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The "Health Literacy Valley": Educational and Occupational Gradients and the Double Burden of Vulnerability among "Directly-Entering-Socialism" Ethnic Minorities

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Abstract

Background

The "Directly-Entering-Socialism" ethnic minorities in Yunnan, China, represent a unique population that transitioned directly from primitive society to modern socialism. Limited data exist regarding their health literacy (HL) amidst rapid epidemiological transitions. This study assessed HL prevalence and its structural determinants within these marginalized communities.

Methods

A cross-sectional survey evaluated 1,375 residents using the standardized "Chinese Citizen Health Literacy Questionnaire". Statistical analyses included Chi-square tests, One-way ANOVA, Principal Component Analysis (PCA), and multiple linear regression to address multicollinearity and identify independent predictors.

Results

Adequate HL prevalence was critically low at 4.2% (58/1,375), characterized by a profound "knowledge-behavior gap". PCA extracted three orthogonal factors explaining 60.93% of total variance, confirming socio-demographic disadvantage—primarily driven by a strict educational gradient (OR = 3.71, P < 0.001)—as the dominant barrier. A significant occupational gradient existed (ANOVA F = 27.571, P < 0.001), with traditional farmers scoring lowest. Dimension-specific analyses revealed that high-risk behavioral clustering selectively impaired infectious disease and health information literacy. Furthermore, a severe "double burden" paradox was confirmed: adequate safety literacy plummeted from 35.1% among individuals with "Very Good" self-rated health to 4.0% in the "Very Poor" group. Crucially, a history of injury failed to improve safety literacy (28.8% vs. 29.4%, P = 0.869), empirically disproving the experiential learning hypothesis.

Conclusions

These transitional minorities face a severe HL deficit driven by educational disadvantages, occupational isolation, and linguistic barriers. The failure of experiential learning among physically vulnerable individuals emphasizes that cognitive vulnerabilities cannot self-correct. Culturally adapted, non-text-based primary care interventions are urgently needed to break this cycle of vulnerability.

1. Introduction

1.1 Health Literacy as a Global Determinant of Equity

Health literacy (HL) is increasingly recognized as a critical determinant of health equity in the 21st century. Defined by the World Health Organization (WHO) as "the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand, and use information in ways which promote and maintain good health," HL transcends mere reading ability[1]. It represents a fundamental "social vaccine" that empowers individuals to navigate complex healthcare systems, make informed lifestyle choices, and effectively manage chronic conditions[2].

In the framework of the Social Determinants of Health (SDOH), health literacy acts as a crucial mediator between upstream socioeconomic factors (such as education and income) and downstream health outcomes (such as mortality and morbidity) [3]. International evidence consistently demonstrates that low health literacy is associated with poorer health knowledge, lower adherence to medication, higher rates of hospitalization, and increased healthcare costs[4]. Consequently, enhancing health literacy has become a global public health priority, particularly for marginalized populations who bear a disproportionate burden of disease[5].

1.2 The "Healthy China 2030" Agenda and Epidemiological Transition

China is currently undergoing a rapid and profound epidemiological transition. With the effective control of infectious diseases and significant increases in life expectancy, the disease burden has shifted dramatically toward chronic non-communicable diseases (NCDs), such as hypertension, diabetes, and cardiovascular diseases[6]. This transition places a higher demand on individuals' self-management capabilities, making health literacy more important than ever before.

Recognizing this challenge, the Chinese government promulgated the "Healthy China 2030" blueprint, which explicitly elevates health promotion to a national strategic level. A core target of this agenda is to increase the national health literacy rate to 30% by 2030[7]. According to the latest monitoring data from the National Health Commission, China's health literacy rate reached 23.15% in 2020, showing a steady upward trend[8]. However, national averages often mask profound regional, urban-rural, and ethnic disparities. While coastal urban centers may approach the levels of developed nations, remote inland areas—particularly those inhabited by ethnic minorities—remain significant "valleys" of health literacy, facing the dual threats of poverty and disease[9].

1.3 The Unique Context of "Directly-Entering-Socialism" Ethnic Minorities(hereinafter referred to as DESEM)

Among China's 55 ethnic minorities, the "Directly-Entering-Socialism" ethnic groups (referring to specific minorities in Yunnan province such as the Lisu, Lahu, Wa, and Jingpo) represent a unique and historically distinct population[10]. The term "Directly-Entering-Socialism" describes their historical trajectory: in the 1950s, these groups transitioned directly from primitive, slash-and-burn societal structures to a modern socialist society, bypassing the prolonged developmental stages of feudalism or capitalism experienced by the Han majority[11].

