TITLE

Does household income mediate the association between education and health in Canada?

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CONTRIBUTIONS

GV conceived of the study; GV and AVY analyzed the data; GV drafted the manuscript; GV and AVY read and approved the final draft of the manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

PUBLISHED IN THE SCANDINAVIAN JOURNAL OF PUBLIC HEALTH (2020)

ABSTRACT

OBJECTIVES: To investigate whether household income mediates the association between education and health in a nationally representative sample of Canadian adults.

METHODS: The data came from the Longitudinal and International Study of Adults linked to income data from the Canada Revenue Agency. Odds ratios and predicted probabilities from binary logistic regression models were used to describe associations between education and (i) self-rated health, (ii) longstanding illness or health problem, (iii) emotional, psychological or mental health problem and (iv) symptoms of psychological distress. The Karlson-Holm-Breen decomposition method was used to investigate the potentially mediating role of household income in these associations. The analyses were conducted separately for women and men.

RESULTS: Education was significantly associated with all four health indicators for both women and men. Of the four health indicators, education was most strongly associated with self-rated health for both women and men. Education was more strongly associated with self-rated health and the presence of an emotional, psychological or mental health problem for women than for men. Curiously, men with a postgraduate degree were significantly more likely than men with a bachelor degree to report symptoms of psychological distress. Only modest proportions of the associations between education and health could be attributed to differences in household income. Education and household income manifested independent associations with all four health indicators among women and with three of four health indicators among men.

CONCLUSION: Education and household income are joint *and* independent predictors of health in Canada. Accordingly both should be included in research on socioeconomic health inequalities in this context.

OBJECTIVES

Previous research has established the existence of associations between education and multiple indicators of health in Canada [1-5] and internationally [6-9]. Researchers have proposed three kinds of explanations for these associations. The first claims that education has a causal effect on health by way of factors such as occupation and income [10], access to valuable social networks and relationships [10], health-related knowledge and information [10], acquired cognitive skills and learned effectiveness [11] and lifestyle practices such as smoking and physical activity [12]. The second claims that the associations are artefacts of confounders such as intelligence, drive and perseverance [10], other genetic characteristics [13, 14] and childhood socioeconomic circumstances [10]. The reverse causation explanation claims that health earlier in life affects educational success later in life [10, 15].

We investigated the plausibility of the causal pathway where education affects household income which in turn affects health. We mobilized a unique dataset, the Longitudinal and International Study of Adults (LISA) linked to income data from the Canada Revenue Agency, to pursue this line of inquiry. The measures of education, general health and mental health contained in the LISA are straightforward. However, the income data provided by the Canada Revenue Agency are unprecedented in Canadian health research in their levels of validity and precision. Previous research has used self-reported income which often has sizeable amounts of missing data that may be missing not at random (MNAR) instead of missing at random (MAR) or missing completely at random (MCAR). MNAR data compromise the validity of indicators of income and the representativeness of the studies that utilize them. The Canada Revenue Agency income data allowed us to investigate the degree to which household income potentially

mediates associations between education and health in a more comprehensive way than has previously been possible in the Canadian context.

METHODS

The data came from the first two waves of the LISA collected by Statistics Canada in 2012 and 2014. The LISA was developed to provide information on labour market, education and training, skills, health and family experiences. The target population for the first wave of the LISA was all residents of Canada's ten provinces aged 15 and older excluding individuals living on reserves and other Aboriginal settlements, official representatives of foreign countries living in Canada and their families, members of religious and other communal colonies, members of the Canadian Armed Forces stationed outside of Canada, persons living fulltime in institutions and persons living in other collective dwellings. 11458 of 15907 (72.0%) randomly selected households participated in the first wave of the study. Attempts were made to survey all members of each participating household who were aged 15 and older, with a person-level response rate of 89.0%. This produced a final survey sample of 23926 respondents in the first wave of the LISA. We restricted our wave one analyses to survey respondents aged 25 or older in 2012, most of whom would have already completed their educational training, producing a working sample of more than 19000 respondents in wave one.

The second wave of the LISA included all survey respondents from wave one who were also interviewed in wave two as well as three other kinds of respondents: (i) individuals who were members of a participating household in wave one but were too young to be interviewed and have since turned 15 years of age, (ii) individuals who were adopted by a permanent member

of the LISA between waves one and two and (iii) individuals who were not members of the household in wave one but resided with a permanent member of the LISA in wave two. The person-level response rate in wave two was 66.6%. We restricted our wave two analyses to respondents aged 25 or older in 2014, producing a working sample of more than 15000 respondents in wave two. Statistics Canada's confidentiality policies when using LISA data linked to CRA income data prevent us from providing unweighted frequency distributions of the variables used in our study.

