Health Literacy and its Association with Prehypertension: Insights from the 2023 Korea National Health and Nutrition Examination Survey

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Abstract

Background: Hypertension represents a significant global health challenge, closely linked to cardiovascular diseases and elevated premature mortality rates. Prehypertension, defined as elevated blood pressure not meeting the diagnostic criteria for hypertension, necessitates early intervention to prevent disease progression. Health literacy, defined as the capacity to comprehend and utilize health-related information, is positively associated with better health outcomes.

Objective: This study investigated the relationship between health literacy and prehypertension in adults in South Korea, aiming to identify how health literacy may influence the management and prevention of prehypertension. Although prior research has concentrated on health literacy in cardiovascular diseases, most have emphasized treatment adherence, behavioral enhancement, and patient outcomes. Furthermore, current health literacy assessment instruments are frequently designed for particular diseases or disadvantaged groups, without considering the broader health context. This study aimed to address the public health concern of prehypertension and its association with health literacy in South Korea, utilizing the most recent Korean population-based sample data to investigate affected subgroups and the correlation between health literacy deficiencies and the risk of prehypertension.

Methods: Data were obtained from the 2023 Korea National Health and Nutrition Examination Survey, a nationally representative cross-sectional study. A stratified, multi-stage clustered sampling design was employed to invite participants. Adults aged 19 years and older who completed the health literacy assessment were included in the analysis. Health literacy was measured using the Korean Health Literacy Index. Prehypertension was defined as a systolic blood pressure of 130–139 mmHg or a diastolic blood pressure of 80–89 mmHg. A multivariable survey-weighted logistic regression model was employed to assess the association between health literacy and prehypertension, adjusting for sociodemographic and health-related co-variates.

Results: Of the 1,873 participants, 319 (17%) had prehypertension, and 58.6% showed inadequate health literacy. After adjusting for confounders, those with low health literacy had a 43% higher likelihood of prehypertension (odds ratio: 1.43; 95% confidence interval: 1.07–1.91) than did those with high health literacy. This association was particularly strong among women, middle-aged adults, individuals with lower education levels, and those with healthy habits.

Conclusions: A substantial association between low health literacy and prehypertension was observed. These findings highlight the importance of enhancing health literacy for the early management and prevention of hypertension. Further longitudinal studies are needed to confirm causal relationships and identify effective interventions.

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Abstract

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model was employed to assess the association between health literacy and prehypertension, adjusting for sociodemographic and health-related co-variates.

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Of the 1,873 participants, 319 (17%) had prehypertension, and 58.6% showed inadequate health literacy. After adjusting for confounders, those with low health literacy had a 43% higher likelihood of prehypertension (odds ratio: 1.43; 95% confidence interval: 1.07–1.91) than did those with high health literacy. This association was particularly strong among women, middle-aged adults, individuals with lower education levels, and those with healthy habits.

Conclusion

A substantial association between low health literacy and prehypertension was observed. These findings highlight the importance of enhancing health literacy for the early management and prevention of hypertension. Further longitudinal studies are needed to confirm causal relationships and identify effective interventions.

Keywords: Hypertension; Prehypertension; Cardiovascular Diseases; Public Health; Prevention; Health Literacy; Awareness; Social Determinant of Health.

Introduction

Hypertension is often referred to as “the silent killer” and is recognized as a leading global risk factor, significantly contributing to several health problems and fatalities, such as stroke, heart attack, heart failure, and kidney failure [1]. In particular, hypertension is the primary individual risk factor for premature mortality, resulting in approximately 10.8 million preventable deaths worldwide each year. The global report on hypertension released by the World Health Organization (WHO) in 2030 indicated that the prevalence of hypertension doubled from 650 million to 1.3 billion individuals over approximately 30 years since 1990 [1]. A similar trend has been observed in South Korea. According to a report by the Health Insurance Review and Assessment Service in December 2024, the number of patients undergoing hypertension treatment in South Korea steadily increased from 6.32 million in 2018 to 7.27 million in 2022 [2]. As of 2021, the hospital admission rate for hypertension was 62.5 per 100,000 persons, exceeding the Organization for Economic Cooperation and Development average of 54.8.

Hypertension increases the risk of vascular diseases as cumulative exposure rises [3]. Consequently, proactive care during the prehypertensive stage is crucial. Moreover, early screening reduces the interval between diagnosis and treatment. Individuals in the prehypertensive stage face a higher risk of developing hypertension and cardiovascular diseases (CVD) than do those with normal blood pressure [4-6]. Moreover, studies indicate that individuals in the prehypertensive stage exhibit more significant target-organ damage, such as vascular alterations and microalbuminuria, than do those with normal blood pressure. Thus, the significance of proactive blood pressure control is evident. Recently, there has been an increasing trend to classify prehypertension as a disease. In the United States, starting in 2017, the American College of Cardiology and the American Heart Association (ACC/AHA) redefined blood pressure readings characterized by a systolic blood pressure (SBP) of 130–139 mmHg or a diastolic blood pressure (DBP) of 80–89 mmHg—previously

termed prehypertension—as stage 1 hypertension, thus categorizing it as a disease rather than just a risk factor or pre-disease condition [7, 8].

