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Association of literacy and numeracy with adult health and socioeconomic outcomes

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Declaration of interest

The authors declare that they have no competing interests.

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Abstract

Literacy and numeracy are cognitive skills which are core components of human capital. Understanding the effect of literacy and numeracy on individual outcomes in adulthood can help identify long term benefits of interventions to improve these skills. Utilising a national survey in Australia, we examine the links between literacy and numeracy and adult health and socioeconomic outcomes including employment status and social capital (measured by volunteering and level of trust). To account for the potential endogeneity of literacy and numeracy and educational attainment, we develop a simultaneous equation model consisting of outcome variables, literacy and numeracy, and education. The results show that literacy and numeracy exert a positive influence on education, health, the probability of being employed, the probability of participating in voluntary work, and having high level of trust.

1 Introduction and Background

Literacy and numeracy are important skills necessary for individual socioeconomic wellbeing and for the development of a productive and cohesive society. Literacy and numeracy are cognitive skills which are core components of human capital and support development of other forms of human capital including health. Human capital influences education, labour force outcomes and social inclusion. In turn, education can influence healthy behavior which improves health, which is itself both an input to and component of human capital (Shomos and Forbes, 2014). Thus, there is an endogenous relationship between literacy and numeracy and adult health and socioeconomic outcomes.

According to Heckman, investment in early childhood education and development will build the skills necessary for future success in health and life (Heckman, 2012). The short term costs of interventions in childhood are offset by long term gains including better health outcomes, reduced need for social services, reduced crime and increased productivity (Heckman, 2012). Previous research by Cronin et al. (2015) has shown that disadvantaged Australian children are more likely to have poor literacy and numeracy skills. Following Heckman's equation, if literacy and numeracy can be improved by interventions in childhood then the cost of such interventions should be weighed against the long term benefits accrued in adulthood. A better understanding of the links between literacy and numeracy and individual outcomes in adulthood can help to identify long term benefits of interventions to improve literacy and numeracy.

There is a substantial literature on the effect of education as a proxy for human capital on health and labour force outcomes. However, the Organisation for Economic Co-operation and Development (OECD) has shown it to be a poor proxy because people with the same level of education show varying skills (Organisation for Economic Co-operation and Development (OECD), 2001). A few studies directly estimate the impact of cognitive skills on health, employment, and earnings by using literacy and numeracy measures. These studies have

demonstrated a positive association between literacy and numeracy and health and labour market outcomes, including wages and employment (Barrett, 2012; Charette and Meng, 1998; Chiswick et al., 2003; de Baldini Rocha and Ponczek, 2011; Dougherty, 2003; Shomos and Forbes, 2014).

The focus of existing studies investigating the relationships between literacy and numeracy and socioeconomic outcomes is on labour force outcomes and associated productivity growth. Whilst the most recent literature in this area recognizes the complexity of the relationship between human capital skills and labour force outcomes, this has not been considered in their econometric modelling. Furthermore, the role of literacy and numeracy in developing social capital has been neglected in adult literacy and numeracy policy and practice (Black and Falk, 2006); this neglect is of reflective the focus on labour force outcomes in the economic literature.

In this study, we model individual outcomes in adulthood associated with literacy and numeracy. We utilise the rich confidentialised unit record file (CURF) data compiled by the Australian Bureau of Statistics (ABS) from the Australian national survey Programme for the International Assessment of Adult Competencies (PIAAC) in 2011-12. Our study aims to expand on the current literature by applying structural equations modelling to estimate the complex relationships between the variables to reduce the possible bias present in existing studies. Specifically, we develop a simultaneous equation model (SEM) consisting of outcome variables (adult health and socio-economic status), literacy and numeracy, and education, to account for the potential endogeneity of literacy and numeracy and educational attainment. Additionally, we fill a gap in the literature by providing evidence on the role of literacy and numeracy in developing social capital.

The results show that literacy and numeracy exert a positive influence on education, health, the probability of being employed, the propensity for participating in voluntary work, and forging a high level of trust. There is evidence of gender heterogeneity in these effects.

