Health Literacy and its Effect on Chronic Disease Prevention: Evidences from China's Data

Lefan Liu
University of Nottingham - Ningbo China https://orcid.org/0000-0003-1699-5981
xujun Qian
Ningbo City First Hospital
zhuo chen
University of Nottingham Ningbo China ,University of Georgia
Tianfeng He (hetfnbcdc@163.com)
Ningbo Municipal Center for Disease Control and Prevention

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Abstract

Background: Improving health literacy is an important public health goal in many countries. Although many studies have suggested that low health literacy has adverse effects on an individual's health outcomes, factors that may be confounding the relationship between health literacy and health outcomes are often not accounted. This paper examines the interplay between health literacy and chronic disease prevention.

Methods: A sample of 2,835 residents aged 14-71 years old in Ningbo province of China were selected from China's National Health Literacy Surveillance Survey in 2017. The multivariate regression analysis is used to untangle the relationship between health literacy and chronic disease prevention.

Results: We find the association between health literacy and the occurrence of the first chronic condition is attenuated after we adjust the results for age and education. In contrast, we find having one or more chronic conditions leads to better knowledge about chronic diseases and thus improved health literacy on chronic disease prevention. Thus, when a respondent has one chronic disease, health literacy could reduce the incidence of a new chronic condition (comorbidities). However, the protective effect of health literacy is only found among our urban sample, suggesting health literacy might be a key factor explaining the rural-urban disparity in health outcomes.

Conclusion: Our findings highlight that health literacy plays a more important role in helping individuals preventing comorbidity than preventing their first chronic disease. Moreover, family support could be a potential channel through which health literacy accumulates and results in beneficial effects on health.

Background

Health literacy refers to the degree to which individuals can obtain, process, and understand the basic health information and services they need to make appropriate health decisions[1]. It represents a constellation of skills necessary for people to function effectively in the health care environment and act appropriately on health care information [2]. Low health literacy is often a significant health challenge in many countries. For example, in 2003, approximately 80 million adults in the US (36 percent) had limited health literacy [2]. In Europe, a 2013 WHO report shows nearly half of all Europeans have inadequate and problematic health literacy skills. Inadequate health literacy comprised between 2 percent and 27 percent of the population in eight European countries being surveyed.Although a significant proportion of the general population have low health literacy, certain groups have higher prevalence of this problem, especially among some socioeconomically disadvantaged population. For example, rates of limited health literacy were higher among the elderly, individuals who have not completed high school, and people living in poverty [2–5].

A growing body of literature looks at the relationship between health literacy and health outcomes. Low literacy is associated with several adverse health outcomes, including low health knowledge, increased incidence of chronic illness, poorer intermediate disease markers, and less than optimal use of preventive

health services[6–9]. Although the strength of evidences remains insufficient, consensus made in these studies is that lower health literacy is associated with poorer outcomes. As a result, promoting health literacy is often a national public health goal in many countries and interventions that aim to improve health literacy are prioritized. This is particularly true for China, who did not its first national health literacy assessment until 2008. The government released its Healthy China 2030 Blueprint in 2016 calling for improving national health literacy level by 200% compared to the 2015 level.

However, to play a role, health literacy needs to be internalised, as knowledge itself does not necessarily predict actual behavioural change and the role that health literacy plays might be subject to many factors[2]. Indeed, one of the key factors could be education as better educated people can better internalise the same health information [10]. Besides attitudes, social norms and self-efficacy are also responsible for most of behaviour intention that leads to subsequent behaviour change[11, 12]. The differences in these intermediate outcomes might result in differences that health literacy plays a role in affecting health outcomes. To make this point further, although interventions to mitigate the effects of low health literacy is to improve health and receipt of health services, the direction or the strength of the effect can be moderated by whether or not the respondent is exposed to their first chronic disease. This has not been explicitly studied in the literature.

This paper starts from examining the role that health literacy plays in affecting a specific health outcome, i.e. preventing chronic diseases. More importantly, we examine the role that health literacy has on preventing comorbidities. The paper unfolds as follows. Section 2 describes our dataand empirical strategy. Section 3reports the main results as well as sensitivity analyses. In our final Sect. 4, wediscuss our findings and concludes.

Methods

Data and Sample Selection

Our data comes from 2017 National Health literacy Surveillance Survey data in Ningbo, which is one of the developed cities in the eastern coastal areas of China.It is representative of the permanent residents of Chinese nationality aged 14-71 years old in 12 counties (or county-level cities) in Ningbo. Residents living in military bases, hospitals, prisons, nursing homes, and dormitories are excluded. Permanent residents refer to residents who have lived in the local area for more than 6 months in the past 12 months, regardless of whether they have local household registration (*hukou*).