The WHO provides information, including previously mentioned guidance on hypertension prevention, to both health professionals and the public [1, 9]. Such health information offers a rational basis for disease prevention, health behaviors, and health-related decision-making [10]. Health literacy encompasses the capacity of individuals to obtain, comprehend, and utilize knowledge to promote and maintain optimal health for themselves, their families, and their communities. According to the WHO, health literacy comprises the following competencies: healthcare encompasses the ability to access and make decisions regarding medical issues; disease prevention involves the capacity to understand and react to information concerning health risks; and health promotion includes the ability to remain educated about health issues and make reasoned judgments on them. People with higher health literacy are less likely to experience medication issues or system process errors, such as ambiguous instructions or contradictory information, because they understand health information more easily. Furthermore, they tend to engage in healthy behaviors and actively participate in accessible healthcare services [11, 12]. Numerous studies have indicated that low health literacy correlates with hypertension and CVD [13-16]. Following the 2014 United Nations General Assembly High-level Meeting, governments worldwide acknowledged the importance of enhancing health literacy for the prevention and management of CVD and other non-communicable diseases, committing to ongoing development, reinforcement, and implementation [17]. In clinical settings as well, health literacy is regarded as a crucial concept closely linked to patient safety [12, 18, 19]. The comprehension of health literacy is emphasized as a major health determinant in public health and clinical contexts [14, 18, 20-22].

Previous studies examining the relationship between health literacy and CVD have predominantly focused on treatment adherence, behavior improvement, and patient prognosis [15, 23-25]. Additionally, the health literacy measurement tools used in prior research were mostly

designed for specific diseases or disadvantaged populations, typically focusing on the functional comprehension of health literacy related to medical terminology or hospital-centered healthcare systems [26]. In 2023, the Korea Disease Control and Prevention Agency (KDCA) developed a health literacy measurement tool that aligns with Korea's 5th Health Plan 2030 and accurately reflects the Korean health environment [27]. The tool was included in the health survey section of the 2023 Korea National Health and Nutrition Examination Survey (KNHANES), where it measured the health literacy of participants, and the results were publicly released in 2025.

In the context of national public health, prehypertension represents a substantial risk for the subsequent onset of hypertension, CVDs, and premature mortality, thereby imposing a significant burden on public health systems. Early intervention is therefore crucial. Moreover, higher health literacy has also been correlated with considerably better health outcomes, such as improved blood pressure control, disease education, medication adherence, exercise, and dietary habits, according to a several studies. In other words, health literacy serves as a modifiable key determinant that improves the potential for lifestyle changes and the efficacy of public health interventions. Consequently, it must be regarded as a fundamental priority in hypertension management strategies.

Therefore, in this study, we aimed to investigate the following: the association between health literacy and prehypertension in the Korean population using data from the KNHANES, subgroups notably impacted by health literacy, and the association between the level of health literacy deficiency and the likelihood of prehypertension.

Methods

Data

This cross-sectional study utilized data from the 2023 KNHANES. The data were collected by the KDCA between January and December 2023. The target population of the KNHANES includes South Korean citizens. A stratified, multi-stage clustered sampling design was employed

within the sample framework. The survey comprised three questionnaire categories: Health Interview Survey, Health Examination Survey, and Nutrition Survey. The initial data collection received approval from the Institutional Review Board of KDCA, and informed consent for secondary data analyses was waived under the same approval (2022-11-16-R-A).

Study Population

Of the 6,929 individuals invited to participate in the KNHANES, this study primarily included respondents aged 19 years and older who completed all health literacy questionnaires. Subsequently, individuals with hypertension (SBP ≥140 mmHg, DBP ≥90 mmHg, or those on antihypertensive medication), diabetes (fasting blood sugar level ≥126 mg/dL, those on diabetes medication or insulin, medically diagnosed cases, or glycated hemoglobin level ≥6.5%), or dyslipidemia (8 h fasting total cholesterol level ≥240 mg/dL, low-density lipoprotein cholesterol level ≥160 mg/dL, high-density lipoprotein cholesterol level <40 mg/dL, 12 h fasting triglyceride level ≥200 mg/dL, or those on cholesterol-lowering medication) were excluded from the study. Furthermore, individuals with missing values for covariates incorporated into the study model were excluded. A total of 1,873 participants were included in the final study sample (Figure 1).

Variables

Prehypertension

Prehypertension was defined as an SBP of 130–139 mmHg or DBP of 80–89 mmHg. The KNHANES employed an oscillometric blood pressure monitor (WatchBP Office; Microlife AG, St. Gallen, Switzerland) for blood pressure measurements. The results and subsequent adjustments were evaluated and published by a panel of experts from the Korean Society of Hypertension and associated disciplines.

Health Literacy

Health literacy was measured using the Health Literacy Index [27]. The 10 self-reported items were scored on a scale from 10 to 40 points. Scores of 31 or higher were categorized as “high health literacy,” whereas scores below 31 were classified as “low health literacy” in accordance with the criteria established in the research that developed the Health Literacy Index.

Covariates

Demographic and socioeconomic variables included sex; age (categorized in 10-year intervals from the 20s to 70s and above); highest educational attainment (below elementary school, middle school, high school, or college and above); household income (high, medium, or low); employment status; residential area (metropolitan, city, or rural); marital status; and type of healthcare coverage (employer-insured, self-employed insured, or receiving medical aid). Health status and lifestyle variables included body mass index (BMI) ($\geq$25 kg/m^2, or $<$25 kg/m^2); comorbidities (clinically verified elevated cholesterol or borderline diabetes); smoking status (smoker or non-smoker); high-risk alcohol consumption—defined as an average intake of seven or more drinks per occasion for men, and five or more for women, with consumption occurring more than twice per week; and physical activity—defined as walking for at least 30 min on 5 or more days per week or completing strength training on at least 2 days per week.

Statistical Analysis

Participant characteristics are presented as frequencies and percentages for categorical variables, and group differences were evaluated using the Rao–Scott chi-squared test. Continuous variables are presented as means and standard deviations, and comparisons between groups were made using two-sample t-tests. A multivariable survey-weighted logistic regression analysis was conducted to evaluate the relationship between health literacy and prehypertension status and to

perform subgroup analyses by independent variables and health literacy domains. Sampling weights were applied to account for the complex survey design. The same regression model was applied to assess dose-response trends (P for trend). A survey-weighted multinomial logistic regression model was used to evaluate the relative likelihood of differing blood pressure levels between low and high health literacy groups, adjusting for demographic, socioeconomic, and health-related covariates.

