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Infectious disease-specific health literacy and its influencing factors

Research results based on a cross-sectional design study carried out in Shandong Province's rural areas

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Abstract

Rural residents face a higher risk of infectious diseases, and infectious disease-specific health literacy (IDSHL) is a crucial means of managing these risks. This study intended to survey the levels of IDSHL among rural residents in Shandong Province, China, and explore the influencing factors of IDSHL. In 2022, a cross-sectional design investigation was carried out in Shandong Province of China, involving 2283 participants recruited through a multistage sampling approach in rural regions. A cognitive questionnaire was used to assess participants' levels of IDSHL. Pearson χ^2 test was performed to compare the differences in the distribution of categorical variables between the adequate and inadequate IDSHL groups. Multicollinearity diagnosis analysis was utilized to evaluate multicollinearity. Multiple logistic regression was used to detect the possible influencing factors of IDSHL. Among the participants, 31.80% had adequate IDSHL. Multiple logistic regression demonstrated that education (odds ratio (OR)$_{\text{junior high school}}$ = .71, 95% confidence interval (CI) of OR: 0.51–0.99, P = .04; OR$_{\text{university or above}}$ = 2.62, 95% CI of OR: 1.67–4.11, P < .01), occupation (OR$_{\text{business}}$ = 2.19, 95% CI of OR: 1.34–3.57, P < .01; OR$_{\text{others}}$ = 1.46, 95% CI of OR: 1.02–2.10, P = .04), family income (OR$_{\text{1–3 10,000 RMB}}$ = 2.83, 95% CI of OR: 1.98–4.05, P < .01; OR$_{\text{3–6 10,000 RMB}}$ = 1.75, 95% CI of OR: 1.21–2.53, P < .01), "whether the participant used a smartphone in daily life" (OR = 2.02, 95% CI of OR: 1.32–3.09, P < .01) and "whether knowledge of infectious disease prevention and control could be acquired" (OR = 11.77, 95% CI of OR: 6.44–21.54, P < .01) were associated with adequate IDSHL. The rural residents' level of adequate IDSHL in China's Shandong Province, was unsatisfactory. Special health education is needed to be implemented to enhance rural residents' IDSHL and should target key populations with low levels of IDSHL.

Abbreviations: CI = confidence interval, COVID-19 = coronavirus disease 2019, HIV = human immunodeficiency virus, IDSHL = infectious disease-specific health literacy, OR = odds ratio, VIF = variance inflation factor.

Keywords: cross-sectional studies, health education, infectious diseases, infectious disease-specific health literacy, public health, rural residents

1. Introduction

Infectious diseases are a category of diseases caused by various pathogens that can be transmitted from person to person, animal to animal, or human to animal.[1] As a priority in response to global public health, infectious diseases are recognized as a leading cause of health loss worldwide.[2] Although the proportion of all deaths worldwide caused by infectious diseases decreased from 30.7% in 2000 to 18.4% in 2019,[3] the burden of infectious diseases is still serious. Infectious diseases are still among the top 10 causes of death worldwide[4] and 3 of the 10 leading causes of death were infectious diseases in 2019.[5] In 2019, infectious diseases accounted for 52.9% of all deaths in the African region and nearly 25% of deaths in the Eastern Mediterranean and Southeast Asian regions.[3] Coronavirus

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This study was approved by the Ethics Review Committee of the Shandong Second Medical University (2023YX-138). All participants included in the study provided written informed consent before participation. All methods were performed following relevant guidelines and regulations.

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disease 2019 (COVID-19) ranked among the top 3 leading causes of death globally in 2020 and 2021, responsible for 4.1 million and 8.8 million lives lost, respectively.[6] In China, it was estimated that 1.3 million deaths were attributed to infections, accounting for 12.1% of the total deaths in 2019.[7] The number of new infectious disease cases in China was 2.67 million, 2.72 million, and 2.43 million in 2020, 2021 and 2022, respectively.[8–10] Infectious diseases not only harm individuals' physical health and safety but also damage social and economic development.[11] During the COVID-19 pandemic, people had to maintain a physical distance of at least 1 m from each other, avoid crowds and close contact, and stay at home.[12] In China, there was a suspension of classes, businesses, and work when COVID-19 was spreading.[13] Infectious diseases impose an enormous burden on individuals, organizations, and governments.[14] One of the most important characteristics of infectious diseases is that they can be prevented, controlled, and cured.[15] Based on the preventable and/or controllable characteristics of infectious diseases, proactive actions should be taken to mitigate the emergence and transmission of infectious diseases.