In terms of sampling method, a stratified multi-stage PPS (Probability Proportionate to Size Sampling) method was adopted. At each monitoring station, i.e., 12 counties (or county-level cities), we selected 4 streets (or townships), and then selected 2 neighbourhood committees (or villages) within each street (or township) using the PPS sampling. If the number of households in the selected village or neighbourhood committee is greater than 750 but less than 1,500, the village or neighbourhood committee is regarded as a primary sampling unit (PSU).If the selected village or neighbourhood committee has more than 1,500 households, it is divided into several units, each of which contains roughly 750 households, and one of

the units is selected by simple random sampling and used as a PSU. In each PSU, our mappers constructed a list of households by field trips, from which 120 households were selected by random sampling. One age-eligible permanent resident aged 15-69 is then chosen randomly in each household. In each PSU, at least 83 respondents were surveyed and a total of 8,299 respondents were surveyed. The sampling weights were calculated based on the five-stage sampling process. In what follows our final sample includes 8,235 respondents (aged 14-71) surveyed in 2017, of whom we have complete information on the variables of interest.

Questionnaire Design and Measure of Health Literacy

Our questionnaire follows the standard form compiled by the National Health Education Centre of National Health Commission in China. China started its first national health literacy assessment in 2008, which was then conducted every year. A group of trained investigators conducted face-to-face interviews with the selected respondent in each household. Each questionnaire has double-entry and is subject to strict quality control.

The complete questionnaire includes 4 sections: letter of consent, basic information, health literacy questions and evaluation to interviewers.The health literacy questions coverthree aspects: (1) basic health knowledge and concepts; (2) healthy lifestyles and behaviours; and (3) basic skills. These questions are either true/false questions or multiple-choice questions (with either one or more correct answers). Correct answer to each question countsone (or two scores for questions with multiple correct answers) towards the total score and the full score is 66. Instructions on weight of each question were also indicated. Following the national standard [13], we classify a respondent as having health literacy if thetotal score obtained is at least 80% of the full score. Each question depending on relevance to public health can be categorized into one of the six topic areas: (1) scientific health knowledge; (2) infectious disease prevention; (3) chronic disease prevention; (4) safety and first aid; (5) basic medical care; (6) health information.

Threshold for each category is pre-defined and is the same (80% of the full score in each category) to classify the health literacy status of an individual in each specific area. Here, we use“health literacy on chronic disease prevention (CDP)” to examine the relationship between health literacy and chronic disease prevention. The score of an individual’s health literacy on CDP is obtained from answering 9 questionsconcerning the benefits of consuming soybean products, benefits of exercises, consequences of smoking, understanding of self-tested blood pressure, the early signals of cancer, the methods of weight control, osteoporosis related knowledge, understanding that vegetables and fruits are not substitutes and adolescents are also vulnerable to depression. If a respondent gives correct answers to all 9 questions, their score would be 12. An individual is classified as having health literacy on CDP if their score obtained is 10 (80%) or above.

Our survey also collected basic information of the respondents on their demographic characteristics and health condition. In particular,respondents were asked whether they had any chronic disease and the type of the disease if any, including hypertension, heart problems, cerebrovascular diseases, diabetes,

malignant tumour (cancer) and other. Respondents were also asked the number of years with their first type of chronic disease since it was diagnosed.

Model Specification

Our baseline model specification is below:

$$disease_i = \beta \cdot lit_i + \alpha \cdot Z_i + e_i \quad (1)$$

where diseasei is the chronic disease condition of a resident living in Ningbo (=1 if has any chronic disease; =0 otherwise); indicates whether a respondent has health literacy on CDP (=1 if has health literacy on CDP, =0 otherwise); is a vector of demographic and socio-economic status factors of the respondent, including region of residence, gender, annual income, number of household members, occupation, age and level of education; and is the error term. Our main estimate of interest is , which informs us of the effect of health literacy on having chronic diseases. For ease of interpretation, a linear probability model (LPM) is used to estimate the coefficients of interest.[1]We use Stata 15.0 for statistical analyses.

Results

Characteristics of the Respondents

Table 1 presents summary statistics for our sampledisaggregated by region of residence (rural/urban). We report four statistics: mean, the standard deviation, minimum and maximum value for each variable. In the final column, we report the p-value to test the equality of the means between the rural and urban samples.

Firstly, we look at the demographic characteristics. Our sample is evenly split between rural and urban areas (48% are urban residents) and about half are men. A typical respondent is about age 50 (the youngest is 14 and the oldest is 71), who lives in a household with 3 members and self-reported earning an annual income of 86,000 yuan (the median is 50,000 yuan and the highest is 3,500,000 yuan). In terms of education, about 9% are illiterate, 16% finished high school, and 17% have a degree of vocational or above. In terms of occupation, about 9% are working in public sectors (including civil servants, medical workers, and teachers), 29% are farmers, 18% are manual labourers, and 17% are working in private sectors. As mentioned earlier, Ningbo is a one of the well-developed coastal cities in China, thus the social-economic status of residents is above the national average.