All estimates were reported as odds ratios (ORs) with corresponding 95% confidence intervals (CIs). A P-value of less than 0.05 was defined as statistically significant, and all analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Multicollinearity was verified using variance inflation factors, confirming no significant multicollinearity among the independent variables included in the model.

Results

Table 1 outlines the general characteristics of the study population, revealing that 319 participants (19%) had prehypertension among the 1,873 surveyed. A total of 1,098 participants (58.6%) were classified as having low health literacy. Participants with low health literacy had a significantly greater prevalence of prehypertension (20.8%) than did those with high health literacy (11.7%), as confirmed by the Rao–Scott chi-squared test (P<0.0001). Moreover, significant differences in the prevalence of prehypertension were observed across various factors, including sex, age, highest level of education attained, household income, marital status, type of healthcare coverage, BMI, presence of pre-chronic disease stages, smoking status, and high-risk drinking behavior. The estimates of population descriptive statistics using survey-weights are presented in Supplementary Table S1.

Table 1. General Characteristics of the Study Population

Variables	Total (%, ±SD)		Prehypertension				*P*-value[b]
			Yes		No		
			N / Mean	(%, ±SD)	N / Mean	(%, ±SD)	
Total	1,873	(100.0)	319	(17.0)	1,554	(83.0)	
Health Literacy[a]							<.0001
Low	1,098	(58.6)	228	(20.8)	870	(79.2)	
High	775	(41.4)	91	(11.7)	684	(88.3)	
Sex							<.0001
Male	659	(35.2)	158	(24.0)	501	(76.0)	
Female	1,214	(64.8)	161	(13.3)	1,053	(86.7)	
Age							<.0001
19-29	394	(21.0)	28	(7.1)	366	(92.9)	
30-39	374	(20.0)	41	(11.0)	333	(89.0)	
40-49	446	(23.8)	74	(16.6)	372	(83.4)	
50-59	275	(14.7)	56	(20.4)	219	(79.6)	
60-69	254	(13.6)	74	(29.1)	180	(70.9)	
70 ≤	130	(6.9)	46	(35.4)	84	(64.6)	
Educational Level							<.0001
Middle school graduate or less	199	(10.6)	63	(31.7)	136	(68.3)	
High school graduate	625	(33.4)	110	(17.6)	515	(82.4)	
College graduate or higher	1,049	(56.0)	146	(13.9)	903	(86.1)	
Household Income							0.017
High	651	(34.8)	89	(13.7)	562	(86.3)	
Middle	1,024	(54.7)	179	(17.5)	845	(82.5)	
Low	198	(10.6)	51	(25.8)	147	(74.2)	
Work Status							0.0521
Employed	1,249	(66.7)	196	(15.7)	1,053	(84.3)	
Unemployed	624	(33.3)	123	(19.7)	501	(80.3)	
Residence							0.1064
Metropolitan or city	1,578	(84.2)	259	(16.4)	1,319	(83.6)	
Rural	295	(15.8)	60	(20.3)	235	(79.7)	
Marital status							0.0004
Married	1,277	(68.2)	251	(19.7)	1,026	(80.3)	
Single	596	(31.8)	68	(11.4)	528	(88.6)	
Healthcare Coverage							0.0094
Employee insured	536	(28.6)	111	(20.7)	425	(79.3)	

Self-employed insured	1,295	(69.1)	199	(15.4)	1,096	(84.6)	
Medical aid	42	(2.2)	9	(21.4)	33	(78.6)	
Body Mass Index (kg/m^2)							<.0001
	22.8	(±3.4)	24.2	(±3.6)	22.6	(±3.3)	
Borderline Dyslipidemia							<.0001
Yes	756	(40.4)	169	(22.4)	587	(77.6)	
No	1,117	(59.6)	150	(13.4)	967	(86.6)	
Pre-diabetes							<.0001
Yes	399	(21.3)	117	(29.3)	282	(70.7)	
No	1,474	(78.7)	202	(13.7)	1,272	(86.3)	
Smoking Status							0.0475
Current smoker	234	(12.5)	50	(21.4)	184	(78.6)	
Never or former smoker	1,639	(87.5)	269	(16.4)	1,370	(83.6)	
High-risk Drinking							0.0026
Yes	183	(9.8)	46	(25.1)	137	(74.9)	
No	1,690	(90.2)	273	(16.2)	1,417	(83.8)	
Physical Activity							0.0941
Yes	1,075	(57.4)	167	(15.5)	908	(84.5)	
No	798	(42.6)	152	(19.0)	646	(81.0)	

[a] Health literacy was measured using the Korean health literacy index developed by Yoon Jung-hee et al. (2023). Following the recommendations presented in the paper, health literacy scores was classified below 31 as low and those above 31 as high.
[b] The Rao-Scott Chi-square test for categorical variables and two-sample t-test for continuous variables were performed at a 0.05 significance level.
*Abbreviation: Standard Deviation, SD.

Table 2 presents the results of the multivariable survey-weighted logistic regression analysis examining the association between health literacy and prehypertension. After adjusting for sociodemographic and health-related factors, the main analysis indicated that individuals with low health literacy had a 43% increased likelihood of prehypertension compared with those with higher health literacy (OR: 1.43; 95% CI: 1.07–1.91).

