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Literacy and self-rated health: Analysis of the Longitudinal and International Study of Adults (LISA)

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ABSTRACT

The relationship between education and health is well-established. The empirical literature finds that individuals with higher levels of education experience lower risks of poor health outcomes compared to individuals with less education. Outstanding to this literature is the examination of a dimension of education – literacy – and its association with health. The objective of this study was to examine the relationship between literacy (reading, numeracy) and health (self-reported health). We use data from the 2012 wave of the Canadian Longitudinal International Survey of Adults (LISA). The LISA includes rich information on health, broader sociodemographic characteristics (income, age, sex, etc.) as well as information on literacy skills from the Program for International Assessment of Adult Competencies (PIAAC). Using logistic regression, we first reaffirm the association between education and self-reported health. We then find that after controlling for measures of literacy, understood as proficiency in reading and numeracy, the magnitude of effect of education on health is reduced. Skills in literacy reduce the risk of reporting poor health, but only for the older subset of respondents (ages 40–65). Our results suggest that literacy should not be understated in empirical research on education and health, and in fact serve to sharpen our understanding of how education impacts health by drawing attention to indirect pathways.

1. Introduction

The relationship between education and health is widely studied and well-established. Generally, individuals with higher levels of education experience lower risks of poor health than those with less education. Education influences health indirectly through better access to employment and, in turn, higher income (Long & Jacobsen, 2018) – a well-documented association. Yet, whereas education has been extensively researched (Miech & Shanahan, 2000; Ross & Wu, 1995), literacy has largely been ignored as a meaningful determinant of health in its own right (Smith-Greenaway, 2015). Literacy presents unique challenges to our understanding of the relationship between education and health.

The objective of this study was to examine the association between domains of functional literacy (reading and numeracy skills) and self-reported health. Employing multivariate logistic regression techniques, we first examine how education influences self-reported health, controlling for relevant sociodemographic variables. In two separate models, we subsequently adjust for two domains of functional literacy, reading and numeracy. We furthermore examine the relationship separately for respondents below the age of 40 and for respondents between the ages of 40–65, respectively. We find that domains of functional literacy explain some of the association between education and self-reported health, but only for older respondents (40–65 years of age). Overall, our results suggest that education indirectly influences self-reported health through dimensions of functional literacy.

In what follows, we present a brief review of the literature on education and literacy's respective associations with health. Following this, we present the data and the methods used in our study. We then present descriptive statistics and regression results. We close with a discussion on the findings, comments on the limitations of the study, and suggestions for future research.

2. Literature review

2.1. Education and health

Education is one of the most commonly cited social determinants of

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health (Miech, Pampel, Kim, & Rogers, 2011), with a large body of research existing on education's influence on health and health disparities (Elo & Preston, 1996; Hayward, Crimmins, Miles, & Yu Yang, 2000; Kitagawa & Hauser, 1973; Lantz, House, Mero, & Williams, 2005; Miech et al., 2011; Mirowsky & Ross, 2008; Pappas, Queen, Hadden, & Fisher, 1993; Ross & Mirowsky, 2010; Ross & Wu, 1995, 1996). The first comprehensive documentation of the association between health and education using national-level data was produced by Kitagawa and Hauser (1973). The authors examined educational differences in mortality and found that the gap is wider for younger adults. Moreover, women experienced slightly larger educational differences in mortality compared to men. More recently, Zajacova and colleagues have consistently found that health disparities follow an education gradient (Zajacova & Lawrence, 2018; Zajacova, Hummer, & Rogers, 2012). Similarly in Canada, Shahidi and colleagues have found significant absolute and relative disparities in premature and avoidable mortality between higher (i.e., post-secondary degree) and lower (i.e., less than high school diploma) educated groups over time, from 1991 to 2016 (Shahidi, Parnia & Siddiqi, 2020).

Furnée, Groot, & Maassenvandenbrink (2008) conducted the first meta-analysis on the relationship between education and health. Drawing on 40 studies, the authors found a strong association between education and health. More recently, Hamad, Elser, Tran, Rehkopf, and Goodman (2018) conducted a systemic review and meta-analysis of the education-health association by examining the influence of compulsory schooling laws (CSLs) on health. Their results suggest positive effects of education on the majority of the health outcomes studied. Similarly, the results from the meta-analysis provided further support for this association, most notably that higher educational attainment was associated with reductions in mortality, smoking and obesity (Hamad et al., 2018).