Respondent education distinguished between less than high school, high school diploma or equivalent, certificate or diploma from a technical school, community college or university, bachelor degree and postgraduate degree. Respondents also recorded the highest educational attainment of their mother or female guardian and their father or male guardian. From these we created a single variable assessing highest parental education that distinguished between less than high school, high school diploma or equivalent, certificate or diploma from a technical school, community college or university, and bachelor degree or higher. Statistics Canada used Social Insurance Numbers to link the study participants to their T1 Family File income tax data from 2011 for wave one and 2013 for wave two. The T1 Family File is a databank of all Canadian tax filers grouped into families that includes income data, both personal and family, before and after taxation. Missing income values were imputed by Statistics Canada using the nearest neighbour method; less than 5% of respondents in waves one and two required imputation of income data.

Two of the dependent variables, self-rated health and the presence of a longstanding health issue or problem, were assessed in wave one. Respondents were asked 'In general, would you say your health is excellent, very good, good, fair or poor?' and 'Do you have any

longstanding illnesses or longstanding health problems that have lasted or are expected to last for 6 months or more?' The other two dependent variables focused on mental health and were assessed in wave two only. Respondents were asked 'Do you have any emotional, psychological or mental health conditions? These may include anxiety, depression, bipolar disorder, substance abuse, anorexia, as well as other conditions.' These conditions may not have been diagnosed as such by a health professional as the respondents were not asked about this issue. Respondents were also asked the ten questions that comprise the Kessler Psychological Distress Scale [16]. We dichotomized the Kessler scale variable at 20 for use in binary logistic regression models.

We executed two binary logistic regression models on each health indicator. The first model included respondent education, age, marital status, immigrant status and parental education while the second model additionally included household income. The models were executed separately for women and men. These models allowed us to assess the nature of the relationship between respondent education and a health indicator controlling for potentially confounding factors (age, marital status, immigrant status and parental education) and then investigate household income as a potentially mediating factor. We conducted post hoc Wald tests (Stata command *testparm*) to determine whether respondent education made statistically significant contributions to the models and generated predicted probabilities of the outcomes for each education category (Stata command *margins*) to complement the odds ratios produced by the logistic regression models. Finally, we applied the Karlson-Holm-Breen method (Stata command *khb*) of decomposing effects in non-linear probability models [17] to investigate the possibility that household income mediates associations between respondent education and health. This method addresses the problem of residual variance in logit models wherein changes in regression coefficients across nested models can reflect changes in the scaling of the

dependent variable rather than mediation or confounding [18]. The models for self-rated health and a longstanding illness or health problem were applied to wave one data whereas the models for an emotional, psychological or mental health problem and the Kessler psychological distress scale were applied to wave two data.

We applied listwise deletion to address the small amounts of missing data evident in our samples (approximately 3.5% in each wave). To account for the complex sampling design of the LISA, we applied the wave-specific responding person weight and 1,000 bootstrap weights provided by Statistics Canada to produce trustworthy point estimates and standard errors, respectively, for the odds ratios generated by the regression models. All statistical analyses were conducted in Stata 16. The study was approved by the Behavioural Research Board at the University of British Columbia.

RESULTS

Self-rated health

The models predicting fair or poor self-rated health are summarized in Table 1. Education was strongly associated with self-rated health in the expected direction for women (p<0.001) and men (p<0.001) before controlling for household income.[1] After controlling for household income the

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[1] The odds ratios comparing the less than high school category to the postgraduate degree category were 6.39 for women and 4.87 for men (Table 1). However, odds ratios can overestimate the strength of an association when the outcome is common [19]. The corresponding relative risks (the ratios of the predicted probabilities for the least and most educated groups) were smaller at 4.99 for women and 3.77 for men but still indicative of strong associations between education and self-rated health. Risk

associations were attenuated. The Karlson-Holm-Breen decomposition method indicated that the odds ratio for less than high school compared to postgraduate degree was reduced by 14.6% (p<0.001) for women and 20.7% (p<0.001) for men. In both samples, education (p<0.001 for women and men) and household income (p<0.001 for women and men) manifested statistically significant associations with self-rated health while controlling for one another.

Longstanding illness or health problem

The models predicting the presence of a longstanding illness or health problem are summarized in Table 2. Education was modestly and negatively associated with the presence of a longstanding illness or health problem for both women (p<0.001) and men (p<0.001) before controlling for household income.[2] The Karlson-Holm-Breen decomposition method indicated that the odds ratio for less than high school compared to postgraduate degree was reduced by 18.6% (p<0.001) for women and 25.5% (p=0.001) for men after controlling for household income. In both samples, education (p<0.001 for women and p=0.020 for men) and household income (p<0.001 for women and men) manifested statistically significant associations with the presence of a longstanding illness or health problem while controlling for one another.