Table 2. Results of Association between Health Literacy and Prehypertension

Variables	Prehypertension	
	OR[a]	95% CI
Health Literacy		
Low	1.43	(1.07 - 1.91)
High	1.00	
Sex		
Male	1.86	(1.39 - 2.51)
Female	1.00	
Age		
19-29	1.00	
30-39	2.07	(1.12 - 3.83)
40-49	3.82	(2.10 - 6.97)
50-59	4.45	(2.28 - 8.70)
60-69	6.62	(3.31 - 13.24)
70 ≤	6.86	(3.07 - 15.32)
Educational Level		
Middle school graduate or less	1.26	(0.73 - 2.17)
High school graduate	1.04	(0.74 - 1.47)
College graduate or higher	1.00	
Household Income		
High	1.00	
Middle	1.09	(0.73 - 1.62)
Low	1.57	(0.79 - 3.15)
Work Status		
Employed	1.00	
Unemployed	1.56	(1.13 - 2.15)
Residence		

Metropolitan or city	1.00				
Rural	0.83	(0.55	-	1.26)	
Marital status					
Married	1.00				
Single	1.36	(0.89	-	2.08)	
Healthcare Coverage					
Employee insured	1.00				
Self-employed insured	0.87	(0.63	-	1.19)	
Medical aid	0.48	(0.19	-	1.26)	
Body Mass Index (kg/m^2)					
	1.13	(1.09	-	1.18)	
Borderline Dyslipidemia					
Yes	1.50	(1.12	-	2.00)	
No	1.00				
Pre-diabetes					
Yes	1.20	(0.87	-	1.67)	
No	1.00				
Smoking Status					
Current smoker	1.16	(0.76	-	1.76)	
Never or former smoker	1.00				
High-risk Drinking					
Yes	1.86	(1.21	-	2.87)	
No	1.00				
Physical Activity					
Yes	1.00				
No	1.25	(0.92		1.70)	

[a] Adjusted for sex, age, education, income, employment, residence, marriage, healthcare coverage, body mass index, borderline dyslipidemia, pre-diabetes, smoking, high-risk drinking, physical activity variables.
*Abbreviation: Odds Ratio, OR; 95% Confidence Interval, 95% CI

Table 3 summarizes the results of the analysis of the correlation between health literacy and prehypertension by subgroup of independent variables. The findings revealed that the association between low health literacy and prehypertension was more pronounced in certain subgroups, including women (OR: 2.27; 95% CI: 1.48–3.47), middle-aged adults ([adults in their 40s] OR: 2.19; 95% CI: 1.22–3.94; [adults in their 50s] OR: 3.20; 95% CI: 1.28–8.05), individuals with a high school education or less (OR: 1.59; 95% CI: 1.01–2.53), high-income households (OR: 2.21; 95% CI: 1.29–3.79), unemployed individuals (OR: 1.81; 95% CI: 1.12–2.93), residents of metropolitan or city areas (OR: 1.38; 95% CI: 1.02–1.87), individuals with a BMI less than 25 kg/m^2 (OR: 1.74; 95% CI: 1.17–2.60), non-smokers (OR: 2.27; 95% CI: 1.48–3.47), and non-high-risk drinkers (OR: 2.27; 95% CI: 1.48–3.47).

Table 3. Results of Subgroup Analysis Stratified by Independent Variables

Variables	Prehypertension				
	Health Literacy				
	High	Low			
		OR[a]	95% CI		
Sex					
Male	1.00	1.04	(0.67	-	1.63)
Female	1.00	2.27	(1.48	-	3.47)

Age			
19-29	1.00	1.20	(0.45 - 3.20)
30-39	1.00	0.73	(0.35 - 1.56)
40-49	1.00	2.19	(1.22 - 3.94)
50-59	1.00	3.20	(1.28 - 8.05)
60-69	1.00	1.63	(0.73 - 3.65)
70 ≤	1.00	0.82	(0.27 - 2.48)
Educational Level			
High school graduate or less	1.00	1.59	(1.01 - 2.53)
College graduate or higher	1.00	1.38	(0.91 - 2.08)
Household Income			
High	1.00	2.21	(1.29 - 3.79)
Middle	1.00	1.18	(0.79 - 1.75)
Low	1.00	1.33	(0.47 - 3.78)
Work Status			
Employed	1.00	1.29	(0.90 - 1.84)
Unemployed	1.00	1.81	(1.12 - 2.93)
Residence			
Metropolitan or city	1.00	1.38	(1.02 - 1.87)
Rural	1.00	1.83	(0.86 - 3.87)
Marital status			
Married	1.00	1.66	(1.20 - 2.28)
Single	1.00	1.10	(0.59 - 2.04)
Body Mass Index (kg/m^2)			
≥ 25 kg/m^2	1.00	0.95	(0.56 - 1.62)
< 25 kg/m^2	1.00	1.74	(1.17 - 2.60)
Borderline Dyslipidemia			
Yes	1.00	1.33	(0.86 - 2.05)
No	1.00	1.49	(0.98 - 2.25)
Pre-diabetes			
Yes	1.00	1.60	(0.92 - 2.78)
No	1.00	1.34	(0.93 - 1.93)
Smoking Status			
Current smoker	1.00	0.82	(0.39 - 1.73)
Never or former smoker	1.00	1.61	(1.18 - 2.20)
High-risk Drinking			
Yes	1.00	1.19	(0.54 - 2.62)
No	1.00	1.49	(1.08 - 2.08)
Physical Activity			
Yes	1.00	1.50	(0.98 - 2.30)
No	1.00	1.41	(0.94 - 2.12)

[a] Adjusted for sex, age, education, income, employment, residence, marriage, healthcare coverage, body mass index, borderline dyslipidemia, pre-diabetes, smoking, high-risk drinking, physical activity variables.
*Abbreviation: Odds Ratio, OR; 95% Confidence Interval, 95% CI

Table 4 presents the results of the subgroup analyses by health literacy domain, along with the outcomes of the response trend test. Our analysis demonstrated that specific domains of health literacy, including disease prevention (OR: 1.54; 95% CI: 1.10–2.17) and healthcare (OR: 1.43; 95% CI: 1.05–1.96), showed a significant association with prehypertension even after adjusting for socioeconomic and health-related variables. Additionally, lower health literacy scores correlated with an increased likelihood of prehypertension, confirming statistical significance for the trend ([≤10th percentile] OR: 2.10; 95% CI: 0.97–4.53; [10th percentile–3rd quartile] OR: 1.62; 95% CI: 0.95–

2.75; [3rd quartile–90th percentile] OR: 1.26; 95% CI: 0.92–2.63; [>90th percentile] OR: 1.00, reference group; P for trend = 0.0234).