Many scholars have attempted to explain the mechanisms that underlie the association between education and health. Seminal contributions have been made by Ross and Wu (1995), as well as Mirowsky and Ross (2003). As one of the most commonly cited explanations for the education-health association (Hamad et al., 2018; Masters, Hummer, & Powers, 2012; Miech et al., 2011), Ross and Wu (1995) propose three mediating pathways. First, education is associated with work and income, two other important social determinants of health. Specifically, individuals with higher levels of education are more likely to hold full-time employment and earn higher income, than individuals with lower levels of education. Through these employment opportunities, individuals are also more likely to secure more comprehensive health insurance. Second, individuals with higher levels of education are more likely to maintain strong social capital through greater social supports and connections. And finally, individuals with higher levels of education are more likely to engage in positive, health promoting behaviours, such as greater frequency of exercise, lower smoking and more balanced diets (Mirowsky & Ross, 2003; Ross & Wu, 1995). Mirowsky, Ross and Wu further elaborated by stating that positive health habits promote self-management of health problems, while high status and better-paying jobs protect against the stresses of economic insecurity (Mirowsky & Ross, 2008; Ross & Wu, 1995).

To complement these hypotheses, scholars have proposed other ways in which education influences risk factors that subsequently affect health, such as having a lower probability of poor housing and working in hazardous environments (Masters et al., 2012). Additionally, although Ross and Wu's (1995) mediating pathways are widely accepted as explaining the indirect effect of education on health, other scholars have suggested that education also has a direct effect on health and mortality risk through knowledge and effective use of health technologies (Glied & Lleras-Muney, 2008; Phelan, Link, & Tehranifar, 2010), as well as the enhancement of cognitive skills (Baker, Leon, Greenaway, Collins, & Movit, 2011) (as cited in Masters et al., 2012).

Miech et al. (2011) argue that higher educated individuals can more readily protect themselves from new health threats, benefit from greater access to health technologies and experience more success in using conventional health practices to improve health. In turn, this privileged position influences the persistence of health disparities between higher and lower educated groups. The authors argue that because health threats are constantly changing, even when people with lower education aim to "close the gap for one [health] outcome," the higher educational group have moved on to improve the outcome for the newest health danger (Miech et al., 2011, p. 916). The argument advanced by Miech et al. (2011) aligns with fundamental causes theory (Link & Phelan, 1995). The fundamental causes of health perspective argues that the cause of persistent health inequalities is due to a "continual stream of widening and newly emergent disparities [that] counteracts the effects of any diminishing disparities" (Miech et al., 2011, p. 915). In line with Wu and Ross' approach, Link & Phelan (1995) argue that money, status, knowledge, and social connections are protective factors against health dangers. For example, belonging to a higher socioeconomic group allows individuals to benefit from changing developments in health; some scholars argue that this phenomenon is illustrated by smoking disparities that persist between socioeconomic groups (Miech, 2011; Pampel, 2005).

Finally, much of the empirical research on the association between education and health recognizes the additional variation in health inequalities by demographic variables, such as age (Lauderdale, 2001; Mirowsky & Ross, 2008; Montez & Hayward, 2014; Montez, Hummer, Hayward, Woo, & Rogers, 2011; Willson, Shuey, & Elder, 2007), race (Farmer & Ferraro, 2005; Monnat, 2014; Williams, Mohammed, Leavell, & Collins, 2010) and gender (Elo & Preston, 1996; Jemal, Ward, Anderson, Murray, & Thun, 2008; Meara, Richards, & Cutler, 2008; Ross & Mirowsky, 2010). Regarding gender, Ross and Mirowsky (2010) suggest that education's influence on health is greater for women because of their disadvantaged ascribed social status, implying relatively lower educational status for women compared to men. However, the findings on gender's influence are mixed. Matthews, Manor, and Power's (1999) findings suggest there is no gender difference in the association between education and self-rated health. Finally, while research in the US finds evidence of an education-health gradient that varies by race (Zajacova & Lawrence, 2018; Zajacova et al., 2012), others find that the effect of education on health has "diminishing returns" for non-white individuals (Farmer & Ferraro, 2005; Monnat, 2014).

2.2. *Literacy and health*

Although scholars have extensively examined the association between education and health, few studies to date have assessed how literacy influences health, independently of education (Baker, Parker, Williams, Clark, & Nurss, 1997; Long & Jacobsen, 2018). Berkman et al. (2004) define literacy as, "an individual's ability to read, write, and speak [in English] and compute and solve problems at levels of proficiency necessary to function on the job and in society, to achieve one's goals, and to develop one's knowledge and potential" (p. 43).