We now turn to their health literacy and conditions of chronic diseases. Table 1 shows that the level of health literacy on CDP is 25.7%, meaning out of 100 people living in Ningbo, 26would give correct answers to more than 80% of questions and be considered as having health literacy on CDP. The prevalence ratefor chronic disease is 26%. The most prevalent disease type is hypertension (19%)

followed by diabetes (5%) and heart problems (2%). The prevalence rate for cerebrovascular diseases and cancer is not high, about 1%, respectively.[1]

Significant differences also arise in rural and urban samples in terms of health literacy and chronic diseases. The urban residents have a higher level of health literacy on CDP. At the same time, they have fewer chronic diseases.Urban residents are also significantly younger (46 vs 51 years), which we think is partly due to the rural-urban migration, whereyounger people from rural areas come to urban areas for better job opportunities. Urban residents tend to live with fewer household members (2.8 vs 2.7). They earn more (102,241 vs 71,195 yuan) and are better educated (19% vs 49% in terms of the proportion of an education of high school or above). Not surprisingly, they are also more likely to work in public sectors and less likely to work as a farmer.

Characteristics of Groups with Different Level of Health Literacy

From Table 1, we find urban residents are significantly better-off in many aspects: they are healthierand have a higher level of health literacy on CDP; and they are younger, better educated and wealthier. In order to investigate the relationship between chronic diseases and health literacy, we further group our respondents by their status of health literacy on CDP(hereafter we term them 'health literate' or 'health illiterate' in short) in Table 2 to examine their respective characteristics.

Not surprisingly, we find the prevalence of chronic diseases is significantly lower among the 'health literate' group. In addition, the'health literate'groupare more likely to live in the urban areas, are younger (45 vs 50), have a higher income, are better educated, and more likely to work in public sectors or employed in private sector.[2] Similar patternsare also observed both in the rural andthe urban sample (See Table A2 in the Appendix).

While we observe a lower prevalence rate of chronic diseases among 'health literate'residents (i.e. classified as having health literacy on CDP), we also find this'health literate' group younger, better educated, and wealthier, which are all factors that are associated with a lower likelihood ofhaving chronic diseases. In other words, the negative relationship we observe between health literacy and chronic disease may not reflect the causal effect that health literacy has on preventing chronic diseases, but actually reflect the observed characteristics, such as age and education in preventing chronic diseases.[3] Next, we will take into account these 'confounders' to untangle the relationship between health literacy and chronic diseases.

Does Health Literacy Prevent Chronic Diseases?

We predict the occurrence of chronic disease with a set of hierarchical equations in Table 3. In column (1) we include no covariate but the binary variable of health literacy alone.Actually, the estimate of in column (1) will merely replay what we observed in Table 2. In columns (2)-(4), we add sequentially three blocks of variables to the equations, representing, in order of entry, region of residence, gender, income and household size; occupation; age and education. This ordering provided a means to observe how each

block of variables added in later explained the effect of health literacy shown in column (1).We will show age and education are the main confounder that explained away the effect of health literacy in column (1). In column (5) we included the full set of covariates rendering us a 'purer' effect of health literacy, which partials out potential confounders.

The first equation in column (1) reveals that having 'health literacy on CDP' is associated with a reduction in the likelihood of having chronic disease by 4.8 percentage points. The second equation in column (2), which added gender, annual income and number of household members, shows that higher income is also associated with a lower likelihood of having chronic diseases and the effect of health literacy remains negative despite a small reduction in magnitude. The effect of household size is also significant, showing that respondents living in a larger household are less likely to have chronic diseases. Equation three in column (3) shows that occupation is also a strong predictor of the respondent's chronic disease condition. Compared to those working in public sectors, farmers (manual labourers) have a higher probability of having chronic disease by 25 percentage points (11 percentage points). More importantly, with the inclusion of occupation, is now half the size as before, implying occupation explains away part of the negative effect health literacy has on chronic diseases. In column (4), we include age and education. The estimate of changes sign and is significant at 10% significance level, implying having health literacy 'increases' rather than 'decreases' the likelihood of having chronic diseases. The size of this effect is not negligible, about 2.3 percentage points. The effects of age and education are expected. Those who are younger and better educated are less likely to have chronic diseases. Those effects are significant both statistically and economically, showing they are important predictors of having chronic diseases.

We thinkage and education are the main confounders to the relationship between health literacy and chronic diseases we observe in column (1)and we are provided with this clue in two places. Firstly, there is asubstantial increase in R-squaredin column (4) at the bottom of the table compared to columns (1)-(3). Secondly, in column (5) we include the full set of covariates and the estimate of health literacy is unaltered compared to column (4). Similar patterns of results are also observedin split rural and urbansamples (TablesA3 and A4 in the Appendix).[4]

How can we explain this positive association between having health literacy and chronic diseases occurrence once we have controlled for age and education? We have to take into account the prognosis of chronic diseases and its interaction with acquiring knowledge about diseases. It is possible that people acquire the knowledge about the diseases (thus becomes 'health literate') after they havehad the disease. Other than books, newspapers or magazines,people can access health knowledge from doctors[10]. Therefore, although the estimate is positive, it does not mean having health literacy is bad, but having chronic diseasemight help a respondent toacquire health literacy on CDP. If this is the case, we are likely to find a stronger effect among the elderly, who are more vulnerable to chronic diseases. We conducted this exercise bysplitting the sample by age and we report the results in Table 4 (next page).Indeed, we find

the positive association between health literacy and chronic disease is only present among those aged 60+ but is absent in the two younger age groups. Similar results are found for rural and urban sample in TablesA5 and A6 in the Appendix.