Table 4. Results of the Sensitivity Analysis of Health Literacy Assessment Items and Response Trends across Different Levels

	Prehypertension	
	OR[a]	95% CI
Domains of Health Literacy Index (Ref. Excellent)		
Disease Prevention	1.54	(1.10 - 2.17)
Health Care	1.43	(1.05 - 1.96)
Technology and Resources	1.38	(0.93 - 2.06)
Health Promotion	1.33	(0.91 - 1.95)
Categorized Health Literacy Scores		
≤ 23 (10th Percentile)	2.10	(0.97 - 4.53)
24-32 (3rd Quartile)	1.62	(0.95 - 2.75)
33-37 (90th Percentile)	1.26	(0.92 - 2.63)
38+	1.00	
P for Trend	*P* = 0.0234	

[a] Adjusted for sex, age, education, income, employment, residence, marriage, healthcare coverage, body mass index, borderline dyslipidemia, pre-diabetes, smoking, high-risk drinking, physical activity variables.
*Abbreviation: Reference group, Ref; Odds Ratio, OR; 95% Confidence Interval, 95% CI

In addition, Figure 2 illustrates the results of the multinomial survey-weighted logistic regression analysis, with the dependent variable categorized according to standard blood pressure classifications. Categorizing blood pressure measurements into three groups revealed that individuals with lower health literacy had a 48% higher likelihood of being classified in the prehypertension stage than did those with normal blood pressure. Specifically, the ORs were as follows: normal group (SBP <120 mmHg and DBP <80 mmHg), OR = 1.00 (reference group); caution group (120 mmHg ≤ SBP < 130 mmHg and DBP <80 mmHg), OR = 1.34, 95% CI = 0.89–2.04; and prehypertension group (130 mmHg ≤ SBP < 140 mmHg and 80 mmHg ≤ DBP < 90 mmHg), OR = 1.48, 95% CI = 1.10–1.99.

Discussion

This cross-sectional, population-based study revealed a significant association between low health literacy and prehypertension, thereby confirming a negative correlation between health literacy and blood pressure levels. This association remained statistically significant even after adjusting for sociodemographic and health-related factors, indicating a tendency for the strength of the relationship to increase as health literacy decreased and blood pressure increased. The relationship was particularly significant among specific subgroups, including women, middle-aged adults, individuals with a high school education or less, those in high-income groups, unemployed individuals, urban residents, persons with a BMI of 25 kg/m^2 or lower, non-smokers, and individuals who were not high-risk drinkers.

Previous studies have investigated the association between health literacy and CVD, including hypertension, from multiple perspectives. Studies involving patients with hypertension have consistently shown that low health literacy is associated with greater difficulty in controlling blood pressure, often resulting in inadequate self-management behaviors such as poor medication adherence and unhealthy lifestyle habits [13, 14, 28-32]. Furthermore, studies focused on the general adult population have indicated that higher health literacy correlates with improved management and prevention of cardiovascular risk factors including blood pressure [15, 16, 33]. Additionally, objective CVD risk indicators, such as the Framingham risk score, have been shown to vary based on health literacy levels [16]. Health literacy has also been recognized as playing a crucial role in medication adherence, self-management, and effective communication with healthcare providers [29, 31, 34, 35].

Domestic studies utilizing population-based data, including health literacy measurement tools such as the Korean Health Panel, have so far been limited by the absence of clinical examinations during data collection [36, 37]. This has resulted in discrepancies from actual diagnostic criteria, as disease prevalence information was predominantly gathered through surveys. This study classified

blood pressure based on clinical diagnostic criteria, utilizing clinical examination data from the KNHANES, and focused on a general population free from major chronic diseases.

The main analysis results indicated a significant association between low health literacy and prehypertension. Given the increased likelihood of developing hypertension during the prehypertensive stage, these findings were consistent with those of most previous studies investigating the correlation between health literacy and blood pressure [13-16, 34]. In particular, Bonaccorsi and Modesti identified that health literacy and lifestyle contributed to 21.7% of the variance in hypertension [34]. They suggested that improving health literacy could be an effective strategy for managing hypertension through patient empowerment. The ACC/AHA noted that low health literacy is associated with reduced medication adherence and higher readmission rates, underscoring its importance in the primary and secondary prevention of CVDs [15].

The association between health literacy and prehypertension was particularly significant in certain subgroups. Some studies have demonstrated that health literacy enhances blood pressure control in women, facilitates the management of CVD risk factors, and improves treatment adherence [38-40]. The effect was significant among older adults and women with lower education levels, showing a similar pattern across different cultural backgrounds. Additionally, the estimated population percentages from this study indicated that 37.2% of men had high literacy levels compared with 46.7% of women, revealing a statistically significant difference (P=0.0005). The study by Pahn reported that female patients with hypertension had significantly higher scores in health literacy and treatment adherence than those of male patients [41]. This difference was attributed, in part, to men’s greater resistance to lifestyle changes than that demonstrated by women [41, 42]. Moreover, some studies have reported that social isolation resulting from unemployment may contribute to reduced health literacy, subsequently elevating the risk of CVDs [43]. In contrast to previous studies that identified a strong correlation between health literacy and hypertension among socially disadvantaged populations in low-income and rural areas [26, 44, 45], this study

revealed an association among wealthy urban residents. Furthermore, among individuals with a BMI below the normal range, non-smokers, and those who were not high-risk drinkers, the correlation between health literacy and prehypertension was substantial. This may indicate that even in populations with fewer risk factors, health literacy influences the management of prehypertension.