In the current literature, three common conceptualizations of literacy have been evaluated to varying degrees: functional literacy, health literacy, and mental health literacy (Lincoln et al., 2017). Lincoln et al. (2017) define functional literacy as, "the skills of reading, writing, numeracy, aural, and oral" (p. 122). Skills in functional literacy can be developed through educational training, but also through the workplace and broader community. The latter implies that functional literacy can be developed over time. Limited functional literacy may prevent access to health-related treatments by interfering with users' abilities to understand prescription labels, educational material, and treatment regimens. Moreover, limited functional literacy may hinder users' abilities to understand important paperwork and complete necessary forms on matters related to health and insurance claims (Baker et al., 1997; Lincoln et al., 2017).

Health literacy refers to "a set of skills that people need to function effectively in the health care environment" (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011, p. 97). This definition includes aspects of print, numeracy and oral literacy defined above but are specific to the health care environment. These skills allow individuals to access and understand health information. Examples include reading labels, understanding medical documents, communicating and speaking effectively to health care providers, and adhering to medication regimens (Berkman et al., 2004). An emerging form of health literacy relates to critical health literacy (Nutbeam, 2000; Sykes, Wills, Rowlands, & Popple, 2013). As one of the first to define the term, Nutbeam defines critical health literacy as higher order cognitive capacities for effective social, political and individual action on health. Where health literacy relates to the ability to "access, understand, appraise and apply health information" (Sykes et al., 2013, p. 2), critical health literacy involves critical appraisal of this information. Within the broader health promotion literature, critical health literacy may be viewed as social and individual empowerment towards the improvement of health. Critical health literacy therefore refers to the ability to critically analyze health information, advocate for oneself, and acheive health equity goals.

Berkman et al. (2004) consolidated the body of literature on health literacy published between 1980 and 2004 in high-income countries. Out of a total of 44 relevant articles "addressing relationships between literacy and use of health care services, health outcomes, costs of health care, and disparities according to race, ethnicity, culture, or age," they found that most of the studies included bivariate relationships between literacy and relevant outcome variables, and 28 adjusted for at least one control variable. Overall, the results were mixed, but they found a positive, significant relationship between low health literacy and smoking among adolescent boys and girls; two out of three studies found a significant relationship between low literacy and diabetes; two of four studies found a significant relationship between low literacy and poor health status in analyses of adult patients; and one study found this same relationship in elderly patients (Berkman et al., 2004).

In 2011, Berkman et al. (2011) updated and expanded their 2004 review. Evaluating 96 studies, their findings suggest that low health literacy is also associated with differential use of certain health care services (i.e., decreases in mammography and increases in hospitalizations); poor ability to take medications properly, interpret labels and health messages; and overall poor health for older adults. Berkman et al.'s (2011) results support Baker et al.'s (1997) theory that low literacy affects health indirectly through increased difficulty to understand "[health] providers' directions for their care" (Baker et al., 1997, p. 1030).

Although functional literacy and health literacy are related, the extent of overlap between the two concepts is still debated. Some scholars argue health literacy is simply general literacy within a health context (Rootman & Gordon-El-Bihbety, 2008). We are rather in agreement with Prins and Monnat (2019) who state that health literacy and functional literacy are distinct concepts and carry implications for health respectively. On the one hand, general functional literacy can influence or be influenced by broader social determinants of health, which may carry long-term consequences for health. On the other, health literacy influences health decisions and behaviours over a shorter time horizon. The conflation of the two concepts limits the ability to fully understand and appreciate each concept's relationship to health, as well as than takes us away from understanding the processes at play.

While health literacy has been extensively researched, functional literacy and its association with health occupies a much smaller space in the growing research on literacy and health. Research conducted in the US finds that domains of functional literacy represent independent social determinants of health, after controlling for various sociodemographic characteristics (Prins & Monnat, 2015; Prins, Monnat, Clymer, & Toso, 2015; Prins & Mooney, 2014). This research also finds that literacy influences health disparities by race and immigration status. For example, Prins and Monnat (2015) find that although Hispanics respondents reported lower literacy scores compared to Asian respondents, both groups derived similar health benefits from literacy (numeracy and literacy). Regarding immigration status, the authors also find that both US-born and immigrants derived benefits from literacy, even though immigrants reported lower literacy scores compared to US-born respondents.

Considering numeracy more specifically, many studies have found significant associations with various domains of health. For example, numeracy skills have been found to influence medication management (Waldrop-Valverde et al., 2010), the understanding of food labels (Rothman, Housam, Weiss, Davis, et al., 2006) and the comprehension of health risks (Reyna, Nelson, Han, & Dieckmann, 2009). In some instances, it has been found that numeracy skills mediate racial disparities in medication adherence and management (Waldrop-Valverde et al., 2010).