Does Having Chronic Disease Help to Acquire Health Literacy?

Despite Table 4, we are unsure whether this indeed is the case unless we explicitly estimate a model that predicts the probability that a respondent has 'health literacy on CDP'. This is our task in this section where we predict the probability that a respondent has 'health literacy on CDP' using a linear probability model. As before, we estimate the model using the full sample and then rural and urban samplesseparately. Because differing results arise in rural and urban samples, we report only urban and rural results in Table 5.We discuss firstthe urban results as a benchmark in Panel A and then highlight differences in rural results in Panel B.

Controlling a series of characteristics of the respondents (gender, annual income, household size, occupation, age and education), we find those with at least one type of chronic disease are indeed significantly more likely to be 'health literate' by 3 percentage points (column 1). If health literacy can be acquired in response to a negative shock such as chronic diseases, we are more likely to observe this effect among those who bear the shock not long ago than those who had itlong time ago. We do not have the retrospective data on the change of health literacy during the prognosis of the disease on a respondent, but we could compare the level of health literacy among those whose first chronic disease was diagnosedless than one year ago and those with their first disease longer. This is what we did in our second equation reported in column (2). It shows that among the group whose first chronic disease was diagnosed within the last year, there is a boost in acquiring health literacy compared to those without chronic diseases, but this effect is absent among those whose first chronic disease was diagnosed 2-4 years ago or earlier. Besides, it appears having more than onedisease(that is comorbidities) increases the likelihood of acquiring health literacythan having only one disease as shown in column (3), but this difference is not statistically significant.[5]

Next, we examine whether this relationship is related to specific type of disease(s). This is done by replacing the number of diseases with six dummy variables indicating the types of diseases in column (4). We find having hypertension is likely to contribute to acquiring health literacy by 4 percentage points (that is 14% increase over 25.8 percentage points - the base rate of health literacy level). It is worth noting the effect of having cancer.This estimate is insignificant but sizable (not very surprising given the prevalence rate for cancer is less than 1% in the sample), showing those with cancer have a higher probability of acquiring health literacy on CDP by 10 percentage points. This sounds ironic but not counterintuitive. More importantly, this finding lends support to our speculation that negative shock prompts people to respond. Thus here, the affected patients (by chronic diseases) are more likely to acquire health literacy on CDP*ceteris paribus*than those who were not affected.

Compared with the results for the urban sample, the effects of duration and the types of diseases in columns (2) and (4) differ significantly from the urban results (see Panel B in Table 5). For rural

respondents, those whose first chronic disease was diagnosed more than 5 years ago are significantly less likely to have health literacy on CDP than the healthy people (not having any chronic diseases). In rural sample, having heart problems is the only disease type that is significantly associated with having health literacy on CDP.

Several potential hypotheses stem from the juxtaposition of these results. First, diagnosis with chronic diseases helps an individual to acquire health literacy on CDP. Second, the acquirement via this channel however is more likely to occur when the respondents were diagnosedwith the disease not long ago.Finally, the response to negative health shock also differ by disease type. Acquiring health literacy is more likely to occur when the respondent wasdiagnosed with hypertension or cancerfor the urban resident (or heart problems for the rural residents). Compared to other chronic diseases, the diagnosis of hypertension is reasonably inexpensive and accurate [14] andthe relationship between hypertension and several other diseases, such as cerebrovascular disease, heart diseases has been widely accepted. The implication is an early discoverymight be helpful.

The effects of other variables have expected signs, which are reported in TableA7 in the Appendix.For example, those who work in public sectors are more likely to have health literacy than farmers; older respondents are less likely to have health literacy (but it is only significant in rural areas) and higher education is associated with higher likelihood of having health literacy on CDP. In particular, for the urban sample, we find a positive association between household size and the probability of having health literacy on CDP, but not in rural sample. We think this might arise because in a larger household, an individualis more likely to be supported by family members especially when there are young members, who have a stronger incentive to acquire new information because the payoff period for any information investment is longer for them [15].

Acquiring Health Literacy after Chronic Diseases: Can Health Literacy Prevent Comorbidity?

