0.010* (0.003, 0.017)	
Median after-tax income, natural log	0.554* (0.418, 0.689)	0.307* (0.176, 0.439)	-0.046* (-0.056, -0.036)	0.582* (0.408, 0.755)	0.322* (0.141, 0.503)	0.227 (-0.295, 0.749)	-0.034 (-0.677, 0.610)	0.281* (0.136, 0.426)	0.341* (0.141, 0.541)	
Real total government expenditure, \$ billions	-0.003* (-0.004, -0.002)	0.002* (0.001, 0.004)	-0.000* (-0.000, 0.000)	-0.003* (-0.004, -0.002)	0.003* (0.001, 0.005)	0.002 (-0.001, 0.005)	-0.004 (-0.012, 0.003)	0.001 (-0.000, 0.001)	-0.000 (-0.003, 0.002)	
Population, millions	-0.052* (-0.063, -0.041)	-0.086* (-0.111, -0.061)	0.005* (0.005, 0.006)	-0.050* (-0.065, -0.036)	-0.090* (-0.125, -0.055)	0.035 (-0.009, 0.078)	0.094 (-0.028, 0.216)	0.011 (-0.002, 0.023)	0.009 (-0.028, 0.045)	
Constant	5.621* (5.574, 5.668)	2.509* (1.061, 3.957)	4.371* (4.368, 4.375)	8.451* (8.393, 8.510)	4.892* (2.896, 6.889)	2.177* (2.013, 2.341)	1.704 (-5.420, 8.828)	1.826* (1.775, 1.877)	-1.759 (-3.987, 0.469)	
Observations	333	333	333	333	333	333	333	296	296	

Note: * indicates p value < 0.05. 95% confidence intervals in parentheses

PAM potentially avoidable mortality, LE life expectancy, PYLL potential years of life lost, IM infant mortality, LBW low birth weight, S/H social-to-health

Table 4 Linear regression results (unadjusted and adjusted) for two-way fixed-effect (province and year) models of men's health outcomes

Variables	PAM		LE		PYLL		IM		LBW	
	Unadjusted model	Adjusted model	Unadjusted model	Adjusted model	Unadjusted model	Adjusted model	Unadjusted model	Adjusted model	Unadjusted model	Adjusted model
Ratio of social-to-health spending, real \$	-0.016 (-0.048, 0.017)	-0.043* (-0.068, -0.018)	0.003* (0.000, 0.007)	0.006* (0.003, 0.008)	-0.003 (-0.042, 0.035)	-0.026 (-0.059, 0.007)	0.005 (-0.079, 0.088)	-0.012 (-0.097, 0.074)	-0.003 (-0.038, 0.033)	0.017 (-0.020, 0.054)
S/H ratio*Gini coefficient		-0.033* (-0.051, -0.015)		0.003* (0.001, 0.005)		-0.028* (-0.053, -0.003)				
Gini coefficient of after-tax income	-0.010* (-0.019, -0.002)	-0.031* (-0.054, -0.008)	0.001* (0.000, 0.002)	0.003* (0.000, 0.005)	-0.004 (-0.015, 0.006)	-0.018 (-0.048, 0.013)	-0.013 (-0.036, 0.010)	-0.014 (-0.040, 0.012)	0.009* (0.001, 0.017)	0.008 (-0.001, 0.017)
Age > 65 years, %	-0.030* (-0.037, -0.023)	-0.023* (-0.030, -0.015)	0.003* (0.002, 0.003)	0.002* (0.001, 0.002)	-0.030* (-0.038, -0.021)	-0.020* (-0.030, -0.010)	-0.008 (-0.028, 0.013)	0.002 (-0.025, 0.029)	-0.018* (-0.026, -0.010)	-0.007 (-0.018, 0.004)
Rural residence, %	-0.001 (-0.008, 0.006)	-0.002 (-0.008, 0.004)	-0.000 (-0.001, 0.001)	0.000 (-0.000, 0.001)	-0.000 (-0.009, 0.008)	-0.002 (-0.010, 0.006)	0.018* (-0.000, 0.036)	0.019 (-0.002, 0.040)	-0.008** (-0.015, -0.001)	-0.004 (-0.012, 0.003)
Unemployment rate, percentage points	0.008* (0.001, 0.015)	0.009* (0.003, 0.014)	-0.001 (-0.001, 0.000)	-0.001* (-0.001, -0.000)	0.006 (-0.002, 0.015)	0.006 (-0.002, 0.014)	0.010 (-0.009, 0.028)	0.008 (-0.013, 0.030)	0.006 (-0.001, 0.012)	0.002 (-0.005, 0.010)
Median after-tax income, natural log	0.660* (0.509, 0.810)	0.439* (0.291, 0.587)	-0.068* (-0.083, -0.053)	-0.052* (-0.066, -0.038)	0.736* (0.554, 0.918)	0.592* (0.394, 0.790)	0.380 (-0.056, 0.817)	0.544* (0.001, 1.086)	0.318* (0.172, 0.465)	0.288* (0.083, 0.493)
Real total government expenditure, \$ billions income, natural log	-0.002* (-0.003, -0.001)	0.004* (0.003, 0.006)	0.000* (0.000, 0.000)	-0.001* (-0.001, -0.000)	-0.002* (-0.003, -0.001)	0.007* (0.004, 0.009)	0.001 (-0.001, 0.004)	0.005 (-0.002, 0.011)	0.001 (-0.000, 0.001)	0.001 (-0.002, 0.003)
Population, millions	-0.045* (-0.058, -0.032)	-0.116* (-0.144, -0.088)	0.005* (0.004, 0.007)	0.014* (0.012, 0.017)	-0.040* (-0.056, -0.024)	-0.142* (-0.180, -0.104)	0.009 (-0.028, 0.046)	-0.031 (-0.133, 0.072)	0.011 (-0.002, 0.023)	-0.002 (-0.039, 0.035)
Constant	6.360* (6.307, 6.413)	2.034* (0.407, 3.662)	4.279* (4.273, 4.284)	4.793* (4.638, 4.948)	9.210* (9.147, 9.273)	3.244* (1.061, 5.427)	2.477* (2.339, 2.615)	-4.155 (-10.166, 1.856)	1.668* (1.616, 1.720)	-1.238 (-3.518, 1.042)
Observations	333	333	333	333	333	333	333	333	296	296