3. Data and methods

Data in our study were from the Canadian Longitudinal and International Survey of Adults (LISA). The LISA is a nationally representative longitudinal household survey conducted by Statistics Canada every two years. This study uses the first wave of the LISA, conducted from November 2011 to June 2012. LISA data were collected using multistage stratified sampling. The survey was conducted by Statistics Canada interviewers via a Computer-Assisted Personal Interview and covered all Canadians living in the ten provinces at the time of the first wave of interviewing. People living on Indigenous reserves, official representatives of foreign countries, members of religious colonies, Canadian Armed Forces members stationed outside of Canada, and full-time residents of institutions (e.g., correctional facilities) were excluded from the survey.

This dataset is unique in that it includes administrative tax data and information on literacy skills from the Program for International Assessment of Adult Competencies (PIAAC) for a subset of respondents. The PIAAC is an international survey initiated by the Organisation for Economic Cooperation and Development (OECD) to measure respondents' literacy, numeracy and problem-solving skills. In the LISA, one member from each household between the ages of 16 and 65 was asked to complete the PIAAC assessment. Systematic sampling was used to select the LISA-PIAAC subsample. In total, 8598 LISA respondents completed the PIAAC assessment in wave one. The respondents constitute the sample of these analyses.

3.1. Measurement of literacy

We use the PIAAC proficiency scales to measure literacy and numeracy. PIAAC proficiency scales represent "degrees of proficiency in a particular aspect of the domain [of literacy]" (Tamassia & Lennon, 2013, p. 3). The PIAAC literacy items used to evaluate proficiency "were developed and selected to represent three major aspects of processing continuous and noncontinuous texts and documents: accessing and identifying, integrating and interpreting, and reflecting on and evaluating information" (Tamassia & Lennon, 2013, p. 3).

The PIAAC assessment "was based on a variant of matrix sampling" (Yamamoto, Khorramdel, & von Davier, 2013, p. 408). Respondents did not answer all the questions; instead, each respondent answered a subset from the total pool of questions. Therefore, "differences in total scores (or statistics based on them) among respondents who took different sets of items may be due to variations in difficulty in the adaptively administered test forms" (Yamamoto et al., 2013, p. 408). Ten plausible values (PVs) were drawn per respondent from an estimated distribution based on the answered subset of questions, background information of the respondents and model parameters (Situ, 2015). For the present study, the average of the 10 plausible values was taken for each respondent and represented their final literacy score. Plausible values range from 0 to 500. Numeracy scores were calculated and coded identically to literacy scores.

The scores are divided into six categories, corresponding with skill proficiency. We recoded the categories to four in line with previous studies (Long & Jacobsen, 2018). The categories of below level 1 and level 1, as well as level 4 and level 5, were respectively collapsed because of limited data. Thus, below 1 is included in level 1, and level 5 is included in level 4 (Fig. 1). Level 1 represents the lowest proficiency (numeracy) score, while Level 4 represents the higher score.

3.2. Measurement of self-reported health

The dependent variable of interest was self-reported health from the LISA. In line with previous studies, the measurement of self-reported health was based on a 5-point scale that we dichotomized into positive self-reported health (good/very good/excellent) and negative self-rated health (fair/poor) (Long & Jacobsen, 2018).

3.3. Education

Respondents' level of education was measured using a 14-point scale. We collapsed the scale into four categories to capture the respondent's level of education: less than high school diploma (no formal education, less than high school diploma); high school diploma (high school diploma or equivalent); below bachelor's degree (non-university certificate or diploma from a college, school of nursing, or technical institute, trade/vocational certificates, apprenticeship certificates, CEGEP diploma or certificates, university transfer programs, and university certificate or diploma programs below bachelor's degree); and bachelor's degree or higher (first professional degree, Master's, Ph.D.).

3.4. Covariates

In line with previous research, we adjusted for demographic variables (Long & Jacobsen, 2018). We dichotomized the age variable into two categories: participants under 40 years of age, and participants aged 40 to 65. The age of 40 was chosen as the cut off age because of noticeable changes in health and health behaviour that occur at this time, including increases in rates of chronic disease and more frequent visits to doctors (Prasad, Sung, & Aggarwal, 2012). The dichotomized age variable was used to group our age stratified analyses. Income was based on total after tax 2011 income and coded into 10,000 dollar increments. Other variables include sex, employment status and immigration (born in Canada versus outside of Canada). We were not able to examine the associations between education, literacy and race because the 2012 cycle of the LISA did not include measures of race, ethnicity or indicators of visible minority status (Statistics Canada, 2011).