Within the domains of health literacy, disease prevention and healthcare-related literacy demonstrated notable associations with prehypertension. Several mechanisms may explain the relationship between health literacy and blood pressure. Individuals with poorer health literacy may struggle to comprehend the risks associated with prehypertension, the importance of lifestyle modifications, or medical advice, which can lead to poor blood pressure control [28, 35]. Health literacy also influences lifestyle behaviors that affect blood pressure [33]. Individuals with higher health literacy are more likely to comprehend and apply recommendations such as reducing salt intake, exercising regularly, and following other health guidelines. Moreover, higher health literacy reportedly correlates with improved self-management of hypertension, encompassing consistent blood pressure monitoring, symptom recognition, and effective communication with healthcare providers [29-31]. Individuals with lower health literacy may encounter difficulties in performing these self-management activities.

Our study, along with prior studies, highlights health literacy as a significant determinant of hypertension. Furthermore, enhancing health literacy via strengthened communication with healthcare providers and education on disease prevention may be effective in improving clinical outcomes. Therefore, enhancing health literacy is crucial for empowering patients and for the prevention and management of hypertension.

Improving individual health literacy involves providing tailored educational materials and intervention programs for the general population and vulnerable groups, as well as implementing health literacy-friendly frameworks within healthcare institutions [15, 34]. Additionally, a cohort study by Halladay et al. suggests that the implementation of stepwise intervention tailored to varying

health literacy levels can help bridge literacy disparities and improve long-term blood pressure control, even among individuals with differing degrees of health literacy [46].

This study had a few limitations. First, the cross-sectional study design precludes causal inference regarding the relationship between health literacy and prehypertension. However, to minimize bias, individuals with chronic diseases were excluded and adjustments were made for potential confounders to clarify the association under comparable conditions. Second, the possibility of unmeasured confounding variables remains, which may have influenced the observed estimates. Third, the generalizability of the findings may be limited in settings with distinct social, cultural, or environmental contexts. Future research should employ longitudinal or intervention designs to better determine causality between health literacy and prehypertension. Additionally, conducting research across diverse populations and contexts will improve the generalizability of the findings and ensure the applicability of conclusions to wider settings.

Despite these limitations, this study has several methodological strengths. It utilized a health literacy assessment tool specifically developed for the Korean population and healthcare context, thereby increasing its contextual relevance and strengthening the study's internal validity. The use of clinically measured blood pressure data, rather than self-reported measures, enhanced the accuracy and reliability of the results. This methodological approach yielded a more robust dataset, facilitating a clearer interpretation of the relationship between health literacy and objectively measured health outcomes. Furthermore, the use of weighted survey data ensured a representative sample reflective of the South Korean population, thereby enhancing the external validity of the findings.

Conclusion

The findings of this study demonstrated a significant association between limited health literacy and the presence of prehypertension. This study provides empirical insight into the role of health literacy during the early stages of hypertension development and highlights its substantial

impact on health management in this critical period. Future research should aim to establish causal relationships between health literacy and prehypertension using longitudinal study designs. Further investigation is needed to elucidate the mechanisms underlying this relationship, as well as to develop effective interventions that enhance health literacy for the prevention and management of hypertension.

Declarations

Ethics approval and consent to participate

The data collected from the KNHANES survey utilized in this study was reviewed and approved by the Institutional Review Board of the KDCA (approval number: 2022-11-16-R-A). The Committee approved this survey study, including the exemption of informed consent for individuals involved in studies using these data.

Consent for publication

All authors have given their consent for the publication of the final version of the manuscript.

Availability of data and materials

The data that support the findings of this study are available from The Korea National Health and Nutrition Examination Survey (KNHANES) website (https://knhanes.kdca.go.kr/knhanes/rawDataDwnld/rawDataDwnld.do).

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Competing interests

The authors declare that they have no competing interests.

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Author contributions: CRediT

J.C.: Conceptualization, Formal analysis, Writing original draft. D.B.K.: Reviewing and editing. S-Y.J.: Reviewing and editing. E-C.P.: Conceptualization, Reviewing and editing, Supervision.

Abbreviations

ACC/AHA, American College of Cardiology and the American Heart Association; BMI, body mass index; CVD, cardiovascular diseases; CI, confidence interval; DBP, diastolic blood pressure; KDCA, Korea Disease Control and Prevention Agency; KNHANES, Korea National Health and Nutrition Examination Survey; OR, odds ratio; SBP, systolic blood pressure; WHO, World Health Organization.