Note: * indicates p value < 0.05. 95% confidence intervals in parentheses

PAM potentially avoidable mortality, LE life expectancy, PYLL potential years of life lost, IM infant mortality, LBW low birth weight, S/H social-to-health

Fig. 3 The relationship between health outcomes and the social-to-health spending ratio (S/H ratio) in high versus low inequality settings. The blue lines are for men; the red lines are for women. The solid lines are low Gini coefficient settings (0.28); the dashed lines are high Gini coefficients settings (0.32)

risk, the government could address that directly through taxes as a redistribution mechanism. Some research on the rise of income inequality in Canada suggests that in a knowledge-based economy wages will become more unequal through a myriad of pathways, including corporate lobbying (Beach 2016), implying tax-based interventions need to become more radical to reduce Gini coefficients, which could be politically infeasible.

Targeting expenditures on social services is appealing in this scenario. After-tax Gini coefficients reflect the net result of tax-based solutions for inequality and continue to increase over time. The government can address the social determinants of health by directly spending on services that mitigate the impact of environments within which those with low income live their lives. Those with low income face low or no real growth in social spending or wages; if social spending improves health, it is intuitive we would observe larger returns to social spending with higher after-tax inequality. In other words, while income inequality is driven by many forces, weakening its association with population health outcomes might be possible through social spending.

Our results suggest that, as income inequality increases, provincial governments should direct resources to social spending. Provincial governments have done the opposite during the period we observe. Our models include overall government spending, implying that redistribution is adequate to achieve the modeled results. There have been calls for researchers and policymakers to move beyond measures of income inequality as an indicator of the macroeconomic environment since it is rooted in political dimensions (de Maio 2012), but inequality itself is routinely measured and acts as any other macro-level indicator that might correlate with an outcome we care about (Dutton and Jadidzadeh 2019). Furthermore, the gains to those at the high end of the income distribution accumulate over time (Bor et al. 2017); those left behind gain from resources directed specifically to services they use, implying that governments can account for future population health trends by redirecting spending now.

The dataset we use identifies social and health spending by function, rather than by ministry; there is no standard for what should be included as social spending categories across province or time (Kneebone and Wilkins 2016). Broadly, social services in these data are largely comprised of social

assistance payments, disability payments and programs, homelessness programs, and programs supporting families, women, or children (safety and support programs). In some cases, spending by ministry includes health spending programs for low-income benefits recipients included with social spending (e.g., drug coverage for low-income groups). These programs tend to make up a small portion (< 10%) of social spending by the ministry, and their inclusion in spending by function depends on provincial classification. Our models compare within-province trends of social-to-health spending ratios and health outcomes; differences in the definition of spending variables across provinces are adjusted by our fixed-effect term. In other words, some provinces might have higher ratios than other provinces due to how they classify social spending, but our models compare fluctuations in those ratios to fluctuations in health outcomes within provinces.

Our study has limitations. One is that we use the Gini coefficient as a measure of income inequality when other measures exist. Some research shows that the Gini coefficient between developed countries is merely indicative of welfare state or political factors (like how much is spent on social security) (Chung and Muntaner 2006). We propose that the provinces of Canada are similar in terms of political philosophy and services delivered when contrasted to differences at the country level among developed countries; thus, comparing the Gini across provinces is comparing a meaningful indicator of income inequality. Furthermore, the Gini coefficient performs similarly to other income inequality measures in the USA with similar two-way fixed-effect models to ours (Hill and Jorgenson 2018).

Conclusion

Our study suggests that men and women have similar associations between health and social spending, characterized as a ratio, and population health outcomes. Income inequality increases the return to social spending which is consistent with the idea that income inequality results in worse environments for those who benefit from the services funded through social spending. Marginal changes in social spending would be a first step to bring the ratio back to levels last seen in the early 1990s, which might benefit population health in the current high Gini coefficient environment.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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