2 Data and Methodology

2.1 Data

We use basic CURF data from the PIAAC survey (2011–12) conducted by ABS on behalf of the OECD. The survey was conducted throughout Australia from October 2011 to March 2012 and collected information on skills and competencies for people aged 15 to 74 years including in the domains of literacy and numeracy. In addition to literacy and numeracy measures, the survey data include a range of indicators of socioeconomic wellbeing. There are 8,600 respondents and the final sample size is 6,108 after dropping observations with missing values.[1]

2.2 Variables

To more fully reflect the potential benefits of interventions that improve literacy and numeracy, we consider the impact of literacy and numeracy on a range of outcomes including employment, health status, and the development of social capital. Employment status is described by labour force states with three categories: not participating in the labour force, unemployed, and employed. The first two categories are further combined into one due to the small sample size in the unemployed group.[2] Health status is measured by a binary indicator variable with a value of 1 if the survey participant reported 'good', 'very good', or 'excellent health'.

It has been established that social capital can facilitate co-operation, exchange and innovation in a society; therefore, it is relevant to investigate whether high literacy and numeracy skills promote the development of social capital. In this study, an individual's social capital is

[1]There are no substantial differences between the original sample and our analysis sample in the distributions of variables used in the estimation. The results are available upon request.
[2]There are 185 unemployed individuals (3%) in the sample.

measured by whether the respondent worked for a charity or volunteer organization in the last 12 months and self-reported levels of trust (Fukuyama, 1995; Inglehart, 1997; Uslaner, 2001). Levels of trust are related to a survey question asking the respondent whether they agree that 'there are only a few people that you can trust completely' (on a scale of 1 to 5 from strongly agree to strongly disagree). We derive a binary indicator variable from the responses to this question with a value of 1 for 'disagree' or 'strongly disagree', representing the presence of a high level of trust.[3]

Our key explanatory variables are literacy and numeracy. Respondents were given various tasks to assess their literacy and numeracy, generating ten plausible values (scores) on a scale ranging from 0 to 500 that measure their literacy and numeracy. There is a strong and positive correlation between literacy and numeracy skills, which induces collinearity issues;[4] therefore, one standardised variable of the average of literacy and numeracy test scores is created to account for both skills. As this variable is a measure of both literacy and numeracy, the effects of these two skills on the outcome variables cannot be identified separately.

Two categories are used for the highest educational attainment: (1) school only, up to Year 12, and (2) tertiary education, including certificate, diploma, and bachelor degree or higher.

Additionally, age, gender, marital status (living with a partner or not), country of birth (Australia, other English-speaking countries, and others), age of youngest children (no children, 0-14 years, 15-24 years, and 25 years or above) are also included. The variable names and definitions used in this paper are summarised in Table 1, along with their mean and standard deviation (for continuous variables).

[3] 0 for answers of 'strongly agree', 'agree', and 'neither agree or disagree'.
[4]The correlation coefficient between literacy and numeracy scores for all observations is 0.92.