Health literacy is able to prevent and control the transmission of infectious diseases.[16] Health literacy refers to "the cognitive and social skills that determine the motivation and ability of individuals to gain access to, understand, and use information in ways that promote and maintain good health."[17] Health literacy is a powerful predictor of health outcomes.[18] Health literacy shows a protective effect on the mental health and quality of life of individuals with or without suspected infectious disease symptoms.[19] Previous studies have shown that health literacy is helpful for the prevention of COVID-19.[20–22] Infectious disease-specific health literacy (IDSHL) is associated with a reduced likelihood of infectious disease symptoms.[23] Generally, poorer health literacy means "more hospitalizations; greater use of emergency care; poorer ability to demonstrate taking medications appropriately; poorer ability to interpret labels and health messages, poorer overall health status, and higher mortality rates."[24] Inadequate health literacy is related to poor adherence to preventive and therapeutic medical recommendations.[25] People with inadequate health literacy are less likely to adopt preventive services and health information technology.[26] For example, inadequate health literacy is detrimental to human immunodeficiency virus (HIV) treatment and the prevention of HIV transmission.[27] Health literacy is not fixed and can be improved through education.[24] Improving health literacy is a strategic approach to the prevention and control of infectious diseases.[19] For example, the promotion of health literacy could be advantageous for preventing and controlling *Opisthorchis viverrini* infection.[28] Improving health literacy can increase vaccination rates, which can decrease the incidence rates of infectious diseases.[25]

Although IDSHL has an enormous effect on the prevention and/or control of infectious diseases, its levels are unsatisfactory in some countries. A previous study showed that only 12% of Americans had adequate health literacy, whereas 36% had basic or below-basic health literacy.[18] In 1 investigation, 33.9% of English speakers and 53.9% of Spanish speakers were classified as having inadequate or marginal health literacy.[29] In a study conducted in Hong Kong, 63.28% of the participants were identified as having inadequate health literacy.[30] In China, the rate of health literacy among national residents was only 25.4% in 2021.[31] As an essential component of health literacy,[11] IDSHL, which represents an individual's ability to use health literacy to cope with infectious diseases, was also unsatisfactory. The rates of IDSHL in China were 27.60%, 28.16%, and 28.02% in 2021, 2022, and 2023, respectively.[31–33] This falls short of China's goal to achieve the 30% IDSHL rate by 2030.[34] In China, rural residents are more vulnerable to infectious diseases than urban residents due to lower levels of economic development, education, healthcare, etc. If infectious diseases spread in rural areas of China, they will cause more harm than in the urban regions of China. As IDSHL reflects people's understanding and application of the initiation, prevention, and treatment of infectious diseases,[11] it is helpful for rural residents to cope with infectious diseases. Thus, there is an urgent need to assess and improve the level of IDSHL among rural residents to respond to the potential threats of infectious diseases.

To our knowledge, there is a lack of specific research to study the level of IDSHL and explore the influencing factors of IDSHL among rural residents in China's Shandong Province. Even in China, most studies have focused on health literacy but few studies focus on IDSHL. Based on the current state of studies, this study intended to survey the level of IDSHL among rural residents in Shandong Province of China, and to explore the potential influencing factors of IDSHL. Then, potential measures targeted at improving the level of rural residents' IDSHL were discussed. Meanwhile, this study will contribute valuable insights to the existing body of research.

2. Method

2.1. Participants

This was a population-based cross-sectional design study. The design of this cross-sectional study had described in our previous study.[35] The study population were rural residents in Shandong Province of China during the 2022 survey cycle. Rural residents were operationally defined as individuals holding a rural *hukou* (household registration) with ≥ 183 days of annual residency in designated rural administrative zones.

The inclusion criteria for the rural residents were as follows: (1) residents holding a rural *hukou* (household registration) with ≥ 183 days of annual residency; (2) residents aged 18 to 71 years; (3) residents who agreed to participate in the study and were able to complete the questionnaire. Exclusion criteria were as follows: (1) students holding a rural *hukou* (household registration) who lived in designated rural administrative zones <183 days of annual residency; (2) residents holding a rural *hukou* (household registration) who lived in designated rural administrative zones <183 days of annual residency; (3) rural residents who were not willing to participate in the survey.

2.2. Sample size

The formula used to calculate the sample size was as follows: $N = 400 \times q \div p$.[36] In this formula, N is the sample size and p is the incidence rate of a certain event $q = 1 - p$. A previous investigation showed that the percentage of adequate IDSHL among Chinese residents was 17.05%.[37] Then, $P = 17.05\%$ was entered into the formula, and the sample size was calculated to be 1946. Given the potential rate of loss to follow-up, the sample size for investigation was expanded by 10% based on the calculated sample size and then calculated to be 2140.

2.3. Sampling strategy

Participants were selected using multistage sampling. Previous studies indicated that social, cultural, and economic conditions have a significant effect on individuals' health literacy levels.[38–40] The demographic characteristics of the 16 cities in Shandong Province also exhibit notable differences due to the influence of various social, economic, and cultural conditions. Thus, the 16 cities of Shandong Province were categorized into 3 distinct clusters during the first phase, with the classification criteria encompassing socioeconomic and cultural factors. Stratification was conducive to minimizing the effect on individuals' IDSHL cognition resulting from different demographic characteristics among the 3 groups. In the second phase, 2 cities were chosen at random from each of the predefined clusters to