Reference

1. WHO, *Global report on hypertension: the race against a silent killer*. 2023: World Health Organization.
2. Office of Evaluation and Operations, C.D.E.D., *Hypertension and Diabetes Adequacy Assessment Results for 2023*. 2024, Health Insurance Review and Assessment Service. p. 1–10.
3. Dehmer, S.P., et al., *Health benefits and cost-effectiveness of asymptomatic screening for hypertension and high cholesterol and aspirin counseling for primary prevention.* The Annals of Family Medicine, 2017. 15(1): p. 23–36.
4. Glasser, S.P., J.N. Basile, and D.T. Lackland, *Does prehypertension represent an increased risk for incident hypertension and adverse cardiovascular outcome?* 2009, Lippincott Williams & Wilkins. p. 954–955.
5. Huang, Y., et al., *Prehypertension and incidence of cardiovascular disease: a meta-analysis.* BMC medicine, 2013. 11: p. 1–9.
6. Han, M., et al., *Prehypertension and risk of cardiovascular diseases: a meta-analysis of 47 cohort studies.* Journal of hypertension, 2019. 37(12): p. 2325–2332.
7. Whelton, P.K., et al., *2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines.* Journal of the American College of Cardiology, 2018. 71(19): p. e127–e248.
8. Jones, D.W., et al., *Management of stage 1 hypertension in adults with a low 10-year risk for cardiovascular disease: filling a guidance gap: a scientific statement from the American Heart Association.* Hypertension, 2021. 77(6): p. e58–e67.
9. WHO, *Guideline for the pharmacological treatment of hypertension in adults*. 2021: World Health Organization.
10. Sørensen, K., et al., *Health literacy and public health: a systematic review and integration of definitions and models.* BMC public health, 2012. 12: p. 1–13.
11. WHO. *Health Promotion*. [cited 2025 June 02]; Available from: https://www.who.int/teams/health-promotion/enhanced-wellbeing/ninth-global-conference/health-literacy.
12. Morrison, A.K., et al., *Health literacy–related safety events: a qualitative study of health literacy failures in patient safety events.* Pediatric quality & safety, 2021. 6(4): p. e425.
13. McNaughton, C.D., et al., *Association of health literacy with elevated blood pressure: a cohort study of hospitalized patients.* Medical care, 2014. 52(4): p. 346–353.
14. Sohrabi, M., et al., *The Relationship between Health Literacy and Hypertension Control: A Cross-Sectional Study.* The Journal of Tehran University Heart Center, 2022. 17(4): p. 243.
15. Magnani, J.W., et al., *Health literacy and cardiovascular disease: fundamental relevance to primary and secondary prevention: a scientific statement from the American Heart Association.* Circulation,

2018. 138(2): p. e48–e74.

16. Rahimi, T., et al., *Association between health literacy and Framingham risk score.* Scientific Reports, 2024. 14(1): p. 12837.
17. UNGeneralAssembly, *Outcome document of the High-Level Meeting of the General Assembly on the Comprehensive Review and Assessment of the Progress Achieved in the Prevention and Control of Non-communicable Diseases :draft resolution*. 2014, UN: New York.
18. WHO, *Global patient safety report 2024*. 2024: World Health Organization.
19. Wolf, M.S. and S.C. Bailey, *The role of health literacy in patient safety.* Perspectives on Safety. San Francisco: Agency for Healthcare Research and Quality, 2009.
20. Urstad, K.H., et al., *Definitions and measurement of health literacy in health and medicine research: a systematic review.* BMJ open, 2022. 12(2): p. e056294.
21. Coughlin, S.S., et al., *Health literacy, social determinants of health, and disease prevention and control.* Journal of environment and health sciences, 2020. 6(1): p. 3061.
22. DeWalt, D.A. and J. McNeill, *Integrating health literacy with health care performance measurement.* NAM Perspectives, 2013.
23. Gaffari-Fam, S., et al., *Adherence to a health literacy and healthy lifestyle with improved blood pressure control in Iran.* Patient preference and adherence, 2020: p. 499–506.
24. Leon-Gonzalez, R., et al., *Health literacy and health outcomes in very old patients with heart failure.* Revista Española de Cardiología (English Edition), 2018. 71(3): p. 178–184.
25. Kanejima, Y., et al., *Impact of health literacy in patients with cardiovascular diseases: A systematic review and meta-analysis.* Patient Education and Counseling, 2022. 105(7): p. 1793–1800.
26. Choi, S.K., et al., *A study for improving health literacy.* 2020.
27. Yoon, J., et al., *Development of health literacy index for the Korea National Health and Nutrition Examination Survey.* 2023.
28. Olalde, D., F. Hernandez, and E. Carro, *Lifestyle-associated health literacy in subjects with systemic arterial hypertension in a first-level unit.* Int J Fam Commun Med, 2024. 8(4): p. 95–99.
29. Persell, S.D., et al., *Associations between health literacy and medication self-management among community health center patients with uncontrolled hypertension.* Patient preference and adherence, 2020: p. 87–95.
30. Fu, S.N., et al., *The association of health literacy with high-quality home blood pressure monitoring for hypertensive patients in outpatient settings.* International Journal of Hypertension, 2020. 2020(1): p. 7502468.
31. Tavakoly Sany, S.B., et al., *Communication skills training for physicians improves health literacy and medical outcomes among patients with hypertension: a randomized controlled trial.* BMC health services research, 2020. 20: p. 1–10.
32. Du, S., et al., *Health literacy and health outcomes in hypertension: An integrative review.*

International journal of nursing sciences, 2018. 5(3): p. 301–309.