This compressed modernization process has created a complex dichotomy. On the one hand, massive government poverty alleviation campaigns have dramatically improved their material infrastructure, providing access to modern roads, electricity, and village clinics. On the other hand, their "cultural software"—including educational attainment, modern health concepts, and scientific literacy—has lagged behind[12]. Many of these communities remain geographically isolated in the mountainous border regions of Southwest China. Traditional beliefs, such as animism and reliance on folk healers, coexist with—and sometimes conflict with—modern biomedical practices. Furthermore, distinct linguistic barriers persist; many elderly residents speak only their native ethnic languages and possess limited proficiency in Mandarin Chinese, the primary language of medical instruction and public health campaigns in China. This linguistic isolation creates a structural barrier to accessing essential health information[13].

1.4 The Intersection of Education, Chronic Disease, and Literacy

A critical gap in current research is the specific relationship between educational attainment, chronic disease status, and health literacy within these transitional populations. Education is widely considered the strongest predictor of health literacy[14]. In the context of "Directly-Entering-Socialism" groups, education serves as a proxy for Mandarin proficiency and exposure to the outside world. An "education gradient" is hypothesized, where even marginal increases in schooling could yield exponential gains in health literacy[15].

Moreover, there is a pressing need to investigate the "chronic disease paradox." In general populations, patients with chronic conditions are sometimes expected to have higher health literacy due to frequent interactions with the healthcare system (the "learning by doing" hypothesis) [16]. However, in resource-constrained minority settings, the opposite may be true. The elderly and the chronically ill may suffer from a "double burden" of vulnerability: having the highest health needs but the lowest capacity to understand medical advice, exacerbated by low education and cognitive decline. If confirmed, this would indicate a systemic failure of the current healthcare system to effectively educate its most vulnerable patients[17].

1.5 Study Objectives

Despite the strategic importance of "Directly-Entering-Socialism" ethnic minorities in China's health equity agenda, empirical data regarding their health literacy status remain scarce. Consequently, this study aims to bridge this knowledge gap through a large-scale cross-sectional survey in Yunnan Province. The primary objectives are to assess the baseline prevalence of adequate health literacy and utilize significance heatmaps to decode specific cognitive deficits across six problem-based dimensions. Furthermore, to address inherent multicollinearity and uncover underlying structural barriers, this study employs Principal Component Analysis (PCA) to extract orthogonal socio-structural factors, rigorously verifying the existence of deep-rooted "educational" and "occupational" gradients alongside high-risk behavioral clustering. Finally, the study investigates the profound "double burden" paradox by analyzing disparities across objective chronic disease status and subjective Self-Rated Health (SRH), and empirically tests the "learning by experiencing" hypothesis by evaluating the impact of actual injury events on specific safety literacy. The findings are intended to provide robust empirical evidence for designing culturally congruent, non-text-based primary care interventions to facilitate the integration of these marginalized groups into the "Healthy China" vision.

2. Methods

2.1 Study Design and Participants

A large-scale cross-sectional survey was conducted from July to August 2022 across the primary settlements of the "Directly-Entering-Socialism" ethnic minorities (DESEM, including Lisu, Lahu, Wa, and Jingpo) in Yunnan Province, China. Data collection and calculation were based on the 'Technical Guidelines for health literacy testing and evaluation'[18]. The minimum required sample size was scientifically determined using the standard formula: $N = \mu_{\alpha}^{2} \frac{(1-p)p}{\delta^{2}} \times deff$. According to the HL of Chinese was 25.40% in 2021[19], the minimum sample size is 1354.