Table 1: Definitions of variables and descriptive statistics

Variable	Description	Mean	SD.
Dependent variable			
Employed	=1 if employed; =0 not in the labour force or unemployed	0.722	
Good health	=1 if self-reported 'good', 'very good' or 'excellent' health; =0 if self-reported 'poor' or 'fair' health	0.845	
Tertiary education	=1 if obtained certificate, diploma, or bachelor degree or above; =0 if Year 12 or below	0.585	
Participation in voluntary work	=1 if work for a charity or volunteer organization in the last 12 months; =0 otherwise	0.431	
High level of trust	=1 if have a high level of trust; =0 otherwise	0.249	
Independent variable			
Literacy and numeracy skills	The standardised value of the average of literacy and numeracy test scores	0.000	(1.000)
Age			
Age 15-24	=1 if age is between 15 and 24; =0 otherwise	0.111	
Age 25-34	=1 if age is between 25 and 34; =0 otherwise	0.166	
Age 35-44	=1 if age is between 35 and 44; =0 otherwise	0.205	
Age 45-54	=1 if age is between 45 and 54; =0 otherwise	0.184	
Age 55-64	=1 if age is between 55 and 64; =0 otherwise	0.193	
Age 65 and above	=1 if age is between 65 and above; =0 otherwise	0.141	
Male	=1 male; =0 female	0.468	
Country of birth			
Australia	=1 if born in Australia	0.728	
English speaking	=1 if born in main English speaking country (not Australia)	0.120	
Others	=1 if born in non-English speaking country	0.152	
Married	=1 if living with spouse or partner	0.575	
Age of the youngest children			
No children	=1 if no children	0.379	
0-14 years	=1 if the age of the youngest children is between 0-14 years	0.250	
15-24 years	=1 if the age of the youngest children is between 15-24 years	0.116	
25 years or above	=1 if the age of the youngest children is 25 years or above	0.256	
English mainly spoken at home	=1 if English is the main language spoken at home; =0 otherwise	0.926	
Level of highest educational qualification of mother or female guardian			
Primary or lower secondary education	=1 if primary or lower secondary education	0.645	
Upper secondary education	=1 if upper secondary education	0.174	
Tertiary education	=1 if short-cycle tertiary education or bachelor degree or above	0.182	
Level of highest educational qualification of father or male guardian			
Primary or lower secondary education	=1 if primary or lower secondary education	0.575	
Upper secondary education	=1 if upper secondary education	0.222	
Tertiary education	=1 if short-cycle tertiary education or bachelor degree or above	0.202	
Number of books in childhood (at age 16)			
10 books or less	=1 if had 10 books or less in household at age 16; =0 otherwise	0.123	
11-25 books	=1 if had 11-25 books in household at age 16; =0 otherwise	0.128	
26-100 books	=1 if had 26-100 books in household at age 16; =0 otherwise	0.339	
101-200 books	=1 if had 101-200 books in household at age 16; =0 otherwise	0.188	
201-500 books	=1 if had 201-500 books in household at age 16; =0 otherwise	0.142	
More than 500 books	=1 if had more than 500 books in household at age 16; =0 otherwise	0.079	

Note: Standard deviations for continuous variables are shown in brackets.

2.3 Empirical method and specification

The employment status of an individual i is modelled by

$$employ_i^* = \alpha_0 + \alpha_1 X_i + \alpha_2 health_i + \alpha_3 skillscore_i + \alpha_4 edu_i + \epsilon_i^1 \quad (1)$$

$$employ_i = \begin{cases} 1 & if\ employ_i^* \geq 0 \\ 0 & otherwise \end{cases} \quad (2)$$

The health determination equation is specified as

$$health_i^* = \beta_0 + \beta_1 X_i + \beta_2 skillscore_i + \beta_3 edu_i + \epsilon_i^2 \quad (3)$$

$$health_i = \begin{cases} 1 & if\ health_i^* \geq 0 \\ 0 & otherwise \end{cases} \quad (4)$$

where $employ_i^*$ and $health_i^*$ can be treated as an index of an unobserved propensity for being employed and having good health, separately. $employ_i$ denotes the observed employment decision of an individual i, taking the value of 1 if an individual is employed and a value of 0 if unemployed or not in the labour force. X_i is a vector of personal characteristics. $skillscore_i$ is the standardized value of the average of the literacy and numeracy skill scores. $health_i$ is an indicator variable, with 1 for self-reporting good health and 0 for poor health. edu_i is an indicator variable, with 1 for having tertiary education and 0 for school only. ϵ_i^1 and ϵ_i^2 are error terms, which are assumed to follow the normal distribution.

The two outcome variables of social capital (participation in voluntary work and level of trust) are modelled separately by

$$S_{i\_j}^* = \theta_{0\_j} + \theta_{1\_j} X_i + \theta_{2\_j} skillscore_i + \theta_{3\_j} edu_i + \epsilon_{i\_j}^3, \quad j = 1, 2 \quad (5)$$

$$S_{i\_j} = \begin{cases} 1 & if\ S_{i\_j}^* \geq 0 \\ 0 & otherwise \end{cases} \quad (6)$$

where $S_{i\_j}^*$ denotes the propensity of participating in voluntary work ($j = 1$) or having a high level of trust ($j = 2$). S_{i_j} with $j = \{1, 2\}$ is the observed choice for voluntary work participation and exhibition of a high level of trust, respectively.