33. Santos, R.D., *Better health literacy can make the difference when control of risk factors for cardiovascular disease and quality of life are concerned*. 2017, SAGE Publications Sage UK: London, England. p. 1878–1879.
34. Bonaccorsi, G. and P.A. Modesti, *Health literacy, a new perspective for patient empowerment in the public health approach to hypertension.* Internal and emergency medicine, 2017. 12(6): p. 737–739.
35. Himmelfarb, C.R.D. and S. Hughes, *Are you assessing the communication" vital sign"?: Improving communication with our low-health-literacy patients.* Journal of Cardiovascular Nursing, 2011. 26(3): p. 177–179.
36. Kim, J., S. Kim, and S.C. Lim, *The Impact of Health Literacy on Medication Utilization Behavior.* Korean Journal of Clinical Pharmacy, 2025. 35(1): p. 65–74.
37. Jae Yeon, J. and J. HeeJeung, *Identifying health literacy levels and related factors focusing on age.* Korea Journal of Hospital Management, 2024. 29(1): p. 64–75.
38. Bae, H., N.-S. Hong, and E.-K. Shin, *Impact of health literacy on hypertension control of elderly women patients receiving home visiting health care services.* Journal of Health Informatics and Statistics, 2019. 44(3): p. 237–244.
39. Hirooka, N., et al., *Association of health literacy with the prevalence of cardiovascular diseases and their risk factors among older Japanese health management specialists.* Gerontology and Geriatric Medicine, 2023. 9: p. 23337214231189059.
40. Metlock, F.E., et al., *Design and rationale of the social determinants of the risk of hypertension in women of reproductive age (SAFE HEART) study: An American Heart Association research goes red initiative.* American heart journal, 2024. 275: p. 151–162.
41. Pahn, J., *Influence of Health Literacy and Self-Efficacy on Compliance in Hypertensive Patients.* J Korean Pubilc Health Nurs, 2024. 38(3): p. 331–343.
42. Kim, Y. and K.A. Kong, *Do hypertensive individuals who are aware of their disease follow lifestyle recommendations better than those who are not aware?* PloS one, 2015. 10(8): p. e0136858.
43. Gutierrez, I., et al., *The association between social functioning and health literacy among rural Southeastern African Americans with hypertension.* Health promotion international, 2023. 38(3): p. daad023.
44. Moon, S., et al., *Influencing Factors on Health Literacy and the Influence of Health Literacy on Healthcare Utilization.* Health and Social Welfare Review, 2024. 44(4): p. 130–150.
45. Cabellos-García, A.C., et al., *Relationship between determinants of health, equity, and dimensions of health literacy in patients with cardiovascular disease.* International Journal of Environmental Research and Public Health, 2020. 17(6): p. 2082.
46. Halladay, J.R., et al., *The association of health literacy and blood pressure reduction in a cohort of patients with hypertension: the heart healthy lenoir trial.* Patient education and counseling, 2017.

100(3): p. 542–549.

Figure captions

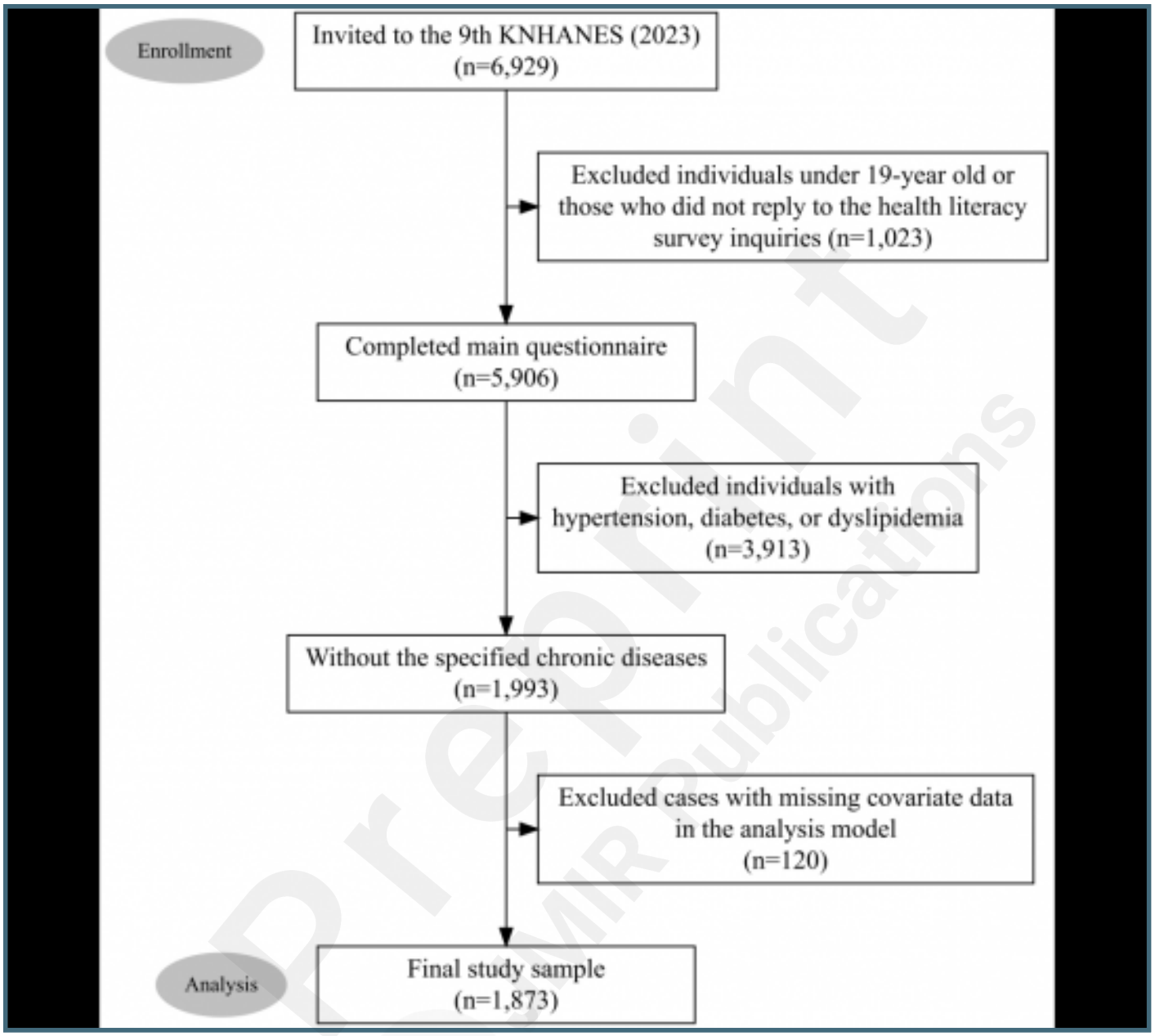
Figure 1. The Procedure of Selecting Study Subjects from the 2023 KNHANES

Figure 2. The Result of Outcome Subgroup Analysis Stratified by Blood Pressure Classification

Supplementary Files

Figures

The Procedure of Selecting Study Subjects from the 2023 KNHANES.



The Result of Outcome Subgroup Analysis Stratified by Blood Pressure Classification.