4. Statistical analyses

We estimate the associations between literacy and health using logistic regression techniques. The following models were run sequentially. The first model included only level of education and the control variables. In the second model, we adjusted for literacy-level variables. In the third model, we adjusted for numeracy-level variables. Numeracy and literacy are almost perfectly correlated and were therefore included in separate models to avoid collinearity. Finally, we ran age stratified analyses for the three aforementioned models. All analyses were weighted and bootstrapped. All analyses were done using Stata (StataCorp, College Station, Texas, US).

Level 1	>=225
Level 2	226- 275
Level 3	276-325
Level 4	<=326

Fig. 1. PIAAC literacy and numeracy proficiency scores.

5. Results

5.1. Descriptive statistics

The mean PIAAC literacy and numeracy scores for each level, as well as the overall PIAAC literacy and numeracy scores by educational attainment and self-reported health are presented in Table 1. For both literacy and numeracy scores, a social gradient is already apparent: individuals in higher educational groups report a higher literacy and numeracy scores. In addition, we also observe higher literacy and numeracy scores for individuals who report better self-reported health.

In descriptive results not shown here, weighted mean ages of respondents by PIAAC literacy level were 44.5 (level 1), 41.8 (level 2), 39.4 (level 3), and 37.6 (level 4), suggesting an inverse relationship between age and literacy levels. All means were statistically different. The proportions of male and female was almost identical across all literacy levels and self-assessed health. There was a slightly higher percent of females (8.08%) in level 1 than males (7.74%) and also a slightly higher percent of males (6.80%) in level 4 than females (5.56%). In total, only 15.8% of the total sample were at level 1, and only 12.4% were at the highest level (level 4). The majority of participants were in level 2 (32.8%) and level 3 (39.1%).

5.2. Poor self-reported health among respondents under 40 years of age

In this section, we report results from the multivariate logistic regression models. We present three models that are age stratified for

Table 1
Respective mean literacy and numeracy scores in PIAAC respondents from the LISA (2012).

Variables	Mean	Std. Err.	[95% Conf. Interval]	
	Literacy Scores			
PIAAC levels				
Level 1	194.0	1.0	192.0	196.0
Level 2	251.7	0.3	251.0	252.4
Level 3	298.3	0.3	297.7	298.9
Level 4	341.6	0.5	340.5	342.7
Self-assessed health				
Positive self-rated health	275.4	0.6	274.2	276.6
Negative self-rated health	247.6	2.2	243.2	252.0
Educational attainment				
Less than high school diploma	230.0	1.7	226.7	233.3
High school diploma	266.3	1.2	264.0	268.7
Below bachelor's degree	275.3	0.9	273.5	277.1
Bachelor's degree or higher	301.4	1.1	299.3	303.6
	Numeracy Scores			
PIAAC levels				
Level 1	190.1	0.9	188.2	191.9
Level 2	251.8	0.3	251.2	252.4
Level 3	297.6	0.3	297.0	298.2
Level 4	344.6	0.7	343.3	345.9
Self-assessed health				
Positive self-rated health	267.4	0.7	266.1	268.7
Negative self-rated health	235.1	2.4	230.3	239.8
Educational attainment				
Less than high school diploma	217.7	1.9	214.0	221.4
High school diploma	256.1	1.4	253.5	258.8
Below bachelor's degree	267.6	1.0	265.6	269.5
Bachelor's degree or higher	296.3	1.2	293.9	298.6

the two age samples: under 40 (Table 2) and 40 to 65 (Table 3). The models reflect the influence of education on poor self-reported health (Model 1), the influence of literacy (Model 2), and the influence of numeracy (Model 3). In all models, the lowest literacy and numeracy category was the reference group (level 1).

In Model 1 (Table 2), respondents under 40 with a bachelor's degree or higher (OR: 0.289) had lower odds of reporting poor health compared to those with less than a high school diploma. Respondents with a high school diploma or below a bachelor's degree did not reach statistical significance. In the same model (Model 1), the odds of reporting poor health increased with age (OR: 1.047), while being employed (OR: 0.623) decreased the odds of reporting health as poor. Females (OR: 1.608) experienced higher odds of reporting poor self-rated health than males. Interestingly, income and being born in Canada had marginal effects on self-reported health and were non-significant.

When adjusting for PIAAC literacy-levels (Model 2, Table 2), the odds of reporting poor health remained insignificant for all education levels except bachelor's degree or higher, which remained relatively stable from Model 1 (OR: 0.269). Turning to the coefficients on the literacy scores, while respondents at level 3 and level 4, surprisingly, had slightly higher odds of reporting poor health than those at level 1, all levels failed to reach statistical significance.