act as representative units. Random sampling ensures the representativeness of the sample to some extent, as it guarantees that each city within the same group has an equal probability of being selected. Jinan and Qingdao were chosen as representative cities of the first distinct cluster. Weifang and Linyi were chosen as representative cities of the second distinct cluster. Dezhou and Jining were chosen as representative cities of the third distinct cluster. In the third phase, 1 county was randomly chosen as the representative county from the pre-chosen city. Huaiyin, Laixi, Anqiu, Pingyi, Qihe, and Qufu were chosen as the representative county of Jinan City, Qingdao City, Weifang City, Linyi City, Dezhou City, and Jining City, respectively. In the fourth phase, 1 town was randomly chosen as the representative town from the pre-chosen county. Yuqing Hu, Wangcheng, Jingzhi, Fengyang, Zhaoguan, and Xiaoxue were chosen as the representative town of Huaiyin County, Laixi County, Anqiu County, Pingyi County, Qihe County, and Qufu County, respectively. In the 5th phase, 1 village was randomly chosen as the representative village from the pre-chosen town and residents in the chosen villages who met the definition about participant of current study formed the sample of this study. This progressive, multi-stage design that integrates multiple sampling methods comprehensively considers differences and hierarchies in aspects such as region, economy, and culture. Finally, there were 2283 rural participants recruited meeting the inclusion criteria and regarded as the sample. The final sample for this study largely met the requirements of representativeness, randomness, and reliability.

This study was approved by the Ethics Review Committee of the Shandong Second Medical University (2023YX-138). All rural residents included in this study signed an informed consent form.

2.4. Questionnaire

Each participant independently completed a separate questionnaire. The questionnaire was adapted from the National Residents' Health Literacy Monitoring Questionnaire developed in China.[41] IDSHL is a key component within the 6 core dimensions of health literacy of the National Residents' Health Literacy Monitoring Questionnaire.[41] By consulting experts of the Center for Disease Control and Prevention of Shandong Province, 8 common infectious diseases in Shandong Province were identified as the target infectious diseases and every disease was a typical representative disease of a certain route of transmission (8 routes of transmission: air-borne/water-borne/food-borne/contact/arthropod-borne/soil-borne/iatrogenic/vertical transmission). The questions of the IDSHL questionnaire in this study were related to the knowledge of infectious disease prevention and control targeting these 8 target infectious diseases and focused on the risk factors/risk behaviors, route of transmission, prevention, and control of infectious diseases. The questions within the questionnaire underwent rigorous discussion and evaluation by a multidisciplinary team comprising experts in epidemiology, statistics, and sociology. Therefore, this questionnaire was developed to address the current situation of infectious diseases in Shandong Province and to be able to assess the ability of individuals to prevent and control infectious diseases. Then, it can assess the level of IDSHL in the target population, to a certain extent. The questionnaire included the participants' sociodemographic data, the way to obtain knowledge of infectious disease prevention and control, and the cognition about the knowledge of infectious disease prevention and control. The cognition about the knowledge of infectious disease prevention and control included the following 9 categories of cognition: cognition about common sense of infectious disease prevention and control, and cognition about knowledge of air-borne/water-borne/food-borne/contact/arthropod-borne/soil-borne/iatrogenic/vertical transmission infectious disease prevention and control. The total score of the IDSHL questionnaire was 68 points (68 questions). Participant would get 1 point if he or she correctly answered 1 above-mentioned cognition question. A certain participant's total score corresponded directly to the number of questions answered correctly by the participant. If the score of a certain participant was greater than or equal to 80% of total score of all cognition questions, (55 questions were correctly answered), this participant had adequate IDSHL.[42] Otherwise, this meant that the participant did not have adequate IDSHL. The questionnaire used in this study had acceptable reliability and validity. The internal consistency reliability test showed a Cronbach alpha coefficient of 0.73. The construct validity analysis indicated a Kaiser–Meyer–Olkin value of 0.97 and Bartlett test of sphericity revealed a result of $\chi^2 = 171567.24$ ($P < .01$).

In this study, the outcome variable was "whether the participants had adequate IDSHL." The independent variables were the demographic characteristics of the participants and factors related to acquiring IDSHL knowledge.

2.5. Statistical method

Data were expressed as "mean ± standard deviation" and "frequencies (%)" for continuous data and categorical data, respectively. When continuous variables exhibited homogeneity of variance between adequate and inadequate IDSHL groups, continuous variables were analyzed with Student *t* test by the comparison of means; otherwise, continuous variables were analyzed with Wilcoxon rank sum test by the comparison of distributional differences. Pearson χ^2 test was conducted to compare the distribution of categorical variables between the adequate and inadequate IDSHL groups. Multicollinearity diagnosis was conducted with variance inflation factor (VIF). If independent variables had VIF < 10, it means that there was no serious multicollinearity among the independent variables. Otherwise, some independent variables with collinearity needed to be deleted to ensure the independence of variables. Multiple logistic regression was used to detect the possible influencing factors of IDSHL. In multiple logistic regression, the dependent variable was "whether the participants had adequate IDSHL" and the independent variables were age, sex, education, marriage, permanent resident population of family, occupation, annual family income, "someone of family has/had attended university," "whether the participant used a smartphone in daily life," "whether the knowledge of infectious disease prevention and control could be acquired." Statistical analyses were performed using Stata version 13.1 (StataCorp LP; College Station, TX). All reported probabilities (*P* values) were two-sided. $P < .05$ was considered statistically significant.