Literary and numeracy and educational attainment in Equations (1), (3), and (5) are not exogenously determined. The endogeneity derives from two sources. First, it may result from omitted variables. The literary and numeracy and educational attainment in the employment, health status, and social capital equations are likely to be correlated with the error terms that capture individuals' unobserved talents, motivation, and preferences. Second, the endogeneity may be the result of reverse causality in the sense that employment and health status could influence how much education or training an individual undertakes, in the practice. For example, individuals who are healthier or who are employed and possess higher income may be more likely to have more human capital investment, resulting in higher literacy and numeracy skills and higher educational levels. The two possible cases of endogeneity would bias the estimates upwards.[5]

In order to correct for the endogeneity of the two variables, we model the literary and numeracy and education equations, (7) and (9), and estimate them simultaneously with the equations for outcome variables, i.e. employment equation, (1), health status equation, (3), and social capital equation, (5).[6]

$$edu_i^* = \gamma_0 + \gamma_1 X_i + \gamma_2 Z_{1i} + \epsilon_i^4 \quad (7)$$

$$edu_i = \begin{cases} 1 & if\ edu_i^* \geq 0 \\ 0 & otherwise \end{cases} \quad (8)$$

$$skillscore_i = \phi_0 + \phi_1 X_i + \phi_2 Z_{2i} + \epsilon_i^5 \quad (9)$$

Identification of the above SEM is achieved by imposing exclusion restrictions in the equations for edu_i and $skillscore_i$, respectively. Specifically, following the literature, we include level of

[5]We estimate the employment equation with literacy and numeracy as an explanatory variable (i.e. the reduced-form equation), the marginal effect of literacy and numeracy is 0.077, suggesting that that one standard division increase in literacy and numeracy skill score is associated with an increased probability of employment of 7.7 percentage points. When we estimate the employment equation jointly with the equation for literacy and numeracy, the marginal effect becomes 0.053. Similarly, the marginal effects of education for employment are 0.136 and 0.127 for these two model specifications, separately. This affirms that the failure to control for the endogeneity of literary and numeracy and educational attainment would have an upward bias on the results.

[6]The error terms in the simultaneous equation system are assumed to follow a multivariate normal distribution.

highest educational qualification of mother or female guardian and level of highest educational qualification of father or male guardian in Z_{1i} in equation (7). These terms provide us with an exclusion restriction, instrumenting edu_i. The underlying assumption is that while parental educational attainment may have a positive effect on the children's educational level, it is unlikely to directly affect the health status and labour market outcomes of their children. Z_{2i}, in equation (9), includes the number of books had in household when the respondent was 16 as an exclusion restriction for the variable measuring the literacy and numeracy. These excluded restrictions are expected to influence the formation of an individual's literacy and numeracy, but they do not affect the health and socio-economic status directly. Table A.1 in Appendix A lists the variables of the SEM used in each equation.

Additionally, the unobservable factors, such as individuals' talents, motivation, and preferences, are set as a latent variable and are incorporated in all sub-equations in the simultaneous equation system, thus allowing a correlation between the unobserved parts of these equations. The SEM is estimated by maximum likelihood (ML) estimation using Stata.

3 Results

Tables 2, 3, and 4 present the estimation results for employment and health status, level of trust, and voluntary work participation, separately. Of particular interest are the coefficients of literacy and numeracy variables in these equations. From Table 2, we can see that better literacy and numeracy skills are associated with a higher probability of being employed, relative to that of not employed. In addition, higher literacy and numeracy skills are also correlated with a higher propensity of having good health status. Educational attainment and good health status have a positive and significant impact on the propensity of being employed. Individuals who have a lower probability of being employed are those who have dependent children age 0-14, who are aged 55 and above, who are females, and who are single. For the health determination equation, people who are married and younger are more likely to have better health status.

The results presented in Tables 3 and 4 suggest that higher literacy and numeracy skills and education levels are associated with a higher probability of participation in voluntary work and a higher probability of having high level of trust. Females, individuals who were born in Australia, and who are aged 65 and above have a higher probability of voluntary work participation and having a high level of trust. Having children gives rise to a higher likelihood of voluntary work participation.