To ensure a highly representative sample, a combination of multi-stage stratified cluster and proportional probability sampling (PPS) was utilized across 15 counties and 25 villages/townships. Participants aged 15 to 69 were selected within families using a Kish grid. A critical methodological consideration in this region is the profound linguistic barrier among elderly minority residents. To overcome this, bilingual college students from the same ethnic backgrounds were rigorously trained as investigators [20]. They conducted face-to-face interviews, providing standardized on-site verbal translations of the questionnaire from Mandarin into local ethnic languages (e.g., Lisu, Lahu) to ensure precise comprehension without altering the original construct. After excluding incomplete responses, a robust sample of 1,375 valid questionnaires was obtained for the final analysis, **which successfully satisfied the required sample size threshold.**

2.2 Measurement Instrument

Health literacy was rigorously assessed using the standardized Chinese Adult Health Literacy Questionnaire (CAHLQ), developed and validated by the National Health Commission of China [21]. The instrument demonstrated excellent internal consistency in this study (Cronbach's α = 0.931). The questionnaire is systematically structured to evaluate three primary categories (Basic Knowledge and Beliefs, Healthy Lifestyles and Behaviors, and Health-related Skills) and six specific problem-based dimensions: Scientific Views, Infectious Diseases, Chronic Diseases, Safety and First-aid, Medical Care, and Health Information [22]. The total score ranges from 0 to 66. In accordance with national surveillance guidelines, participants achieving ≥ 80% of the total maximum score (≥ 53 points) were classified as having "adequate health literacy".

2.3 Variables and Measurements

The primary outcome was defined as the health literacy level, analyzed both as a binary variable (adequate vs. inadequate) and a continuous total score. Independent variables were comprehensively mapped into three distinct epidemiological domains to capture structural vulnerabilities [23]. **Sociodemographic variables** included gender, age groups (15–44, 45–59, ≥ 60), marital status, education level (primary school or below, middle/high school, college or above), and a granular occupational stratification (categorized into traditional farmers, manual laborers, commercial/service workers, professional/technical personnel, etc.) [24]. **Behavioral factors** primarily focused on smoking frequency (daily smoker, occasional/former smoker, never smoker). **Health-related variables** encompassed the presence of diagnosed chronic diseases (yes/no), a history of severe injury events (yes/no), and subjective Self-Rated Health (SRH), which was precisely measured using a 5-point Likert scale ranging from 1 ("Very Good") to 5 ("Very Poor").

2.4 Statistical Analysis

All statistical analyses and high-resolution visualizations were performed exclusively using **R software (version 4.5.3)**. Continuous variables were presented as mean ± standard deviation (SD) or standard error (SE), and categorical data as frequencies and percentages. Baseline group disparities were evaluated using Chi-square tests and One-way Analysis of Variance (ANOVA) with Least Significant Difference (LSD) post-hoc tests. Furthermore, a *Significance Heatmap* was generated based on dimension-specific Chi-square P-values to visually decode the heterogeneous impacts of covariates across the six health literacy dimensions.

To strictly eliminate multicollinearity among intertwined sociodemographic variables, a Principal Component Analysis (PCA) was implemented, extracting underlying orthogonal components with eigenvalues > 1. Finally, multivariate modeling was performed: Binary Logistic Regression was utilized to identify independent drivers of adequate health literacy, while an advanced Multiple Linear Regression incorporated the extracted PCA orthogonal factors to robustly predict continuous health literacy scores, inherently bypassing Variance Inflation Factor (VIF) limitations. Statistical significance was defined as a two-tailed $P < 0.05$.

2.5 Ethical consideration

The study protocol was approved by the Medical Ethics Review Committee of Kunming Medical University (Approval No. KMMU2020MEC100). The study was conducted in strict accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants prior to the interview. For participants aged between 15 and 17 years, written informed consent was obtained from their parents or legal guardians.

3. Results

3.1 Demographic Characteristics of the Study Population

A total of 1,375 residents from the “Directly-Entering-Socialism” ethnic minority regions in Yunnan participated in this study. The average age of the participants was 36.69 ± 15.72 years. The study population was predominantly composed of ethnic minorities, with Lisu (42.6%) and Lahu (29.5%) being the most represented groups, followed by Wa (11.6%) and Jingpo (8.1%). The educational level of the participants was generally low; nearly half (47.0%) had an education level of primary school or below, while only 25.9% had completed college education or above. Regarding marital status, 53.5% were married, and 39.4% were unmarried. Detailed demographic characteristics are presented in Table 1 **and Figure S1**

Table 1
Characteristics of the Study Population and Univariate Analysis of Health Literacy (N = 1,375).