2.6. Quality control

Some measures were used to control for possible biases. Firstly, the calculated sample size was expanded by 10% to control potential follow-up bias. Secondly, investigators underwent structured training and required to adhere to uniform standards during investigation in order to control investigation bias. Thirdly, dual-person data entry procedures were enforced to control input errors. Fourth, multiple logistic regression was used to control for the effects of potential confounding factors. In univariate analysis, the effect of certain independent variables on the dependent variable may be distorted because of the effect of other uncontrolled independent variables on the dependent variable. This deficiency can be controlled by multiple logistic regression. In this study, confounding variables, including age, sex, and education, were treated as independent variables in the multiple logistic regression. Continuous data (such as age) were included in the multiple logistic regression directly. Categorical data (such as sex and education) were included in the multiple logistic

regression in the form of dummy variables. One of the most important uses of multiple logistic regression was precisely that "of controlling for confounding" to allow the effect of the risk factor of interest on the study outcome.[43,44] Multiple logistic regression allows estimation of the effect of a given independent variable on a given dependent or outcome variable after controlling for the confounding effect of other independent variables.[43,44]

3. Results

3.1. Demographic characteristics analysis

A total of 2283 rural residents were included, and 2283 valid questionnaires were retrieved (valid response rate: 100%). Data from 2283 valid questionnaires were analyzed. The demographic characteristics of the participants were shown in Table 1. Among the participants, 31.80%, 50.07%, 76.04%, and 28.60% had adequate IDSHL, health literacy about common sense of infectious disease prevention and control, air-borne transmission IDSHL, and IDSHL of other transmission routes (except air-borne transmission), respectively. The distributions of these 4 categories of health literacy between the adequate and inadequate IDSHL groups were significantly different (χ^2 value = 1304.21, $P < .01$). There was a significantly different distribution ($P < .008$) when any 2 categories of health literacy were compared with each other.

The age of the adequate IDSHL group was significantly younger than that of the inadequate IDSHL group ($Z = 9.20$, $P < .01$).

The percentage of participants with adequate IDSHL was significantly higher in women than that in males (χ^2 value = 5.55, $P = .02$).

There were significantly different proportions of participants with adequate IDSHL among participants with different education levels (χ^2 value = 155.15, $P < .01$). When any 2 proportions of participants with adequate IDSHL between different education levels were compared with each other, there were significant differences ($P < .008$) except in the comparison between participants with a primary school or below and participants with junior high school education level.

The proportions of participants with adequate IDSHL among families with different numbers of permanent residents were significantly different (χ^2 value = 63.98, $P < .01$). Families with 3 permanent residents or more (3–4/5 or more permanent residents) had more participants with adequate IDSHL than families with 1 or 2 permanent residents ($P < .008$).

The percentages of participants with adequate IDSHL were significantly different among participants with different occupations (χ^2 value = 69.02, $P < .01$). Participants whose occupation was agriculture had a lower proportion of adequate IDSHL than participants whose occupation was not agriculture ($P < .006$).

There were significantly different percentages of participants with adequate IDSHL among participants with different annual family incomes (χ^2 value = 58.02, $P < .01$). Participants with an annual family income less than 10,000 RMB had a lower proportion of adequate IDSHL than participants with the annual family income greater than 10,000 RMB ($P < .006$).

Participants with a relative who attended university had a higher proportion of adequate IDSHL than participants who did not have a relative who attended university (χ^2 value = 5.61, $P = .02$).

The proportion of adequate IDSHL among participants who could acquire knowledge of infectious disease prevention and control was higher than that among participants who could not acquire knowledge of infectious disease prevention and control (χ^2 value = 132.61, $P < .01$).

The percentages of participants with adequate IDSHL were significantly different among participants with different levels of "whether the knowledge of infectious disease prevention and control could be acquired conveniently" (χ^2 value = 38.81, $P < .01$). There were significant differences ($P < .02$) when the percentages of participants with adequate IDSHL between any 2 levels of "whether the knowledge of infectious disease prevention and control could be acquired conveniently" were compared with each other.

Participants who used smartphones in daily life had a higher proportion of adequate IDSHL than participants who did not use smartphones in daily life (χ^2 value = 75.39, $P < .01$).

The proportions of participants with adequate IDSHL were significantly different among participants with different levels of "whether the participants browsed WeChat on their smartphones in daily life" (χ^2 value = 39.05, $P < .01$). Participants who often browsed WeChat had a higher proportion of adequate IDSHL than participants who occasionally or never browsed WeChat ($P < .008$).

The percentages of participants with adequate IDSHL were significantly different among participants with different levels of "whether participants used other smartphone applications except WeChat" (χ^2 value = 41.56, $P < .01$). The percentage of adequate IDSHL in participants who often browsed smartphone applications except WeChat was greater than that in participants who occasionally or never browsed smartphone applications except WeChat ($P < .008$).