Table 2: Estimation results for employment and health status regressions

	Employed		Good health		Literacy and numeracy		Tertiary education	
Variables	(1)		(2)		(3)		(4)	
Literacy and numeracy	0.166***	(0.055)	0.303***	(0.064)				
Tertiary education	0.335**	(0.154)	0.353**	(0.172)				
Good health	0.646***	(0.061)						
Age categories (base is age15-24)								
Age 25-34	0.216**	(0.104)	-0.455***	(0.122)	0.215***	(0.042)	1.480***	(0.098)
Age 35-44	0.321***	(0.105)	-0.591***	(0.122)	0.212***	(0.045)	1.389***	(0.103)
Age 45-54	0.240**	(0.095)	-0.708***	(0.111)	0.078*	(0.046)	1.164***	(0.105)
Age 55-64	-0.420***	(0.094)	-0.738***	(0.111)	-0.018	(0.050)	1.085***	(0.114)
Age 65 and above	-1.556***	(0.100)	-0.668***	(0.111)	-0.335***	(0.056)	0.772***	(0.127)
Male	0.369***	(0.040)	-0.069	(0.042)	0.144***	(0.021)	0.016	(0.048)
Country of birth (base is in other countries)								
Born in Australia	0.008	(0.068)	-0.002	(0.070)	0.241***	(0.036)	-0.382***	(0.086)
Born in other main English speaking countries	-0.025	(0.085)	0.029	(0.089)	0.351***	(0.046)	-0.272**	(0.106)
Married	0.202***	(0.049)	0.147***	(0.050)	0.194***	(0.024)	0.321***	(0.054)
The age of the youngest children (base is no children)								
Youngest children age 0-14	-0.459***	(0.065)	0.084	(0.068)	-0.110***	(0.033)	-0.190**	(0.076)
Youngest children age 15-24	0.131	(0.083)	0.073	(0.082)	-0.183***	(0.042)	-0.110	(0.095)
Youngest children age 25+	-0.069	(0.081)	0.020	(0.084)	-0.214***	(0.043)	-0.333***	(0.095)
English mainly spoken at home	0.137	(0.095)	0.029	(0.099)	0.445***	(0.049)	0.080	(0.117)
Number of books had in household at age 16 (base is 10 or less books)								
11-15 books					0.375***	(0.041)		
26-100 books					0.477***	(0.035)		
101-200 books					0.674***	(0.039)		
201-500 books					0.869***	(0.041)		
More than 500 books					0.947***	(0.048)		
Highest educational attainment of mother or female guardian (base is primary or lower secondary education)								
Upper secondary education							0.254***	(0.070)
Tertiary education							0.441***	(0.078)
Highest educational attainment of father or male guardian (base is primary or lower secondary education)								
Upper secondary education							0.233***	(0.062)
Tertiary education							0.560***	(0.075)
Constant	-0.193*	(0.106)	1.300***	(0.109)	-1.174***	(0.057)	-0.815***	(0.127)
Number of observations	6108							

Note: Numbers in parentheses are standard errors. * p<0.10, ** p<0.05, *** p<0.01.

Table 3: Estimation results for level of trust regressions

Variables	High level of trust (1)		Good health (2)		Literacy and numeracy (3)		Tertiary education (4)	
Literacy and numeracy	0.644***	(0.120)	0.315***	(0.061)				
Tertiary education	1.081***	(0.274)	0.387**	(0.162)				
Good health	0.100	(0.177)						
Age categories (base is age15-24)								
Age 25-34	-0.426***	(0.151)	-0.468***	(0.119)	0.215***	(0.042)	1.478***	(0.098)
Age 35-44	-0.405***	(0.149)	-0.606***	(0.120)	0.212***	(0.045)	1.387***	(0.103)
Age 45-54	-0.114	(0.120)	-0.717***	(0.110)	0.078*	(0.046)	1.162***	(0.105)
Age 55-64	0.041	(0.118)	-0.746***	(0.110)	-0.019	(0.050)	1.077***	(0.114)
Age 65 and above	0.323**	(0.130)	-0.669***	(0.112)	-0.336***	(0.056)	0.764***	(0.127)
Male	-0.243***	(0.056)	-0.071*	(0.043)	0.143***	(0.021)	0.015	(0.048)
Country of birth (base is in other countries)								
Born in Australia	0.256***	(0.091)	-0.001	(0.070)	0.241***	(0.036)	-0.373***	(0.086)
Born in other main English speaking countries	0.149	(0.103)	0.030	(0.090)	0.352***	(0.046)	-0.269**	(0.106)
Married	-0.103*	(0.062)	0.143***	(0.050)	0.194***	(0.024)	0.324***	(0.054)
The age of the youngest children (base is no children)								
Youngest children age 0-14	0.051	(0.076)	0.087	(0.068)	-0.110***	(0.033)	-0.190**	(0.076)
Youngest children age 15-24	0.055	(0.096)	0.075	(0.082)	-0.184***	(0.042)	-0.105	(0.095)
Youngest children age 25+	0.145	(0.106)	0.025	(0.083)	-0.215***	(0.043)	-0.331***	(0.095)
English mainly spoken at home	-0.133	(0.126)	0.026	(0.098)	0.445***	(0.049)	0.077	(0.116)
Number of books had in household at age 16 (base is 10 or less books)								
11-15 books					0.375***	(0.041)		
26-100 books					0.478***	(0.034)		
101-200 books					0.672***	(0.038)		
201-500 books					0.873***	(0.041)		
More than 500 books					0.937***	(0.048)		
Highest educational attainment of mother or female guardian (base is primary or lower secondary education)								
Upper secondary education							0.212***	(0.069)
Tertiary education							0.430***	(0.077)
Highest educational attainment of father or male guardian (base is primary or lower secondary education)								
Upper secondary education							0.259***	(0.060)
Tertiary education							0.581***	(0.073)
Constant	-1.513***	(0.235)	1.296***	(0.110)	-1.174***	(0.057)	-0.820***	(0.127)
Number of observations					6108			