Now we are back to the question we asked at the outset, but in a slightly different form. If being diagnosed with achronic disease also helps one to acquire health literacy on CDP, could this acquirement prevent the respondent from anewchronic disease? That is to say, does health literacy help patients deal with a comorbidity before it takes place? For example, we might be interested in knowing whether having health literacy reduces the likelihood of having another disease such as hypertensionfor patients diagnosed with diabetes. We will address this question using the following specification:

$$hbp_i = \beta_1 \cdot literacy_i + \beta_2 \cdot diabe_i + \beta_3 \cdot literacy_i \cdot diabe_i + \alpha \cdot Z_i + e_i \qquad (2)$$

where indicates the hypertension condition of a respondent (=1 if has hypertension; =0 otherwise); indicates the diabetes condition of a respondent*i* (=1 if has diabetes, =0 otherwise). and have the same definitions as before. The estimate of informs us in the absence of diabetes, of the effect that health literacy has on an individual's likelihoodof having hypertension. The estimate of is likely to be positive because chronic diseases are often caused by common risk factors, thus, having one chronic disease is

usually associated with having another chronic disease. Our key estimate of interest is . If it is negative, it implies that the effect that health literacy has on hypertensionoccurrence changes withwhether the respondent also has diabetes; health literacy fills a gap among patients with one condition to help them to prevent a new condition.[6] Strictly speaking, we could not interpret acquiring health literacy as occurring after the diagnosis of diabetes because our data is cross-sectional.

We experimented the above specification alternating the predicting disease variable and the explanatory disease pairs. And we do it for three samples, full sample, rural sample and urban sample, separately. We find among urban samples, there are five pairs of disease types that entail a significant interaction effect but not for the rural or the full sample and we report it in Table 6. Separate results for rural sample are available upon request.

In columns (1)-(2), we predict the probability of having comorbid cerebrovascular diseases. Expectedly, having heart problems raises the likelihood of cerebrovascular disease by 6 percentage points when an individual does not have health literacy on CDP. The coefficient on health literacy is not significantly different from zero, meaning health literacy has little role to play in preventing an individual from having cerebrovascular diseasesas the first chronic disease. However, if an individual has had heart problems,having health literacy reduces the likelihood of having cerebrovascular disease by 7 percentage points. This interaction effectcould more than offset the comorbid effect of having heart problems. In column (2), we replace health problems withcancer and again predict the probability of having comorbid cerebrovascular diseases. Having cancer is associated with a higher probability of having cerebrovascular diseases (by 5 percentage points) and the interaction effect is 6 percentage at borderline significance, which again could more than compensate the positive comorbid disease effect.[7]

In columns (3), we predict the probability of having comorbid heart problems with cerebrovascular disease (the reversed case as in column 1). Having cerebrovascular disease is strongly associated with a respondent's likelihood of having heart problems when the respondent has no health literacy on CDP. The size of interaction effect is substantial. If a respondent has had cerebrovascular disease, health literacy on CDP could help prevent the respondent from having heart problems by 23.4 percentage points.

In columns (4)-(5), we predict the probability of having comorbid diabetes. The interaction effect is insignificant but sizable, showing health literacy reduces the likelihood of having diabetes by 4 percentage points if a respondent has heart problems. Similarly, health literacy reduces the likelihood of having diabetes by 16.4 percentage points if a respondent has cerebrovascular diseases.

Sensitivity Analyses

In this section, we look into the sensitivity of our results. We added regional fixed effects (12 dummies indicating monitor stations or 112 dummies indicating village/communities) and re-estimated equation(2). The results are not altered with the inclusion of regional fixed effects (reported in Table A8 in the Appendix). Similar to what we have in Table 6: the interaction effects become greater in sizebut the

significance is not altered, showing our findings are not confounded by the heterogeneity of respondents coming from different monitoringstations or different village/communities.

Next, we apply the sample weights and re-estimated equations (2) (reported in Table A9 in the Appendix). A noticeable difference is the interaction for cancer reduces in size and significance but all else are similar, and heart problems and cerebrovascular diseases in columns (1) and (3) remain significant.

Although LPM is easier to interpret, they might suffer from problems such as the error terms will not be normally distributed, there will be heteroskedasticity, and predicted values will fall outside the logical boundaries of 0 and 1. We re-estimated parallel results for Table 3 and 5 using logit model and find similar results(reported in Table A10 and Table A11).[8]

We find that using specific health literacy is relevant to our studying the occurrence of chronic diseases, we also experimented using alternative health literacy variables given the availability of a more generic measurement of health literacy.Our key information is not changed. These results are not reported but available upon request.

Discussion

Using the National Health Literacy Surveillancedata in Ningbo province of China, we examine the role thatthe “health literacy on CDP”play inpreventing an individual from having chronic diseases. Although descriptive statistics show people with health literacy are less likely to have any chronic disease, this is mainly driven by the fact that more ‘health literate’ people are also younger and more educated. Once controlling for these differences, people with health literacy are found to be more likely to have chronic diseases. We do not think this means causally more ‘health literate’ people are more likely to have chronic diseases. Instead,having chronic disease is likely to contribute to the acquirement of health literacy. Results in our data seem to favour this explanation as this effect is more pronounced among those respondents who are exposed to the negative shock within the past year (but absent among those whose first chronic disease was diagnosed two or more years ago) and is likely to accumulate with comorbidities. Besides, the channel through which health literacy acquirement is likely to be associated with the support of family members. As to preventing chronic diseases, if respondents have one condition, for some diseases, health literacy plays a protective role in preventing a new disease. This effect however is only present among urban residents.