3.2. Influencing factors analysis of IDSHL cognition

Multiple logistic regression was used to detect the possible influencing factors of IDSHL. Multicollinearity diagnosis showed that VIFs of independent variables were no more than 3 (Table 2), which means that there was no collinearity among the independent variables included in this study. The results of multiple logistic regression were shown in Table 3. Multiple logistic regression in this study demonstrated that influencing factors of IDSHL cognition included education (odds ratio $(OR)_{\text{junior high school}} = 0.71$, 95% confidence interval (CI) of OR: 0.51–0.99, $P = .04$; $OR_{\text{university or above}} = 2.62$, 95% CI of OR: 1.67–4.11, $P < .01$), occupation ($OR_{\text{business}} = 2.19$, 95% CI of OR: 1.34–3.57, $P < .01$; $OR_{\text{others}} = 1.46$, 95% CI of OR: 1.02–2.10, $P = .04$), family income ($OR_{\text{1–3 10,000 RMB}} = 2.83$, 95% CI of OR: 1.98–4.05, $P < .01$; $OR_{\text{3–6 10,000 RMB}} = 1.75$, 95% CI of OR: 1.21–2.53, $P < .01$), "whether the participant use smartphone in daily life" (OR = 2.02, 95% CI of OR: 1.32–3.09, $P < .01$) and "whether the knowledge of infectious disease prevention and control could be acquired" (OR = 11.77, 95% CI of OR: 6.44–21.54, $P < .01$). Compared with participants with primary school or below education, participants with university or above education were 2.62 times more probability to have adequate IDSHL. Participants whose occupation was business were 2.19 times more probability to have adequate IDSHL than participants whose occupation was agriculture. Participants with an annual family income of 1 to 3 10,000 RMB and 3 to 6 10,000 RMB were 2.83 and 1.75 times more likely to have adequate IDSHL than participants with an annual family income of less than 10,000 RMB, respectively. Compared with participants who did not use smartphone in daily life, participants using smartphone in daily life were 2.02 times probability to have adequate IDSHL. Participants who could acquire the knowledge of infectious disease prevention and control were 11.77 times more likely to have adequate IDSHL than participants who could not acquire the knowledge of infectious disease prevention and control.

4. Discussion

This study indicated that 31.80% of rural residents in China's Shandong Province demonstrated adequate IDSHL. Occupation, education, annual family income, "whether the participant used a smartphone in daily life" and "whether the knowledge of

Table 1

The comparisons of some demographic characteristics between adequate infectious disease-specific health literacy and inadequate Infectious disease-specific health literacy groups.

Variable	Subgroup	Inadequate IDSHL	Adequate IDSHL	Statistical value	*P* value*
Health literacy	Infectious disease-specific health literacy	1557 (68.20)	726 (31.80)	1304.21†‡	<.01‡
	Health literacy about common sense of infectious disease prevention and control	1140 (49.93)	1143 (50.07)		
	Air-borne transmission infectious disease-specific health literacy	547 (23.96)	1736 (76.04)		
	Other transmissions infectious disease-specific health literacy	1630 (71.40)	653 (28.60)		
Age		48.73 ± 14.74	42.77 ± 13.00	9.20*	<.01
Region	Dezhou city	297 (72.79)	111 (27.21)	130.55†	<.01
	Jinan city	124 (53.68)	107 (46.32)		
	Jining city	221 (52.87)	197 (47.13)		
	Linyi city	219 (62.39)	132 (37.61)		
	Qingdao city	344 (81.52)	78 (18.48)		
	Weifang city	352 (77.70)	101 (22.30)		
Sex	Male	760 (70.63)	316 (29.37)	5.55†	.02
	Female	797 (66.03)	410 (33.97)		
Education	Primary school or below	336 (79.25)	88 (20.75)	155.15†	<.01
	Junior high school	844 (74.56)	288 (25.44)		
	Senior high school	272 (57.63)	200 (42.37)		
	College/university diploma or above	105 (41.18)	150 (58.82)		
Marriage	Single	118 (65.92)	61 (34.08)	2.66†	.26
	Married	1384 (68.11)	648 (31.89)		
	Widowed	55 (76.39)	17 (23.61)		
Permanent resident population of family	1 person	63 (81.82)	14 (18.18)	63.98†	<.01
	2 persons	410 (81.19)	95 (18.81)		
	3–4 persons	779 (64.86)	422 (35.14)		
	5 or more persons	305 (61.00)	195 (39.00)		
Occupation	Agriculture	739 (77.38)	216 (22.62)	69.02†	<.01
	Local migrant worker' s work	414 (62.44)	249 (37.56)		
	Non-local migrant worker's work	225 (64.47)	124 (35.53)		
	Business	50 (55.56)	40 (44.44)		
	Others	129 (57.08)	97 (42.92)		
Annual family income	Less than ten thousand RMB	271 (83.64)	53 (16.36)	58.02†	<.01
	1–3 ten thousand RMB	428 (62.66)	255 (37.34)		
	3–6 ten thousand RMB	427 (67.89)	202 (32.11)		
	6–9 ten thousand RMB	272 (71.96)	106 (28.04)		
	More than 9 ten thousand RMB	159 (59.11)	110 (40.89)		
Someone of family have/had attended university	Yes	745 (65.87)	386 (34.13)	5.61†	0.02
	No	812 (70.49)	340 (29.51)		
Whether the knowledge of infectious disease prevention and control could be acquired	Yes	1253 (63.70)	714 (36.30)	132.61†	<.01
	No	304 (96.20)	12 (3.80)		
Whether the knowledge of infectious disease prevention and control could be acquired conveniently	Very convenient	640 (58.34)	457 (41.66)	38.81†	<.01
	Convenient	559 (69.18)	249 (30.82)		
	Inconvenient	54 (87.10)	8 (12.90)		
Whether the participant used a smartphone in daily life	Yes	1264 (64.72)	689 (35.28)	75.39†	<.01
	No	293 (88.79)	37 (11.21)		
Whether the individual browsed WeChat on their smartphone in daily life	Often	794 (60.66)	515 (39.34)	39.05†	<.01
	Occasionally	394 (70.74)	163 (29.26)		
	When someone sends link	23 (79.31)	6 (20.69)		
	Never	53 (91.38)	5 (8.62)		
Whether the participant used other smartphone applications except WeChat	Often	786 (60.23)	519 (39.77)	41.56†	<.01
	Occasionally	403 (71.84)	158 (28.16)		
	When someone sends link	20 (86.96)	3 (13.04)		
	Never	55 (85.94)	9 (14.06)		