In Model 3 (Table 2), we adjusted for numeracy levels. Although the odds of poor health slightly increased for respondents with a high school diploma, and below a bachelor's degree compared to those with less than a high school diploma, they remained insignificant. Conversely, the odds of poor health for respondents with a bachelor's degree and higher (OR: 0.317) remained significant and experienced a slight increase when adjusting for numeracy (+0.028). When comparing Model 3 to Model 1, adjusting for numeracy skills leads to a reduction in the education advantage on health for this group (71% lower odds to 68% lower odds). When examining each numeracy level, all levels failed to reach statistical significance. Age (OR: 1.045) and gender (OR: 1.578) remained significant, and the odds of reporting poor health for these variables changed minimally across all models (Models 1–3, Table 2).

Table 2
Logistic regression of poor self-rated health outcomes of PIAAC respondents under 40 years of age.

Variables	Model 1	Model 2	Model 3
Education (reference: less than high school diploma)			
High school diploma	1.001	0.977	1.035
(C.I.)	(0.627–1.598)	(0.609–1.568)	(0.644–1.664)
Below bachelor's degree	0.664	0.642	0.693
(C.I.)	(0.407–1.084)	(0.378–1.090)	(0.410–1.172)
Bachelor's degree and higher	0.289***	0.269***	0.317***
(C.I.)	(0.157–0.533)	(0.143–0.505)	(0.168–0.598)
Employed	0.623*	0.626*	0.619*
(C.I.)	(0.411–0.946)	(0.413–0.950)	(0.409–0.937)
Born in Canada	0.936	0.92	0.949
(C.I.)	(0.600–1.459)	(0.585–1.447)	(0.601–1.500)
Female	1.608**	1.615**	1.578*
(C.I.)	(1.127–2.295)	(1.129–2.309)	(1.098–2.270)
Income1	0.907	0.903	0.912
(C.I.)	(0.808–1.017)	(0.805–1.012)	(0.814–1.021)
age	1.047**	1.048**	1.045**
(C.I.)	(1.017–1.078)	(1.019–1.079)	(1.015–1.076)
Literacy levels (reference: level 1)			
Level 2		0.909	
(C.I.)		(0.549–1.505)	
Level 3		1.078	
(C.I.)		(0.639–1.819)	
Level 4		1.102	
(C.I.)		(0.541–2.243)	
Numeracy levels (reference: level 1)			
Level 2			1.02
(C.I.)			(0.640–1.623)
Level 3			0.903
(C.I.)			(0.550–1.481)
Level 4			0.802
(C.I.)			(0.358–1.797)
_cons	0.043***	0.043***	0.046***
(C.I.)	(0.019–0.097)	(0.018–0.101)	(0.020–0.106)

Note: *p < 0.05; **p < 0.01; ***p < 0.001, [1] income measured in 10,000 increments, Dependent variable: Poor self-rated health, (C.I.): 95% Confidence Interval.

Table 3
Logistic regression of poor self-rated health outcomes of PIAAC respondents aged 40 to 65.

Variables	Model 1	Model 2	Model 3
Education (reference: less than high school diploma)			
High school diploma	0.465***	0.554***	0.556***
(C.I.)	(0.339–0.637)	(0.401–0.764)	(0.403–0.768)
Below bachelor's degree	0.518***	0.643**	0.661**
(C.I.)	(0.396–0.679)	(0.481–0.859)	(0.497–0.879)
Bachelor's degree and higher	0.293***	0.403***	0.444***
(C.I.)	(0.202–0.426)	(0.268–0.606)	(0.295–0.668)
Employed	0.246***	0.246***	0.254***
(C.I.)	(0.189–0.319)	(0.190–0.320)	(0.196–0.329)
Born in Canada	0.778	0.88	0.879
(C.I.)	(0.590–1.026)	(0.666–1.162)	(0.665–1.162)
Female	0.582***	0.588***	0.554***
(C.I.)	(0.467–0.725)	(0.473–0.731)	(0.443–0.693)
Income1	0.880***	0.894***	0.897***
(C.I.)	(0.996–1.028)	(0.848–0.942)	(0.852–0.945)
age	1.012	1.011	1.011
(C.I.)	(0.458–3.065)	(0.995–1.027)	(0.995–1.027)
Literacy levels (reference: level 1)			
Level 2		0.755*	
(C.I.)		(0.578–0.985)	
Level 3		0.502***	
(C.I.)		(0.367–0.687)	
Level 4		0.602	
(C.I.)		(0.348–1.043)	
Numeracy levels (reference: level 1)			
Level 2			0.690**
(C.I.)			(0.533–0.894)
Level 3			0.503***
(C.I.)			(0.366–0.693)
Level 4			0.373**
(C.I.)			(0.196–0.709)
_cons	1.185	1.288	1.264
(C.I.)	(0.458–3.065)	(0.496–3.343)	(0.489–3.267)

Note: *p < 0.05; **p < 0.01; ***p < 0.001, [1] income measured in 10,000 increments, Dependent variable: Poor self-rated health, (C.I.): 95% Confidence Interval.