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differences (the difference between the predicted probabilities for the least and most educated groups) of 17.0% for women and 16.6% for men in this instance are also indicative of strong associations between education and self-rated health.

[2] The corresponding relative risks were 1.62 for women and 1.42 for men and the corresponding risk differences were 16.7% for women and 11.2% for men.

Emotional, psychological or mental health condition

The models predicting the presence of an emotional, psychological or mental health condition are summarized in Table 3. Education was strongly and negatively associated with an emotional, psychological or mental health condition for women (p<0.001) and modestly and negatively associated with an emotional, psychological or mental health condition for men (p=0.022) before controlling for household income.[3] The Karlson-Holm-Breen decomposition method indicated that the odds ratio for less than high school compared to postgraduate degree was reduced by 15.2% (p=0.024) for women and 53.7% (p=0.003) for men after controlling for household income. Education (p<0.001) and household income (p=0.008) manifested statistically significant associations with an emotional, psychological or mental health condition in the second model for women while only household income (p<0.001) was significantly associated with an emotional, psychological or mental health condition in the second model for men.

Kessler psychological distress scale

The models predicting a Kessler score of 20 or higher are summarized in Table 4. Education was strongly and negatively associated with symptoms of psychological distress for women (p<0.001). Education was strongly and (mostly) negatively associated with symptoms of psychological distress for men (p<0.001) before controlling for household income. Notably, the risk of symptoms of psychological distress was lower for men with bachelor degrees than for

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[3] The corresponding relative risks were 2.75 for women and 1.86 for men and the corresponding risk differences were 12.2% for women and 5.3% for men.

men with postgraduate degrees.[4] The Karlson-Holm-Breen decomposition method indicated that the odds ratio for less than high school compared to postgraduate degree was reduced by 28.9% (p=0.002) for women and the odds ratio for less than high school compared to bachelor degree was reduced by 26.5% (p=0.007) for men after controlling for household income. Education (p=0.001 for women and p=0.002 for men) and household income (p<0.001 for women and men) both manifested statistically significant associations with symptoms of psychological distress while controlling for one another.

DISCUSSION

Consistent with previous research in Canada [1, 2, 20-22], education was significantly associated with all four health indicators for both women and men. However, education was more strongly associated with self-rated health than with the presence of a longstanding illness or health problem, the presence of an emotional, psychological or mental health problem and symptoms of psychological distress. This may reflect the general nature of self-rated health which reflects multiple aspects of physical and mental health simultaneously. Education was also more strongly associated with both self-rated health and the presence of an emotional, psychological or mental health problem among women than among men. This is partly consistent with previous research

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[4] The relative risk comparing the less than high school category to the postgraduate degree category was 2.42 for women and the relative risk comparing the less than high school category to the bachelor degree category was 2.76 for men. The risk difference between the less than high school category and the postgraduate degree category was 12.9% for women and the risk difference between the predicted probabilities for the less than high school and bachelor degree categories was 11.6% for men.

in Canada. For example, education was more strongly associated with body mass index among women than among men in one study [21]. We hypothesize that education provides access to valuable support networks or health-related information that ameliorate stressors which are disproportionately experienced by women, such as child stress, environmental stress and family health stress [23]. That being said, the finding that education was negatively and significantly associated with psychological distress for women but not for men in another study [24] was not supported by our models within which education and psychological distress were strongly associated for both genders. Lastly, the gradient between education and mental health was askew for men in that postgraduate degree holders were significantly more likely than bachelor degree holders to report symptoms of psychological distress. This kind of "glitch in the gradient" has been reported elsewhere [25] but has not previously been documented in Canada. We hypothesize that the nature of the occupations that follow from these kinds of credentials explain the relatively high rates of psychological distress among postgraduate degree holders.

We found some evidence for the proposition that household income mediates the potentially causal association between education and health. After controlling for household income, associations between education and health were attenuated for all four health indicators. Education may influence household income by way of occupational opportunities facilitated by educational credentials [26] but also by way of educational homophily wherein higher educated Canadians tend to have higher educated and therefore higher earning spouses [27]. Household income may influence health by way of factors such as stress induced by financial insecurity, living conditions of homes and neighbourhoods and dietary practices [28]. We also found that household income explained a greater proportion of the association between education and presence of an emotional, psychological or mental health problem among men than among

women, a result that may be reflective of the close links between money, status and masculinity [29].