Data were displayed as "mean ± SD" (quantitative data) or "frequency (%)" (qualitative data).

IDSHL = Infectious disease-specific health literacy.

*Wilcoxon rank sum test.

†Pearson's χ^2 test.

‡There was significant difference when any two groups were compared with each other ($P < .008$).

infectious disease prevention and control could be acquired" were the influencing factors of adequate IDSHL in multiple logistic regression.

In Shandong Province of China, the proportion (31.80%) of adequate IDSHL among rural residents in this investigation was higher than that (27.60%) among residents in China in 2021.[31] In Shandong Province in China, this proportion was higher than the same proportions (residents in Tai'an City in 2020: 20.96%,[45] rural residents in Tai'an City in 2020: 18.29%,[45] residents in Qingdao City in 2019: 17.47%[46]) reported in previous studies carried out in Shandong Province. This proportion was also higher than those reported in previous studies conducted in other provinces in China (residents in Yunnan Province in 2018: 16.95%,[47] urban residents in Hubei

Province in 2018: 27.4%,[48] rural residents in Hubei Province in 2018: 16.8%,[48] rural residents in Guizhou Province in 2019: 6.38%[49] and rural residents in Sichuan Province in 2017: 14.1%[50]). There are some possible explanations for the higher level of adequate (31.80%) revealed by current study. First, many health education measures were implemented during the COVID-19 pandemic from 2019 to 2022 in China, especially health education about knowledge of air-borne transmission infectious disease prevention and control.[51] Consequently, the level of IDSHL among residents in China was improved.[51] This may be 1 reason why the level of adequate IDSHL in 2022 was higher than that before 2022. Second, residents' IDSHL is related to the local economy, education, and other socioeconomic factors.[52] Generally, higher levels of economic development and/or education indicate higher levels of adequate IDSHL.[23] A high level of economy means that more moneies can be allocated for health education (including health education about infectious disease prevention and control) for government and residents can invest more time and resources in education. With a high level of economy and education, residents have more time and ability to acquire and master knowledge (including knowledge about infectious disease prevention and control). Then, residents may have high level of health literacy. In China, Shandong Province demonstrated significantly higher levels of economic development and educational attainment compared to Yunnan, Hubei, Guizhou and Sichuan Province.[10] Benefiting from the high level of economy and education, rural residents in Shandong Province developed a high level of adequate IDSHL. This may explain why rural residents of Shandong Province had higher level of adequate IDSHL compared with rural residents of the above-mentioned provinces in China. Third, the different questionnaires used in these studies may result in different levels of adequate IDSHL. Thus, developing the specialized survey questionnaire becomes the next research focus. Interestingly, the level of health literacy regarding air-borne transmission (76.04%) was significantly higher than that of health literacy regarding common sense of infectious disease prevention and control (50.07%) and other transmission routes (28.60%). This may attribute to the health education about air-borne diseases provided during the COVID-19 pandemic, which resulted in residents having greater cognition of air-borne diseases compared with that of other routes transmission diseases. Therefore, health education about infectious disease prevention and control is necessary to improve residents' IDSHL.