Note: Numbers in parentheses are standard errors. * p<0.10, ** p<0.05, *** p<0.01.

Table 4: Estimation results for voluntary work participation regressions

	Participation in voluntary work		Good health		Literacy and numeracy		Tertiary education	
Variables	(1)		(2)		(3)		(4)	
Literacy and numeracy	0.812***	(0.166)	0.261***	(0.054)				
Tertiary education	1.522***	(0.374)	0.234	(0.149)				
Good health	0.111	(0.218)						
Age categories (base is age 15-24)								
Age 25-34	-1.145***	(0.252)	-0.400***	(0.112)	0.215***	(0.042)	1.490***	(0.098)
Age 35-44	-0.691***	(0.194)	-0.539***	(0.112)	0.212***	(0.045)	1.386***	(0.103)
Age 45-54	-0.608***	(0.170)	-0.669***	(0.102)	0.078*	(0.046)	1.164***	(0.105)
Age 55-64	-0.201	(0.138)	-0.707***	(0.104)	-0.019	(0.050)	1.083***	(0.113)
Age 65 and above	0.331**	(0.149)	-0.662***	(0.109)	-0.336***	(0.056)	0.772***	(0.127)
Male	-0.281***	(0.069)	-0.063	(0.042)	0.144***	(0.021)	0.019	(0.048)
Country of birth (base is in other countries)								
Born in Australia	0.370***	(0.108)	-0.005	(0.069)	0.242***	(0.036)	-0.383***	(0.086)
Born in other main English speaking countries	0.017	(0.113)	0.037	(0.088)	0.352***	(0.046)	-0.272**	(0.106)
Married	-0.136*	(0.073)	0.164***	(0.049)	0.195***	(0.024)	0.322***	(0.053)
The age of the youngest children (base is no children)								
Youngest children age 0-14	0.461***	(0.114)	0.070	(0.066)	-0.110***	(0.033)	-0.182**	(0.075)
Youngest children age 15-24	0.241**	(0.116)	0.058	(0.080)	-0.183***	(0.042)	-0.109	(0.095)
Youngest children age 25+	0.352***	(0.133)	-0.005	(0.081)	-0.214***	(0.043)	-0.327***	(0.094)
English mainly spoken at home	-0.169	(0.137)	0.053	(0.096)	0.445***	(0.049)	0.066	(0.117)
Number of books had in household at age 16 (base is 10 or less books)								
11-15 books					0.362***	(0.040)		
26-100 books					0.468***	(0.034)		
101-200 books					0.665***	(0.038)		
201-500 books					0.866***	(0.041)		
More than 500 books					0.942***	(0.048)		
Highest educational attainment of mother or female guardian (base is primary or lower secondary education)								
Upper secondary education							0.231***	(0.067)
Tertiary education							0.455***	(0.075)
Highest educational attainment of father or male guardian (base is primary or lower secondary education)								
Upper secondary education							0.229***	(0.059)
Tertiary education							0.558***	(0.072)
Constant	-1.046***	(0.295)	1.306***	(0.110)	-1.168***	(0.057)	-0.806***	(0.127)
Number of observations	6108							

Literacy and numeracy and educational attainment equations serve as the 'first stage' equations. The variables excluded from the second stage equations, number of books in household at age 16 in the literacy and numeracy equation and parents' level of education in the education equation, are highly significant, showing the validity of our instruments. Their estimated coefficients imply that having more books at home in childhood lead to higher literacy and numeracy skills. The level of parental education impacts positively on their children's education.