Lastly, we found that education and household income manifested statistically significant associations with all four indicators of health while controlling for one another. Education retained a significant association with all four dependent variables with only one exception: the association between education and an emotional, psychological or mental health problem did not persist after controlling for household income for men. Household income in turn retained a significant association with all four dependent variables for both women and men. This is also consistent with previous research. For example, one study found that education and income both remained significant predictors of self-rated health among older Canadians after controlling for factors such as financial stress, self-esteem, mastery, social support, smoking, alcohol consumption and physical activity [30]. Another study found that education and income both remained significant predictors of the Health Utility Index after controlling for risk factors such as body mass index and physical activity and access to health care [20]. Similarly, education and income were both associated with self-rated health among women after controlling for chronic stressors and sociodemographic factors in a recent study [31]. This indicates that education and household income are both relevant to socioeconomic health inequalities in Canada, and that it would be preferable to introduce them separately to statistical models so that the degree to which they are entwined as predictors of health can be discerned.

Strengths and limitations

Strengths of the current study include the nationally representative sample and multiple measures of general health and mental health. Perhaps the most noteworthy strength of the study concerns the unprecedented valid and precise measures of household income utilized in the study, indicators that typically have sizeable amounts of missing data and are less valid and precise when self-reported in surveys. Nevertheless we do not have data on informal sources of income and thus may have underestimated the incomes of respondents with lower levels of education. Other limitations of the study include the fact that the data are cross-sectional and therefore causality cannot be established. Importantly, we were able to control for some (e.g., parental education) but not all (e.g., genetic characteristics, personality characteristics, parental wealth, health in childhood) of the factors that could produce spurious associations between education and health. The longitudinal nature of the LISA might eventually allow for fixed effects modelling of the associations investigated here as a means of addressing issues of causal directionality and confounding; currently, however, the three existing waves of the LISA demonstrate insufficient change in education scores between wave one (2012) and wave three (2016) to warrant fixed effects modelling at this time. Lastly, because the LISA was not created with the explicit intent of explicating health inequalities we were not able to examine the multitude of potentially mediating factors, including health-related practices such as alcohol consumption, smoking, physical activity and dietary choices and psychosocial stressors related to social relationships and living environments, that might explain the associations between education and health uncovered in our study which were not explained by differences in household incomes.

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Table 1: Binary logistic regressions on fair or poor self-rated health (weighted and bootstrapped wave one data)

WOMEN	MODEL 1		MODEL 2	
	OR (95% CI)	*PP*	*OR (95% CI)*	*PP*
Education				
less than high school	6.39 (3.92-10.40)	0.212	5.04 (3.07-8.26)	0.197
high school diploma or equivalent	3.99 (2.47-6.46)	0.146	3.32 (2.04-5.39)	0.142
certificate or diploma from ts/cc/uni	3.41 (2.14-5.44)	0.128	2.96 (1.85-4.74)	0.129
bachelor degree	2.14 (1.29-3.54)	0.086	2.01 (1.21-3.22)	0.093
postgraduate degree (reference)	1.00	0.042	1.00	0.049
Logged household income			0.41 (0.28-0.59)	

MEN	MODEL 1		MODEL 2	
	OR (95% CI)	*PP*	*OR (95% CI)*	*PP*
Education				
less than high school	4.87 (3.20-7.41)	0.226	3.63 (2.38-5.55)	0.206
high school diploma or equivalent	2.89 (1.90-4.40)	0.152	2.36 (1.54-3.62)	0.148
certificate or diploma from ts/cc/uni	2.28 (1.54-3.39)	0.125	1.90 (1.28-2.83)	0.124
bachelor degree	1.42 (0.92-2.19)	0.082	1.31 (0.84-2.03)	0.090
postgraduate degree (reference)	1.00	0.060	1.00	0.071
Logged household income			0.33 (0.22-0.49)	

Note: Each model adjusts for age in years, age squared, marital status, immigrant status and parental education. OR = odds ratio, CI = confidence interval and PP = predicted probability.