This proportion (31.80%) of adequate IDSHL in this study was different from the results of other countries' studies. Internationally, IDSHL is often assessed by measuring the health literacy levels of people with infectious diseases, and also by developing measurement tools for specific infectious diseases to assess the IDSHL levels of both patients and the general public.[53] A cross-sectional study in Indonesia found that 61.5% of people living with HIV had high levels of health literacy.[54] Approximately 49.9% of participants in Germany had sufficient coronavirus-related health literacy.[55] A cross-sectional study focused on the susceptible population residing in a COVID-19 hotspot of urban Jodhpur, Rajasthan found that 17.9% of participants had adequate health literacy levels.[22] An Australian study conducted during the Pandemic 2020 Stage 3 Restrictions found that 87% of subjects had adequate health literacy.[56] A South African study on HIV and AIDS prevention found that 44% of participants had adequate health literacy.[57] There are some possible explanations for the difference in IDSHL in various countries. First, the international assessment system for IDSHL is not uniform, specifically in terms of assessment scales.[53] General IDSHL, covering multiple infectious diseases, is often assessed using health literacy scales, such as the Rapid Estimate of Adult Literacy in Medicine and the Short Test of Functional Health Literacy in Adults.[53] Given the variation in common infectious diseases across countries and the specificity of knowledge required for each, the health literacy scales may not fully capture the cognitive and social skills that determine the motivation and ability of individuals to gain access to, understand, and use information for the prevention and control of infectious diseases. Single-disease IDSHL questionnaires, such as Coronavirus-Related Health Literacy Survey Questionnaire,[55] help address this limitation to some extent. However, their focus on a particular infectious disease does not provide a comprehensive picture of the population's general IDSHL. This makes the comparing IDSHL levels across countries challenging. Second, demographic, social and cultural circumstances (e.g., socioeconomic status, employment, income, social support, culture, and language) have influenced IDSHL levels.[52] Then, the differences of IDSHL levels across countries resulted from the differences of demographic, social and cultural circumstances across countries may occur. Third, health education may be inadequate in some countries, resulting in individuals with different levels of health literacy.

Table 2

Variance inflation factor analysis of variables.

Variable	VIF
Age	2.02
Sex	1.03
Education	1.62
Marriage	1.23
Permanent resident population of family	1.22
Occupation	1.12
Annual family income	1.14
Someone of family has/had attended university	1.12
Whether the knowledge of infectious disease prevention and control could be acquired	1.20
Whether the participant used a smartphone in daily life	1.47

VIF = variance inflation factor.

In line with previous national and international studies,[20,26,58,59] occupation was an influencing factor for an adequate IDSHL. There were some possible explanations for why residents whose occupation was agriculture had a lower proportion of adequate IDSHL compared with residents whose occupation was not agriculture. First, residents whose occupation was agriculture had relatively low levels of education and economic status. A lower level of education leads to a lower ability to understand and/or utilize knowledge of infectious disease prevention and control. A lower economic level means that there is less spare time and energy to acquire and learn about knowledge of infectious disease prevention and control. Second, residents in China, whose occupation is agriculture, generally live where their households are registered. Thus, they have fewer opportunities to contact with the world outside where they live. Third, health education in China is provided more often in urban areas than in rural areas.[60] These factors may result in that residents whose occupation were agriculture had few opportunity to obtain knowledge of infectious disease prevention and control. Accordingly, these residents had a lower level of adequate IDSHL compared to residents whose occupation was not agriculture. More special health education about the knowledge of infectious disease prevention and control should be conducted in rural areas to improve the residents' level of IDSHL during the slack season in farming.

In this study, education was positively correlated with adequate IDSHL, which was consistent with the findings of domestic and international studies.[20,23,49,61] To a certain extent, education is the embodiment of a person's comprehensive qualities. Education is related to the ability to read, understand, analyze, and obtain knowledge. Compared with residents with higher education levels, residents with lower education levels may generally have barriers in accessing, understanding, and/

Table 3

Logistic regression about the influence factors of infectious disease-specific health literacy.

Variable	Subgroup	OR	*P* value	95% CI of OR
Age		0.99	.40	0.98–1.01
Sex	Male*	1.00	–	–
	Female	1.16	.15	0.95–1.41
Education	Primary school or below*	1.00	–	–
	Junior high school	0.71	.04	0.51–0.99
	Senior high school	1.44	.06	0.98–2.10
	University or above	2.62	<.01	1.67–4.11
Marriage	Single*	1.00	–	–
	Married	1.48	.06	0.98–2.25
	Widowed, divorced or others	1.88	.11	0.88–4.06
Permanent resident population of family	1 person*	1.00	–	–
	2 persons	0.97	.93	0.47–1.98
	3–4 persons	1.79	.10	0.89–3.59
	5 persons or more	1.79	.11	0.87–3.68
Occupation	Agriculture*	1.00	–	–
	Local migrant worker's work	1.23	.11	0.95–1.58
	Non-local migrant worker's work	1.19	.25	0.88–1.61
	Business	2.19	<.01	1.34–3.57
	Others	1.46	.04	1.02–2.10
Annual family income	Less than 10,000 RMB*	1.00	–	–
	1–3 10,000 RMB	2.83	<.01	1.98–4.05
	3–6 10,000 RMB	1.75	<.01	1.21–2.53
	6–9 10,000 RMB	1.06	.76	0.71–1.59
	More than 9 10,000 RMB	1.42	.10	0.93–2.18
Someone of family has/had attended university	Yes*	1.00	–	–
	No	1.14	.21	0.93–1.40
Whether the participant used a smartphone in daily life	No*	1.00	–	–
	Yes	2.02	<.01	1.32–3.09
Whether the knowledge of infectious disease prevention and control could be acquired	No*	1.00	–	–
	Yes	11.77	<.01	6.44–21.54

CI = confidence interval, OR = odds ratio.