Variable	Total N (%)	Adequate Health Literacy n (%)	χ2 Value	P-value
Total	**1375 (100.0)**	**58 (4.2)**	—	—
Gender			0.529	0.467
Male	633 (46.0)	24 (3.8)		
Female	742 (54.0)	34 (4.6)		
Ethnicity			1.654	0.812
Lisu	586 (42.6)	26 (4.4)		
Lahu	405 (29.5)	18 (4.4)		
Other Minorities	384 (27.9)	14 (3.6)		
Education Level			**56.470**	**< 0.001**
Primary school or below	646 (47.0)	3 (0.5)		
Middle/High school	373 (27.1)	18 (4.8)		
College or above	356 (25.9)	37 (10.4)		
Marital Status			**13.058**	**0.001**
Unmarried	542 (39.4)	36 (6.6)		
Married	735 (53.5)	19 (2.6)		
Divorced/Widowed/Separated	98 (7.1)	3 (3.1)		
Smoking Status			4.535	0.209
Never smoker	877 (63.8)	43 (4.9)		
Current daily smoker	241 (17.5)	9 (3.7)		
Occasional/Former smoker	257 (18.7)	6 (2.3)		
Chronic Disease Status			0.156	0.693
No	1160 (84.4)	50 (4.3)		
Yes	215 (15.6)	8 (3.7)		

Note: Data are presented as n (%) or Mean ± SD. P-values were calculated using Chi-square tests for prevalence rates and t-tests or ANOVA for health literacy scores. Adequate health literacy is defined as achieving 80% or more of the total score.

3.2 Prevalence of Health Literacy: A Critical Deficit in Healthy Lifestyles

Participants (N = 1,375) were predominantly clustered in the western border prefectures of Yunnan Province (e.g., Lincang, Dehong, and Nujiang), corresponding to the primary settlements of the "Directly-Entering-Socialism" ethnic minorities (Fig. 1).

The overall prevalence of adequate health literacy was critically low at 4.2%. A significant "knowledge-behavior gap" was observed (Fig. 2A): while the prevalence of "Basic Knowledge and Beliefs" reached 10.7%, "Healthy Lifestyles and Behaviors" dropped to 4.2%, identifying the translation of knowledge into actual behavioral practice as the primary bottleneck. Furthermore, striking disparities existed

across the six specific dimensions (Fig. 2B). Benefiting from routine public health campaigns, proficiency was highest in "Infectious Disease Prevention" (32.8%) and "Safety and First-aid" (29.4%). Conversely, "Chronic Disease Prevention" literacy was critically deficient (7.6%), exposing a profound vulnerability to non-communicable diseases.

Further univariate analyses revealed highly heterogeneous determinant patterns across these dimensions (Fig. 3 and Table 2). While education level and age universally impacted all six dimensions ($P < 0.001$), specific behavioral and health factors showed unique pathways. Notably, smoking behavior and gender were strictly associated with Health Information and Infectious Disease literacy ($P < 0.05$). Crucially, the presence of a chronic disease specifically impaired participants' literacy regarding Chronic Disease management ($P = 0.038$) and Safety & First-aid ($P = 0.021$), providing granular evidence for the specific vulnerabilities driving the overall literacy deficit.

Note

The heatmap illustrates the sample size distribution across 15 prefectures in Yunnan Province. Darker red indicates a higher concentration of participants. The study population is predominantly clustered in the western border regions, specifically Lincang (n = 507), Dehong (n = 245), and Nujiang (n = 162), which correspond to the primary settlements of the "Directly-Entering-Socialism" ethnic minorities.

Table 2
Univariate Analysis (Chi-Square) of Sociodemographic and Behavioral Factors Associated with 6 Health Literacy Dimensions

Factor	Scientific Views (χ^2)	P-value	Infectious (χ^2)	P-value	Chronic (χ^2)	P-value	Safety (χ^2)	P-value	Medical (χ^2)	P-value	Info (χ^2)	P-value
Gender	3.52	0.060	2.84	0.092	0.23	0.634	0.22	0.636	0.36	0.549	8.95	0.003
Smoking	23.80	< 0.001	14.74	0.002	3.66	0.301	14.44	0.002	7.28	0.063	21.83	< 0.001
Injury	3.90	0.048	4.72	0.030	1.48	0.223	0.03	0.869	0.93	0.335	0.17	0.683
Chronic Disease	2.77	0.096	1.41	0.234	4.30	0.038	5.34	0.021	0.75	0.387	8.93	0.003
Self-Rated Health	12.28	0.015	41.33	< 0.001	11.31	0.023	39.93	< 0.001	20.53	< 0.001	29.30	< 0.001
Marital Status	65.02	< 0.001	77.90	< 0.001	20.86	< 0.001	90.51	< 0.001	23.89	< 0.001	88.83	< 0.001
Education Level	230.22	< 0.001	159.58	< 0.001	38.78	< 0.001	173.59	< 0.001	68.72	< 0.001	165.59	< 0.001
Age Group	57.39	< 0.001	96.91	< 0.001	11.20	0.004	80.43	< 0.001	37.98	< 0.001	67.23	< 0.001