Table 2: Binary logistic regressions on the presence of a longstanding illness or health problem (weighted and bootstrapped wave one data)

WOMEN	MODEL 1		MODEL 2	
	OR (95% CI)	*PP*	*OR (95% CI)*	*PP*
Education				
less than high school	2.20 (1.65-2.93)	0.434	1.90 (1.43-2.54)	0.420
high school diploma or equivalent	1.71 (1.31-2.22)	0.377	1.53 (1.17-1.99)	0.371
certificate or diploma from ts/cc/uni	1.62 (1.26-2.08)	0.365	1.48 (1.15-1.91)	0.365
bachelor degree	1.32 (1.01-1.73)	0.322	1.27 (0.97-1.67)	0.333
postgraduate degree (reference)	1.00	0.267	1.00	0.284
Logged household income			0.62 (0.51-0.76)	

MEN	MODEL 1		MODEL 2	
	OR (95% CI)	*PP*	*OR (95% CI)*	*PP*
Education				
less than high school	1.76 (1.35-2.29)	0.380	1.52 (1.16-2.00)	0.367
high school diploma or equivalent	1.28 (1.00-1.64)	0.315	1.16 (0.90-1.49)	0.312
certificate or diploma from ts/cc/uni	1.39 (1.10-1.76)	0.331	1.27 (1.00-1.61)	0.330
bachelor degree	1.21 (0.92-1.58)	0.303	1.16 (0.89-1.51)	0.312
postgraduate degree (reference)	1.00	0.268	1.00	0.284
Logged household income			0.62 (0.49-0.78)	

Note: Each model adjusts for age in years, age squared, marital status, immigrant status and parental education. OR = odds ratio, CI = confidence interval and PP = predicted probability.

Table 3: Binary logistic regressions on the presence of an emotional, psychological or mental health problem (weighted and bootstrapped wave two data)

WOMEN	MODEL 1		MODEL 2	
	OR (95% CI)	*PP*	*OR (95% CI)*	*PP*
Education				
less than high school	3.26 (2.02-5.26)	0.192	2.76 (1.67-4.54)	0.180
high school diploma or equivalent	2.71 (1.74-4.22)	0.166	2.40 (1.53-3.76)	0.161
certificate or diploma from ts/cc/uni	2.01 (1.31-3.07)	0.129	1.82 (1.18-2.80)	0.128
bachelor degree	1.36 (0.87-2.11)	0.092	1.31 (0.84-2.04)	0.096
postgraduate degree (reference)	1.00	0.070	1.00	0.076
Logged household income			0.56 (0.36-0.86)	

MEN	MODEL 1		MODEL 2	
	OR (95% CI)	*PP*	*OR (95% CI)*	*PP*
Education				
less than high school	2.01 (1.11-3.63)	0.115	1.42 (0.74-2.76)	0.100
high school diploma or equivalent	1.55 (0.94-2.55)	0.092	1.20 (0.73-2.00)	0.087
certificate or diploma from ts/cc/uni	1.40 (0.85-2.29)	0.084	1.15 (0.70-1.90)	0.083
bachelor degree	0.90 (0.53-1.53)	0.056	0.81 (0.48-1.38)	0.061
postgraduate degree (reference)	1.00	0.062	1.00	0.074
Logged household income			0.27 (0.15-0.49)	

Note: Each model adjusts for age in years, age squared, marital status, immigrant status and parental education. OR = odds ratio, CI = confidence interval and PP = predicted probability.

Table 4: Binary logistic regressions on a Kessler score of 20 or higher (weighted and bootstrapped wave two data)

WOMEN	MODEL 1		MODEL 2	
	OR (95% CI)	*PP*	*OR (95% CI)*	*PP*
Education				
less than high school	2.86 (1.80-4.56)	0.219	2.22 (1.37-3.61)	0.199
high school diploma or equivalent	2.02 (1.31-3.12)	0.166	1.68 (1.08-2.61)	0.159
certificate or diploma from ts/cc/uni	1.57 (1.05-2.36)	0.135	1.36 (0.90-2.06)	0.134
bachelor degree	1.22 (0.79-1.90)	0.109	1.16 (0.75-1.79)	0.116
postgraduate degree (reference)	1.00	0.091	1.00	0.102
Logged household income			0.37 (0.24-0.57)	

MEN	MODEL 1		MODEL 2	
	OR (95% CI)	*PP*	*OR (95% CI)*	*PP*
Education				
less than high school	1.83 (1.08-3.09)	0.182	1.27 (0.73-2.20)	0.158
high school diploma or equivalent	1.29 (0.82-2.05)	0.137	0.98 (0.62-1.55)	0.128
certificate or diploma from ts/cc/uni	0.94 (0.60-1.48)	0.104	0.77 (0.49-1.21)	0.104
bachelor degree (reference)	0.57 (0.34-0.93)	0.066	0.51 (0.31-0.83)	0.073
postgraduate degree	1.00	0.110	1.00	0.130
Logged household income			0.24 (0.15-0.39)	

Note: Each model adjusts for age in years, age squared, marital status, immigrant status and parental education. OR = odds ratio, CI = confidence interval and PP = predicted probability.