The literacy and numeracy and other socio-demographic factors may have a different effect on these outcome variables by gender; the simultaneous equation models are estimated for men and women separately as a subsample analysis. Table 5 lists the marginal effects of literacy and numeracy and education for men and women. One standard deviation increase in literacy and numeracy skill score is associated with an increased probability of employment of 4.0 and 4.3 percentage points for men and women, respectively. Marginal effects for educational attainment on being employed are positive, but larger for men (9.8 percentage points) than for women (8.8 percentage points). Higher education attainment leads to better health status only for males but not for females. Literacy and numeracy skills contribute more to high level of trust for males than that for females. Another interesting finding is that the effect of children on employment varies by gender. The presence of young dependent children (less than age 14) reduces the job participation of females but not of males; this suggests that family factors still remain a barrier for the job participation of females in Australia. Males with children aged 15-24 are more likely to participate in the labour force while no such trend is revealed for females.[7]

[7]Results for subsample analysis are available upon request.

Table 5: Marginal effects of literacy and numeracy and education

	Literacy and numeracy (standardised score)			Tertiary education		
Outcome variables	All	Male	Female	All	Male	Female
(1) Employed	0.041***	0.040**	0.043**	0.085**	0.098*	0.088*
	(0.013)	(0.018)	(0.018)	(0.040)	(0.059)	(0.053)
Good Health	0.067***	0.076***	0.050***	0.080**	0.127**	0.029
	(0.012)	(0.017)	(0.017)	(0.038)	(0.065)	(0.048)
(2) High level of trust	0.161***	0.207***	0.126***	0.264***	0.062***	0.174***
	(0.018)	(0.032)	(0.020)	(0.045)	(0.019)	(0.053)
(3) Participation in voluntary work	0.205***	0.195***	0.213***	0.433***	0.442***	0.438***
	(0.016)	(0.023)	(0.022)	(0.065)	(0.101)	(0.085)

In addition, we re-define the health status and educational attainment as variables with 3 categories and utilise the ordered probit model as an alternative model specification. Consistent results are found. We also introduce a two-way relationship between literacy and numeracy skills and education levels; the results show a positive and significant association between them, suggesting that literacy and numeracy can be enhanced through formal education and higher literacy and numeracy facilitate higher educational attainment.

4 Conclusion

Literacy and numeracy skills are shown to exert a positive influence on education, health, the probability of being employed, the probability of participating in voluntary work and having high level of trust. After controlling for education, the effect of literacy and numeracy on health and socioeconomic outcomes is still statistically significant, suggesting that literacy and numeracy skills have an indirect effect through formal education on individual outcomes in adulthood and

also influence them directly. The results can inform an economic model which can be used to estimate the costs and benefits of interventions to improve adult literacy and numeracy and associated outcomes.

Literacy and numeracy can be acquired in many channels, including during early childhood, through formal education, and through informal means (in day-to-day activities at home or on-the-job training). A direction of future research is to consider the relative importance of these pathways.

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6 Appendix A

Table A.1: Variables used in sub-equation of the simultaneous equations model

	Equation					
	Employment	Health status	Volunteer work	Level of trust	Education	Literacy and numeracy skill
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
Literacy and numeracy skill	X	X	X	X		
Education	X	X	X	X		
Health status	X		X	X		
Age	X	X	X	X	X	X
Male	X	X	X	X	X	X
Country of birth	X	X	X	X	X	X
Married	X	X	X	X	X	X
Age of the youngest children	X	X	X	X	X	X
English mainly spoken at home	X	X	X	X	X	X
Level of highest educational qualification of mother or female guardian					X	
Level of highest educational qualification of father or male guardian					X	
Number of books in household at 16						X