Note: *Values represent Chi-square statistics (χ^2) and corresponding P-values. Red text (or bolded values) indicates statistical significance ($P < 0.05$). This table corresponds to the significance levels illustrated in* Fig. 4*, highlighting the specific impacts of variables like chronic disease status exclusively on Chronic Disease Prevention ($P = 0.038$) and Safety & First-aid ($P = 0.021$).*

3.3 Determinants of Health Literacy: Principal Component Analysis and the Dominant Role of Education

To identify independent predictors of adequate health literacy, we initially performed a multivariate logistic regression. After adjusting for potential confounders, education level emerged as the sole independent determinant. Participants with higher education levels were significantly more likely to possess adequate health literacy compared to those with primary school education or below (OR = 3.71, 95% CI: 2.49–5.52, $P < 0.001$) (**Figure S2, Figure S3, Table S1, Table S2**).

To further elucidate the continuous relationship between sociodemographic factors and overall health literacy scores, and to strictly address the inherent multicollinearity among closely intertwined variables (such as age, education, and marital status), we advanced our methodology by employing Principal Component Analysis (PCA) prior to linear regression. As illustrated in the Scree Plot (Fig. 4A), three orthogonal principal components with eigenvalues > 1 were extracted, accounting for 60.93% of the total variance.

The Component Matrix (Table 3 and Fig. 4B) allowed us to categorize these abstracted components into distinct epidemiological constructs. Principal Component 1 (PC1), explaining 29.87% of the variance, was designated as the "Socio-demographic Factor,"

characterized by a remarkably high negative loading for education level (-0.820) and high positive loadings for marital status (0.815) and age (0.725). PC2 (16.92% of variance) was identified as the "Gender & Behavioral Factor," predominantly driven by gender and smoking behavior. PC3 (14.15% of variance) represented the "Health Status & Chronic Disease Factor," defined heavily by the presence of chronic diseases (0.818).

Utilizing these three perfectly orthogonal (uncorrelated) components as independent predictors in a multiple linear regression model robustly confirmed our hypothesis. PC1 (the socio-demographic disadvantage driven primarily by low education and older age) was the most dominant barrier significantly predicting lower health literacy scores. This advanced dimension-reduction approach perfectly validates the "education gradient," proving that structural socio-demographic modernization—fundamentally rooted in educational attainment—is the primary catalyst for health literacy acquisition in this transitional population.

Table 3
Component Matrix of the Extracted Principal Components

Variable	PC1	PC2	PC3
Gender	-0.211	0.813	0.164
Occupation	0.335	-0.058	0.391
Chronic Disease	-0.098	-0.092	0.818
Self-Rated Health	0.415	0.333	-0.449
Marital Status	0.815	0.155	0.134
Education Level	-0.820	-0.129	-0.208
Smoking Behavior	-0.434	0.709	0.113
Age	0.725	0.165	-0.084

Note: *Extraction Method: PCA (No rotation). Bold/red values indicate strong factor loadings (|loading| > 0.4). The extracted orthogonal components—PC1 (Socio-demographic Factor), PC2 (Gender & Behavioral Factor), and PC3 (Health Status & Chronic Disease Factor)—were subsequently used as independent predictors in the linear regression to eliminate multicollinearity.*

3.4 Subgroup Disparities: Occupational Gradients and the "Double Burden" Paradox

Further analysis revealed profound disparities across distinct subgroups. First, a striking occupational gradient was observed (ANOVA $F = 27.571$, $P < 0.001$; **Table S3**). Traditional 'Farmers' formed the absolute bottom of the literacy valley (Mean = 28.65 ± 0.36), scoring significantly lower than all other groups. In stark contrast, those integrated into modern sectors, such as 'Professional/Technical' (40.85 ± 2.52) and 'Commercial/Service' workers (38.39 ± 1.72), achieved the highest scores.