5.3. Poor self-reported health among respondents aged 40 to 65

In Model 1 (Table 3), for respondents 40–65 years of age, all respondents with at least a high school diploma or higher (OR: 0.465 [high school diploma], 0.518 [below bahcelor's degree], 0.293 [bachelor's degree or higher]) had significantly lower odds of reporting poor health than those with less than a high school diploma, thus revealing a clear education-health gradient. As expected, respondents with the highest level of education – a bachelor's degree or higher (OR: 0.293) – had the lowest odds of reporting poor health compared to those with the lowest level of education (less than a high school diploma). The odds of reporting poor health decreased with additional income (OR: 0.880). Although the odds of reporting poor health were lower for individuals born in Canada compared to those born outside of Canada, like with the under 40 respondents, these results did not reach statistical significance. Being employed (0.246) and female (0.582) lowered the odds of reporting poor health compared to being unemployed and male, respectively. Of interest, older age group, the effect of employment and female both lower the odds of poor health when comparing to the young age group. Age was not significant.

After adjusting for PIAAC literacy-level variables (Model 2, Table 3), the odds of reporting poor health significantly increased for all levels of education. This implies that adjustment for functional literacy explains part of the education-health gradient for older adults. Respondents with a level 2 (OR: 0.755) literacy level had lower odds of reporting poor health than those at level 1, while respondents at level 3 (OR: 0.502) had even lower odds. Surprisingly, while respondents with a level 4 (OR: 0.602) literacy level had lower odds of reporting poor health than level 1, the difference was not as large as between level 3 and level 1, nor was it statistically significant (though at the 10% significance level). Thus, the higher the level of literacy, the lower the odds of reporting poor health – with the exception of level 4, which was not significant. The odds of reporting poor health for the employed (OR: 0.246) remained unchanged from Model 1, and there was only a marginal increase in magnitude (+0.006) in odds of reporting poor health for females (0.588) after adjusting for literacy.

When we adjusted for numeracy-level variables (Model 3, Table 3), the increase in odds of for poor health for respondents with at least a high school diploma or higher compared to those with less than a high school diploma was slightly larger for numeracy than for literacy. Similar to Model 2, respondents with the highest level of education – bachelor's degree or higher (OR: 0.444) – experienced the lowest odds of reporting poor self-reported health compared to those with less than a high school diploma. Employment (OR: 0.254), gender (OR: 0.544) and income (OR: 0.897) remained significant and experienced marginal changes in odds of reporting poor self-reported health. Examining numeracy, all levels reached statistical significance. Compared to level 1, the odds of reporting poor health were lowest for those with the highest level of numeracy proficiency – level 4 (OR:0.373). This implies that as levels of numeracy skills increased, there was a decrease in the odds of poor self-reported health.

6. Discussion

In this study, we examined the association between dimensions of education, literacy and self-reported health. As a first step, our analyses reaffirmed the education-health gradient: respondents with higher levels of education (bachelor's degree and higher) were less likely to report poor health compared to respondents with less education (less than high school). In a subsequent step, when adjusting for literacy, we find evidence of a reduction in the education-health gradient, providing evidence of a mediating effect from literacy. In addition, similar to Long and Jacobsen's findings (2018), we found a significant relationship between literacy and health, independent of education we find evidence of a reduction in the education-health gradient, providing evidence of a mediating effect from literacy. However, these findings were only significant for our older sub-sample, namely respondents aged 40 to 65. For this group of respondents, the findings indicated that as literacy and numeracy proficiency increased, the odds of reporting poor health decreased.

The observed decrease in the effect of education on health after adjustment for functional literacy provides insight into underlying explanatory mechanisms. Interestingly, numeracy represented a slightly stronger relationship to self-reported health than literacy. This could partly be due to numeracy's association with accessing and effectively using health services. Chen and Feeley (2014) suggest that "the pervasiveness and intricacy of numerical health information place demands on individuals' health numeracy, the ability to understand and use numbers in a health information context" (p. 843).