One of the limitations in our work is that it isbased on cross-sectional data, so the causal interpretations is not free from problem. But a contribution of this paper is it is the first paper, as far as we know, to investigate the relationship between health literacy and comorbid chronic diseases, which might shed light to future work in this direction.

The implication of our study is threefold. Firstly, it points to the importance of improving health outcomes among people low limited health literacy. Early shock could be a trigger and health workers could potentially take use of the opportunity to transfer the knowledge to patients to prevent new illnesses or

even the illness of close family members living together. Secondly, the preventive effect of health literacy is not found in the rural sample, showing the difference in the channel through which urban residents and rural residents acquire health literacy might result in the difference in health outcomes. Earlier diagnosis and education could help those who are well-to-do and more educated but might play a limited role among those who are poor and less educated. Third, family support could be a potential channel through which health literacy accumulates and result in beneficial effect on health.It is possible that on condition of an existing chronic condition, health literacy not only reduce the incidence of additional chronic condition for the individual, but also offer protective effects for the family members against chronic conditions.

Conclusion

Although we usually may find lower chronic disease prevalence among people with high health literacy, this association tells us little about the role health literacy plays in protecting individuals from chronic diseases. Our findings highlight health literacy plays a more important role in helping individuals preventing comorbidity than preventing their first chronic disease. Moreover, family support could be a potential channel through which health literacy accumulates and results in beneficial effects on health. These might help policymakers promote health literacy education among the general public. At the same time, taking advantage of the network effect of health literacy accumulation to achieve goals in healthy China.

Abbreviations

WHO: World Health Organization.

PPS: Probability Proportionate to Size Sampling

PSU : primary sampling unit.

CDP: chronic disease prevention.

LPM: linear probability model.

Declarations

Ethics approval and consent to participate The survey protocols, instruments, and the process for obtaining the informed consent for participants were approved by the ethics committee of Ningbo Municipal Center for Disease Control and Prevention. All participants provided written informed consents prior to the surveys(For participants under 16 years old, their parents fill in informed consent instead.).

Consent to publish Not applicable.

Availability of data and materials Not applicable.

Competing interests The authors declare that they have no conflict of interest.

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Authors' contributions Liu LF performed preliminary statistical analysis, interpreted results, drafted the initial manuscript, and submitted the final manuscript. Chen Z revised manuscript critically for important content. He TF and Qian XJ contributed to the study design, reviewed and organized the field work. He TF was responsible for the field work, data collection and quality control. All authors read and approved the final manuscript.

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Tables

Table 1 Summary statistics

Sample	All				Rural	Urban	Rural vs Urban
Number of Observations	N=8,235				n=4,223	n=4,012	
Variables	mean	s.d.	min	max	mean	mean	p-value
Key variables of interest							
Any chronic diseases (=1)	0.262	0.440	0	1	0.295	0.227	0.000
Hypertension (=1)	0.190	0.393	0	1	0.216	0.163	0.000
Heart problems (=1)	0.019	0.138	0	1	0.021	0.018	0.267
Cerebrovascular disease (=1)	0.007	0.082	0	1	0.008	0.006	0.251
Diabetes (=1)	0.049	0.217	0	1	0.056	0.043	0.006
Cancer (=1)	0.007	0.086	0	1	0.009	0.006	0.225
Other chronic diseases (=1)	0.036	0.186	0	1	0.040	0.032	0.063
Health literacy on CDP[a] (=1)	0.258	0.437	0	1	0.232	0.285	0.000
Demographics							
Region (=1 urban)	0.487	0.500	0	1	0.000	1.000	0.000
Has local hukou (=1)	0.928	0.258	0	1	0.965	0.889	0.000
Gender (=1 male)	0.489	0.500	0	1	0.493	0.484	0.428
Age in years	49.004	13.308	14	71	51.470	46.408	0.000
1:Aged14-44	0.340	0.474	0	1	0.244	0.442	0.000
2:Aged45-59	0.387	0.487	0	1	0.427	0.346	0.000
3:Aged60-71	0.272	0.445	0	1	0.329	0.212	0.000
Household size	2.825	1.524	1	50	2.877	2.770	0.001
Annual income (1,000 RMB)	86.321	102.999	0	3500	71.195	10.224	0.000
Education level							
1:Illiterate	0.087	0.282	0	1	0.133	0.039	0.000
2:Elementary	0.274	0.446	0	1	0.364	0.180	0.000
3:Middle school	0.300	0.458	0	1	0.309	0.291	0.069
4:High school	0.168	0.374	0	1	0.116	0.222	0.000
5:Vocational or above	0.171	0.376	0	1	0.077	0.269	0.000
Occupation							
1:Working in public sectors	0.093	0.291	0	1	0.061	0.127	0.000
2:Farmers	0.291	0.454	0	1	0.451	0.122	0.000
3:Manual labourers	0.183	0.387	0	1	0.189	0.177	0.151
4:Working in private sectors	0.171	0.377	0	1	0.093	0.254	0.000
5:Other	0.261	0.439	0	1	0.205	0.321	0.000

Note: The p-value is calculated using either the t-test (if continuous) or the proportion test (if binary); a pre-test of equality of variance is also conducted. [a] CDP refers to chronic disease prevention.