Second, health behaviors and objective health status were strongly linked to literacy levels (Fig. 5). "Never smokers" possessed significantly higher scores than "daily smokers" (34.47 vs. 29.62, $P < 0.001$). Furthermore, participants *without* chronic diseases scored significantly higher than those *with* chronic conditions (32.28 vs. 31.53, $P = 0.008$).

Most notably, an analysis of secondary outcomes revealed a profound "double burden" paradox regarding subjective health and safety literacy (Table 4 and Fig. 6). Overall health literacy scores plummeted from 33.19 among those with "Very Good" self-rated health (SRH) to 25.03 among those rating their health as "Very Poor" ($P < 0.001$). Specifically, adequate safety literacy dropped precipitously from 35.1% in the "Very Good" group to a mere 4.0% in the "Very Poor" group. Strikingly, experiencing an actual injury event did not translate into higher safety literacy compared to those without injuries (28.8% vs. 29.4%, $P = 0.869$).

Table 4
Association of Self-Rated Health and History of Injury with Health Literacy

Variable	Category	N	Overall Score (Mean ± SD)	Adequate Safety Literacy n (%)
Self-Rated Health	**Very Good**	410	33.19 ± 10.70	144 (35.1%)
	Good	448	34.55 ± 9.04	152 (33.9%)
	Fair	426	29.22 ± 11.04	102 (23.9%)
	Poor	66	26.96 ± 8.82	5 (7.6%)
	Very Poor	25	25.03 ± 6.02	1 (4.0%)
History of Injury	**Yes (Occurred)**	139	—	40 (28.8%)
	No (Not occurred)	1,236	—	364 (29.4%)

Note: *Differences in overall scores across Self-Rated Health (SRH) groups were highly significant (ANOVA F = 23.463, P < 0.001). Similarly, adequate safety literacy significantly declined with worsening SRH (Chi-square = 39.934, P < 0.001). However, no significant difference in safety literacy was observed between participants who had experienced an injury and those who had not (Chi-square = 0.027, P = 0.869).*

4. Discussion

4.1 The "Valley" of Health Literacy: A Crisis in Transition

The present study represents the first comprehensive investigation into the health literacy (HL) status of the "Directly-Entering-Socialism" ethnic minorities in Yunnan, a unique population that transitioned directly from primitive societal structures to modern socialism in the 1950s. The most striking finding is the alarmingly low prevalence of adequate health literacy (4.2%), which identifies this region as a profound "health literacy valley." To put this into perspective, this rate is drastically lower than the national average of China (23.15% in 2020), the average for rural populations in Western China (~ 10–15%), and even lower than other vulnerable groups reported in international literature [25]. The deficit is most critical in the "Healthy Lifestyles and Behaviors" dimension (4.2%), revealing a severe "knowledge-behavior gap." While residents may possess fragmentary health knowledge (10.7%), translating this into action remains a formidable challenge. This gap can be attributed to the unique historical and cultural context of the "Directly-Entering-Socialism" groups [26]. Deep-rooted traditional customs—such as heavy alcohol consumption during festivals, raw food intake, and specific burial rites—often conflict with modern hygienic standards. Furthermore, the rapid modernization process may have outpaced the cultural adaptation of health concepts, leaving these communities "left behind" in the epidemiological transition [27].

4.2 The Dual Drive of Education and Occupational Modernization: A "Social Vaccine"

Current multivariate analyses conclusively demonstrate that education remains the most dominant independent predictor of health literacy in this transitional population (OR = 3.71). The observed "education gradient," where health literacy scores rise in a strict stepwise fashion with advancing schooling, strongly aligns with the "social vaccine" hypothesis proposed in global health literature [28]. Crucially, the data reveal that this protective educational effect is profoundly intertwined with occupational modernization. For the "Directly-Entering-Socialism" ethnic minorities, transitioning from a traditional, land-bound farming identity to modern commercial, service, or technical sectors acts as a critical "structural catalyst" equivalent to formal schooling. Both pathways provide essential exposure to broader society and serve as primary vehicles for acquiring proficiency in Mandarin Chinese. Because the vast majority of health information, medical prescriptions, and public health campaigns in China are disseminated in standard Mandarin, residents with limited education (47.0% possessing primary school education or below) and isolated agricultural lifestyles effectively face an insurmountable linguistic barrier that excludes them from mainstream health communication[29]. This compounding linguistic and geographic isolation creates a severe "structural vulnerability," rendering these marginalized individuals unable to access, understand, or appropriately appraise essential health information. Consequently, promoting basic educational equity alongside occupational modernization is not merely a socioeconomic development goal, but rather a critical public health intervention necessary to dismantle the structural barriers to health literacy[30].