More generally, previous studies suggest education's influence on health can be explained by Ross and Wu's (1995) three mediating variables – better jobs and earnings, greater social support, and better health habits. And yet, our results suggest that dimensions of functional literacy likely represent unique challenges that would not be fully explained by these factors – specifically, they reflect a potential challenge to the access and effective use of health care. Although indicators for all of Ross and Wu's (1995) mediating variables were not available in the LISA/PIAAC, this is a potential point of interest for future research. Would the association between literacy and self-reported health be fully explained by certain jobs, greater social support, and positive health habits, or is literacy proficiency fundamental to health in ways that are not captured by Ross and Wu's (1995) theory?

Numeracy and literacy could also be affecting health indirectly through employment and income. In a report published by the National Research and Development Centre for adult Literacy and Numeracy (NRDC), Parsons and Bynner (2005) looked at the effect of low literacy and numeracy on employment. Although they found no difference in effect for low literacy and low numeracy for men, they found a substantial difference for women (Parsons & Bynner, 2005). For women, low numeracy had a greater negative effect on employment than low literacy – even when it was combined with competent literacy. Parsons and Bynner (2005) suggest this is a result of the nature of female-centric employment that require numeracy skills, making it a fundamental skill for employment.

It is interesting to find that literacy plays a more important role for older individuals. Numeracy and literacy proficiency has the potential to decline over time. However, the frequency at which these skills are used – whether at work or outside of work – contribute to the potential for ongoing learning and further development of these skills (Long & Jacobsen, 2018). Thus, while highly related to education, literacy presents unique challenges not captured by educational attainment as they may change over time. A likely explanation for the differences in ages could be that as people age, they are more likely to report poor health because of "chronic disease and activity limitation" (Long & Jacobsen, 2018, p. 30). In turn, literacy and numeracy become more important as protective factors against poor health as people age because health literacy – which functional literacy and numeracy are both components of (Berkman et al., 2011) – is necessary for navigating health care (Kickbusch, Pelikan, Apfel, & Tsouros, 2013).

Finally, we comment on some of the other associations of interest between self-reported health and our covariates. The findings that employment is associated with lower odds of reporting poor health compared to being unemployed is in line with previous studies (Kessler, House, & Turner, 1987; Long & Jacobsen, 2018; Ross & Mirowsky, 1995). Moreover, the significant association with increased income and lower odds of poor self-reported health were also consistent with previous research (Deaton & Paxson, 1998; Gunasekara, Carter, & Blakely, 2011). Additionally, in contrast to the changes in educational attainment, after respectively adjusting for literacy and numeracy-level variables, the odds of reporting low self-repoorted health for age, income, gender, and employment remained generally consistent across all models for both age samples.

The significant associations between functional literacy and self-reported health are important for several reasons. First, these findings suggest literacy and numeracy are deserving of consideration as unique determinants of self-reported health, independent from education. Second, numeracy is often neglected in literacy research, yet we find it has a stronger relationship to self-reported health than literacy. Finally, our results suggest that functional literacy may represent an underlying mechanism to explain the well established education-health gradient.

This study is not without limitations. Most notably, although the LISA is a longitudinal survey, we did not capitalize on the panel structure of the data as relevant variables were only available for wave 1 (2012). This inhibits us from making claims on the direction of a causal relationship. It is possible that poor health influences the attainment and maintenance of literacy and numeracy skills. Moreover, the PIAAC only included measures of two components of functional literacy (reading and numeracy). The inclusion of oral, aural, and writing could provide more insight to the multidimensional nature of literacy and how it influences self-rated health. Finally, the 2012 wave of the LISA does not include information on respondents' race or ethnicity.

7. Conclusion

Literacy proficiency relates to skills in reading and writing, as well as broader capabilities to process information. Literacy can be viewed as an important subset to education, often developed or sharpened through educational means and work, and may evolve over time. Our study contributes to the burgeoning literature on the association between literacy and health and complements the empirical literature on the relationship between education and health. Our findings that the effect of literacy on health varies with age warrants further theoretical and empirical attention on skills - use and development - over the life course on different domains of health. Finding that literacy and numeracy significantly influence self-reported health should encourage further research in this area as well as programs and policies that support skill acquisition in school and work.

Ethics approval

Lynda McNeil, Associate Director, Research Ethics, McGill University, confirmed that access to these data meets the criteria for exemption from ethics review as described in the TCPS Article 2.2: 'Article 2.2. Research does not require REB review when it relies exclusively on information that is: publicly available through a mechanism set out by legislation or regulation and that is protected by law'.

Declaration of competing interest

None.

Author statement (CRediT roles)

Emma MacDonald: Conceptualization; Formal analysis; Methodology; Writing - Original Draft. Emmanuelle Arpin: Validation; Writing - Review and Editing. Amélie Quesnel-Vallée: Conceptualization; Data curation; Methodology; Supervision; Validation; Writing - Review and Editing.

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