Table 2 Summary statistics by status of health literacy on CDP

Sample	w/ health literacy	w/o health literacy	
Number of observations	n=2,123	n=6,112	
Variables	mean	mean	p-value
Key variables of interest			
Any chronic diseases (=1)	0.226	0.274	0.000
Hypertension (=1)	0.165	0.199	0.001
Heart problems (=1)	0.022	0.018	0.294
Cerebrovascular disease (=1)	0.005	0.007	0.292
Diabetes (=1)	0.039	0.053	0.011
Cancer (=1)	0.007	0.008	0.612
Other chronic diseases (=1)	0.031	0.038	0.118
Health literacy on CDP[a] (=1)	1.000	0.000	0.000
Demographics			
Region (=1 urban)	0.539	0.469	0.000
Has local hukou (=1)	0.939	0.924	0.021
Gender (=1 male)	0.484	0.490	0.645
Age in years	45.289	50.295	0.000
1:Aged14-44	0.456	0.300	0.000
2:Aged45-59	0.359	0.397	0.002
3:Aged60-71	0.185	0.302	0.000
Household size	2.933	2.788	0.000
Annual income (1,000 RMB)	106.093	79.453	0.000
Education level			
1:Illiterate	0.054	0.098	0.000
2:Elementary	0.178	0.308	0.000
3:Middle school	0.258	0.315	0.000
4:High school	0.206	0.154	0.000
5:Vocational or above	0.305	0.124	0.000
Occupation			
1:Working in public sectors	0.153	0.072	0.000
2:Farmers	0.246	0.306	0.000
3:Manual labourers	0.171	0.188	0.090
4:Working in private sectors	0.220	0.155	0.000
5:Other	0.210	0.279	0.000

Note: The p-value is calculated using either the t-test (if continuous) or the proportion test (if binary); a pre-test of equality of variance is also conducted. [a] CDP refers to chronic disease prevention

Table 3 OLS estimates on having any chronic disease

Dep: Has any chronic disease	(1)	(2)	(3)	(4)	(5)
Sample	All	All	All	All	All
Health literacy on CDP (=1)	-0.048***	-0.035***	-0.026**	0.018*	0.018*
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Region (=1 urban)		-0.061***			0.017*
		(0.010)			(0.010)
Gender (=1 male)		0.001			0.000
		(0.010)			(0.009)
Annual income (log)		-0.024***			-0.010***
		(0.003)			(0.003)
Household size		-0.027***			-0.005
		(0.003)			(0.003)
Occupation (Base: 1:Public sectors)					
2:Farmers			0.246***		0.019
			(0.018)		(0.020)
3:Manual labourers			0.107***		0.022
			(0.019)		(0.020)
4:Private sectors			0.034*		0.011
			(0.019)		(0.018)
5:Other			0.121***		-0.009
			(0.018)		(0.019)
Age group (Base: 1:Aged 14-44)					
2:Aged45-59				0.200***	0.198***
				(0.012)	(0.012)
3:Aged60-71				0.404***	0.398***
				(0.015)	(0.015)
Education (Base: 1:Illiterate)					
2:Elementary				-0.028	-0.027
				(0.017)	(0.018)
3:Middle				-0.069***	-0.064***
				(0.018)	(0.019)
4:High school				-0.066***	-0.060***
				(0.020)	(0.022)
5:Vocational or above				-0.085***	-0.075***
				(0.022)	(0.024)
Observations	8,235	8,235	8,235	8,235	8,235
R-squared	0.002	0.026	0.039	0.154	0.157

Note: The dependent variable is a binary variable indicating the chronic disease condition of a resident living in Ningbo (=1 if has any chronic disease; =0 otherwise). Estimates on the constant are not reported. ***p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