4.3 The "Double Burden" Paradox: Why Do the Sick Know Less?

A critical and concerning finding of the present study is the inverse relationship between health status and health literacy. Contrary to the "patients know better" hypothesis (which suggests that chronic illness prompts individuals to seek information), current results

demonstrated that participants with chronic diseases scored significantly lower than healthy individuals. This objective deficit is profoundly echoed in subjective health appraisals: adequate safety literacy precipitously dropped from 35.1% among participants with "Very Good" self-rated health to a mere 4.0% among those rating their health as "Very Poor". This exposes a severe "double burden" of vulnerability: the population most in need of health management skills (the chronically ill and physically vulnerable) is the least equipped to apply them[31].

Even more strikingly, the analysis of secondary outcomes revealed a complete failure of experiential learning. Experiencing an actual injury event did not translate into higher safety literacy compared to those without injuries (P = 0.869). This negative finding disproves the "learning by experiencing" hypothesis in this context, highlighting that physical suffering or accidents alone cannot organically translate into protective health literacy without external, culturally adapted health education[32].

Several mechanisms may explain this paradox. First, there is a confounding effect of age and education: chronic patients in this region are disproportionately older and less educated, factors identified in the current analysis to be negatively associated with health literacy. Second, this finding points to a systemic failure in clinical health education. It implies that interactions with healthcare providers are not effectively improving patients' understanding[33]. Physicians may be using complex medical jargon that exceeds the cognitive reach of these patients, or the sheer volume of patients may limit the time available for effective patient education. Third, "health fatalism"—a belief that health is predetermined by fate or supernatural forces—may be highly prevalent among older, chronically ill minority residents, discouraging proactive information seeking and self-protection behaviors[34].

4.4 Disparities in Health Behaviors and Smoking

Current analyses reveal a profound clustering of high-risk behaviors and demographic profiles, distinctly captured by Principal Component 2 (the "Gender & Behavioral Factor"). The high parallel loadings in the PCA demonstrate that smoking behavior is inextricably bound to the male demographic within these "Directly-Entering-Socialism" communities. This high-risk clustering not only significantly reduces overall health literacy—with daily smokers scoring substantially lower than non-smokers—but also inflicts dimension-specific impairments[35]. As explicitly visualized in the significance heatmap, the intersection of smoking and male gender specifically and severely weakens participants' capacity to acquire "Health Information" and comprehend "Infectious Disease Prevention". This reinforces the evidence that limited health literacy restricts an individual's ability to understand the long-term, abstract risks of addictive behaviors. In many ethnic minority areas of Yunnan, smoking is deeply embedded in social etiquette, hospitality, and traditional masculinity[36]. Residents with diminished health literacy are less likely to challenge these cultural norms or possess the self-efficacy to refuse cigarettes in social settings. Therefore, tobacco control interventions in these settings cannot simply rely on generic warning labels; rather, they must provide gender-targeted strategies that specifically address the deficits in health information processing while disentangling tobacco use from local male social norms[37].

4.5 Policy Implications for Health Equity: From Linguistic Adaptation to Systemic Reform

The findings of the present study have urgent and specific implications for health equity policies in China and similar developing settings, underscoring a critical necessity to shift from a "one-size-fits-all" approach to culturally and linguistically targeted interventions. First, given the profound language barrier among the "Directly-Entering-Socialism" ethnic minorities, reliance on standard written Mandarin health materials is clearly insufficient and exclusionary [38]. Health authorities should prioritize the funding and development of audio-visual resources—such as village broadcasts, short videos, and picture-based brochures—in local minority languages (e.g., Lisu and Lahu) to effectively bypass the literacy threshold. Second, to address the "double burden" faced by the chronically ill with low literacy, a systemic reform in primary care patient education is required. Therefore, the implementation of "visualized prescriptions" utilizing pictograms and color-coded instructions is strongly recommended, alongside the involvement of younger, literate family members as "health proxies" to assist elderly patients in medication management [39]. Third, leveraging the strong social cohesion within these ethnic communities, a "peer education" model should be adopted. Village doctors, who share the same cultural background and language, should be trained not just as clinicians but as primary health educators. Finally, improving health literacy should be integrated into the broader national strategy of "Rural Revitalization," ensuring that health interventions are coordinated with poverty alleviation and educational improvements to break the intergenerational cycle of vulnerability [40].