* Reference classification.

or using health information, health services, and especially special knowledge of infectious disease prevention and control.[17,26] In addition, people with higher education levels, to a certain extent, tend to have higher levels of social status and economic status, and they may also have greater autonomy in learning about infectious diseases.[25] Accordingly, people with higher education levels have more opportunities to acquire, understand, and utilize knowledge of infectious disease prevention and control. As a result, people with higher education levels usually have higher levels of IDSHL. On the contrary, rural residents with low levels of education usually have lower levels of IDSHL. The rural residents with low levels of education are a vulnerable group in terms of IDSHL and need to be targeted in health education. Although the level of academic education of residents cannot be improved, special health education about knowledge of infectious disease prevention and control can be conducted to improve residents' level of IDSHL.[24,62]

The results of this study showed that whether participants used smartphones in daily life was an influencing factor for an adequate IDSHL. In the Internet era, an increasing number of units and individuals prefer to publish health information online. Applications on smartphones, such as WeChat and Douyin in China, are attractive platforms for publishing and/or learning health information.[63–65] Many healthcare professionals use these platforms to provide comprehensive and systematic information on common diseases. Additionally, medical websites allow patients to consult with specialists without leaving their homes. Simultaneously, an increasing number of residents tend to search for health information through the Internet and social media worldwide.[20,63,66,67] When a resident searches for a specific disease through the Internet, the first result of searches is usually a specialized medical website which provides detailed information about the disease. The health information includes prevention methods, diagnosis, and treatment of common diseases that can be accessed through smartphones. Thus, residents can obtain and/or acquire knowledge about infectious disease prevention and control using smartphones. In contrast, residents who do not use smartphones lose some opportunities to obtain knowledge of infectious disease prevention and control. This may be the reason why residents who used smartphones had a higher proportion of adequate IDSHL than those who did not. Therefore, health education for infectious disease prevention and control through smartphones is a recommended approach.

There are several recommendations based on the current study about health education. Firstly, multiple forms of health education should be adopted. Health education should include both online and offline. For online health education, it is important for government to establish authoritative accounts on multiple platforms to disseminate accurate and easy-to-understand health information. For offline health education, organizational training, face-to-face presentation of relevant information by staff, leaflets and announcements are useful. Secondly, health education is a task that takes a long time. Therefore, health education should be carried out as part of the daily routine in healthcare facilities and integrated with the daily work and life of the population. Third, in this study, rural residents with low level of education were likely to have low levels of IDSHL. Health education efforts should be more focused on this population group. Health education for rural residents with low levels of education should be conducted in a simple and understandable form. For example, basic literacy-style infectious disease knowledge popularization activities combining pictures, stories and other forms can be carried out to gradually improve their ability to understand health information. Simultaneously, a monitoring and evaluation system for infectious disease health literacy in rural areas should be

established to regularly assess residents' knowledge levels. This will enable timely adjustment of educational strategies and resource allocation in order to ensure that various intervention measures effectively improve rural residents' infectious disease health literacy levels. Moreover, the inclusion of health education in the 9-year compulsory education curriculum, the development of school health services and the promotion of health-promoting schools can reduce the adverse impact of low levels of education on IDSHL.

This study had several strengths. Firstly, the questionnaire was adapted from the National Residents' Health Literacy Monitoring Questionnaire developed in China. It had acceptable reliability and validity. Therefore, this questionnaire can be used to estimate the capacity of rural residents dealing with infectious diseases in Shandong Province. Then, it is conducive to understanding rural residents' IDSHL and developing appropriate public health education policies. Secondly, factors influencing IDSHL were explored. Based on the findings, populations with low IDSHL levels were identified. Health education targeting these key populations should then be conducted. Thirdly, the findings of the current study can fill the gap in the existing research.

This study have some potential limitations. First, given the inherent limitations of cross-sectional study, bias (for example recall bias) may have adversely affected the accuracy of the obtained results. In cross-sectional studies, recall bias may occur when participants need to recall past events and participants can't remember past events clearly. Recall bias may result in the exposures being exaggerated or covered. Then, the true relationship between exposure and outcome will be overestimated or underestimated. Furthermore, the cross-sectional design limits the ability to infer causal relationships between the factors identified and IDSHL levels. Therefore, prospective studies are needed to further verify the findings of this study. Second, the questionnaire utilized in current research was not identical to the questionnaires utilized in previous researches, even though the questionnaire utilized in current study demonstrated acceptable reliability and validity. This may have affected the comparison between this study and the previous studies. A questionnaire that is universally applicable to IDSHL across countries and regions can help to compare IDSHL levels across countries and regions. Therefore, it is needed to develop a universal questionnaire in the future.

This study showed that the level of adequate IDSHL of rural residents in China's Shandong Province was unsatisfactory. Education, occupation, family income, "whether the participant used a smartphone in daily life" and "whether the knowledge of infectious disease prevention and control could be acquired" were related to adequate IDSHL This study found that health education about infectious disease prevention and control was still needed for rural residents in Shandong Province in order to improve the level of IDSHL. Health education should pay more attention to populations with low levels of IDSHL, such as those with low levels of education, those engaging in agricultural production, and those with low levels of family income. Although the findings of this study need to be further confirmed, they verify the results of previous similar studies and provide research interest for future studies.

Author contributions

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