Table 4 OLS estimates on having any chronic disease by age group

Dep: Has any chronic disease	(1)	(2)	(3)	(4)
Sample	All	Aged 60-71	Aged 45-59	Aged 14-44
Health literacy on CDP (=1)	0.018*	0.061**	0.015	-0.004
	(0.011)	(0.028)	(0.019)	(0.009)
Region (=1 urban)	0.017*	0.003	0.033*	0.010
	(0.010)	(0.024)	(0.018)	(0.010)
Gender (=1 male)	0.000	-0.042*	0.001	0.030***
	(0.009)	(0.022)	(0.016)	(0.009)
Annual income (log)	-0.010***	-0.011	-0.011**	-0.010***
	(0.003)	(0.008)	(0.005)	(0.002)
Household size	-0.005	-0.008	-0.010*	0.002
	(0.003)	(0.007)	(0.006)	(0.003)
Occupation (Base: 1:Public sectors)				
2:Farmers	0.019	-0.085	0.020	0.058***
	(0.020)	(0.068)	(0.043)	(0.021)
3:Manual labourers	0.022	-0.011	-0.005	0.032**
	(0.020)	(0.072)	(0.043)	(0.015)
4:Private sectors	0.011	-0.098	0.009	0.022*
	(0.018)	(0.074)	(0.043)	(0.013)
5:Other	-0.009	-0.097	-0.030	0.013
	(0.019)	(0.067)	(0.042)	(0.014)
Age group (Base: 1:Aged 14-44)				
2:Aged45-59	0.198***			
	(0.012)			
3:Aged60-71	0.398***			
	(0.015)			
Education (Base: 1:Illiterate)				
2:Elementary	-0.027	-0.030	0.002	-0.107**
	(0.018)	(0.028)	(0.035)	(0.051)
3:Middle	-0.064***	-0.055	-0.050	-0.147***
	(0.019)	(0.036)	(0.034)	(0.048)
4:High school	-0.060***	-0.042	-0.045	-0.145***
	(0.022)	(0.057)	(0.039)	(0.049)
5:Vocational or above	-0.075***	-0.050	-0.075	-0.145***
	(0.024)	(0.086)	(0.051)	(0.049)
Observations	8,235	2,240	3,191	2,804
R-squared	0.157	0.010	0.008	0.021

Note: The dependent variable is a binary variable indicating the chronic disease condition of a resident living in Ningbo (=1 if has any chronic disease; =0 otherwise). Estimates on the constant are not reported. ***p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

Table 5 OLS estimates on having health literacy on CDP: Disease effects

Dep: Has health literacy on CDP	(1)	(2)	(3)	(4)
Panel A: Urban sample				
Any chronic diseases (=1)	0.030*			
	(0.018)			
Duration first chronic disease: One year		0.063**		
		(0.029)		
Duration first chronic disease: 2-4 years		0.025		
		(0.026)		
Duration first chronic disease: 5+ years		0.009		
		(0.027)		
One disease			0.028	
			(0.019)	
Two+ diseases			0.042	
			(0.038)	
hypertension (=1)				0.041**
				(0.021)
Heart problems (=1)				0.033
				(0.053)
Cerebrovascular disease (=1)				-0.001
				(0.092)
Diabetes (=1)				-0.022
				(0.035)
Cancer (=1)				0.101
				(0.088)
Observations	4,012	4,004	4,012	4,012
R-squared	0.077	0.078	0.077	0.078
Panel B: Rural Sample				
Any chronic diseases (=1)	0.010			
	(0.015)			
Duration first chronic disease: One year		0.089***		
		(0.021)		
Duration first chronic disease: 2-4 years		-0.017		
		(0.022)		
Duration first chronic disease: 5+ years		-0.079***		
		(0.025)		
One disease			0.003	
			(0.016)	
Two+ diseases			0.049	
			(0.031)	
hypertension (=1)				0.004
				(0.017)
Heart problems (=1)				0.133***
				(0.045)
Cerebrovascular disease (=1)				-0.025
				(0.073)
Diabetes (=1)				0.021
				(0.028)
Cancer (=1)				-0.036
				(0.069)
Observations	4,223	4,216	4,223	4,223
R-squared	0.046	0.053	0.046	0.048

Note: Dependent variable is a binary variable indicating the status of health literacy (=1 if has health literacy on CDP, =0 otherwise). Other covariates include gender, annual income, household members, occupation, age and education (and constant). Other diseases (=1) is also included in column (4), not reported to save space. Sample size differs in column (2) due to incomplete information provided by

respondents on year diagnosed with the first chronic disease. ***p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

Table 6 OLS estimates on having comorbid chronic diseases - Urban sample

Dep: Has a specific chronic disease	Cerebro. (1)	Cerebro. (2)	Heart (3)	Diabetes (4)	Diabetes (5)
Sample	Urban	Urban	Urban	Urban	Urban
Health literacy on CDP (=1)	0.001	0.001	0.005	-0.002	-0.001
	(0.003)	(0.003)	(0.005)	(0.007)	(0.007)
Heart problems (=1)	0.064***			0.033	
	(0.011)			(0.028)	
Health literacy on CDP Heart problems	-0.073***			-0.044	
	(0.021)			(0.055)	
Cancer		0.049***			
		(0.018)			
Health literacy on CDP Cancer		-0.059*			
		(0.032)			
Cerebrovascular disease (=1)			0.188***		0.091*
			(0.031)		(0.047)
Health literacy on CDP Cerebrovascular disease			-0.234***		-0.164
			(0.066)		(0.101)
Observations	4,012	4,012	4,012	4,012	4,012
R-squared	0.018	0.011	0.032	0.037	0.038

Note: The dependent variable is a binary indicating the specific chronic disease condition of a resident living in Ningbo (e.g. in column (1), =1 if has cerebrovascular disease =0 otherwise).Other covariates in each column include gender, annual income, household members, occupation, age and education (and constant). ***p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.

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