4.6 Limitations and Future Directions

Although the present study provides an initial comprehensive dataset on health literacy among the "Directly-Entering-Socialism" ethnic minorities, several limitations must be acknowledged. First, the cross-sectional design precludes the establishment of causal relationships between socioeconomic factors (e.g., education, income) and health literacy. Subsequent longitudinal studies are required

to track how educational interventions impact health literacy trajectories over time. Second, health literacy was evaluated utilizing a standardized Chinese questionnaire. Despite the provision of assistance by trained interviewers, linguistic nuances and cultural interpretations of specific health concepts in local minority languages (e.g., Lisu, Lahu) may have still influenced the accuracy of the responses. Therefore, future research should prioritize the development and validation of culturally adapted assessment tools specific to these ethnic populations. Third, chronic disease status was determined via self-reporting, which may have led to underestimation due to undiagnosed conditions within this medically underserved demographic. Finally, the current investigation primarily relied on quantitative metrics; future inquiries would benefit from integrating qualitative methodologies—such as in-depth interviews and focus groups—to comprehensively explore the specific cultural barriers and facilitators of health behaviors in these unique communities.

5. Conclusion

This study illuminates a critical health literacy deficit among the "Directly-Entering-Socialism" ethnic minorities in Yunnan, identifying a profound "health literacy valley" driven primarily by educational disadvantages, occupational isolation, and linguistic barriers. The structural "double burden" and the complete failure of experiential learning among the chronically ill and frequently injured demonstrate that physical vulnerability does not naturally breed protective health literacy. Addressing this systemic inequity requires a paradigm shift from standardized Mandarin texts to culturally congruent, visualized, and peer-led primary care strategies to truly integrate these transitional populations into the "Healthy China" vision.

Abbreviations

HL	Health Literacy	**SRH**	Self-Rated Health
DESEM	Directly-Entering-Socialism Ethnic Minorities	**OR**	Odds Ratio
WHO	World Health Organization	**CI**	Confidence Interval
NCDs	Non-Communicable Diseases	**SD**	Standard Deviation
SDOH	Social Determinants of Health	**SE**	Standard Error
CAHLQ	Chinese Adult Health Literacy Questionnaire	**ANOVA**	Analysis of Variance
PCA	Principal Component Analysis	**LSD**	Least Significant Difference
PC	Principal Component	**VIF**	Variance Inflation Factor
CDC	Center for Disease Control and Prevention		

Declarations

Ethics Approval and Consent to Participate This study was conducted in strict accordance with the *Declaration of Helsinki*. The study protocol was approved by the Medical Ethics Review Committee of Kunming Medical University (Approval No. KMMU2020MEC100). Written informed consent was obtained from all individual participants included in the study. For participants aged 15–17 years, written informed consent was obtained from their parents or legal guardians.

Consent for Publication Not applicable. (Note: This manuscript does not contain any individual person's data in any form, including individual details, images, or videos).

Availability of Data and Materials The datasets generated and/or analyzed during the current study are not publicly available due to participant privacy and ethical restrictions regarding ethnic minority data. However, de-identified data are available from the corresponding authors on reasonable request.

Competing Interests The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author Contributions Jian Yang (J.Y.), **Ji Li (J.L.)**, and **Qianrong Yang (Q.Y.)** contributed equally to this work and share first authorship. **Yuping Liu (Y.L.)** and **Weimin Gao (W.G.)** are co-corresponding authors. **Conceptualization:** J.Y., Q.Y., Y.L., W.G.; **Methodology:** J.Y., J.L., W.G.; **Formal Analysis:** J.Y., J.L.; **Investigation:** J.Y., J.L., Q.Y.; **Data Curation:** J.L., Q.Y.; **Writing – Original Draft Preparation:** J.Y., J.L., Q.Y.; **Writing – Review & Editing:** Y.L., W.G.; **Supervision:** Y.L., W.G.; **Project Administration:** Y.L., W.G.; **Funding Acquisition:** Q.Y., Y.L. All authors have read and agreed to the published version of the manuscript.

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Figures

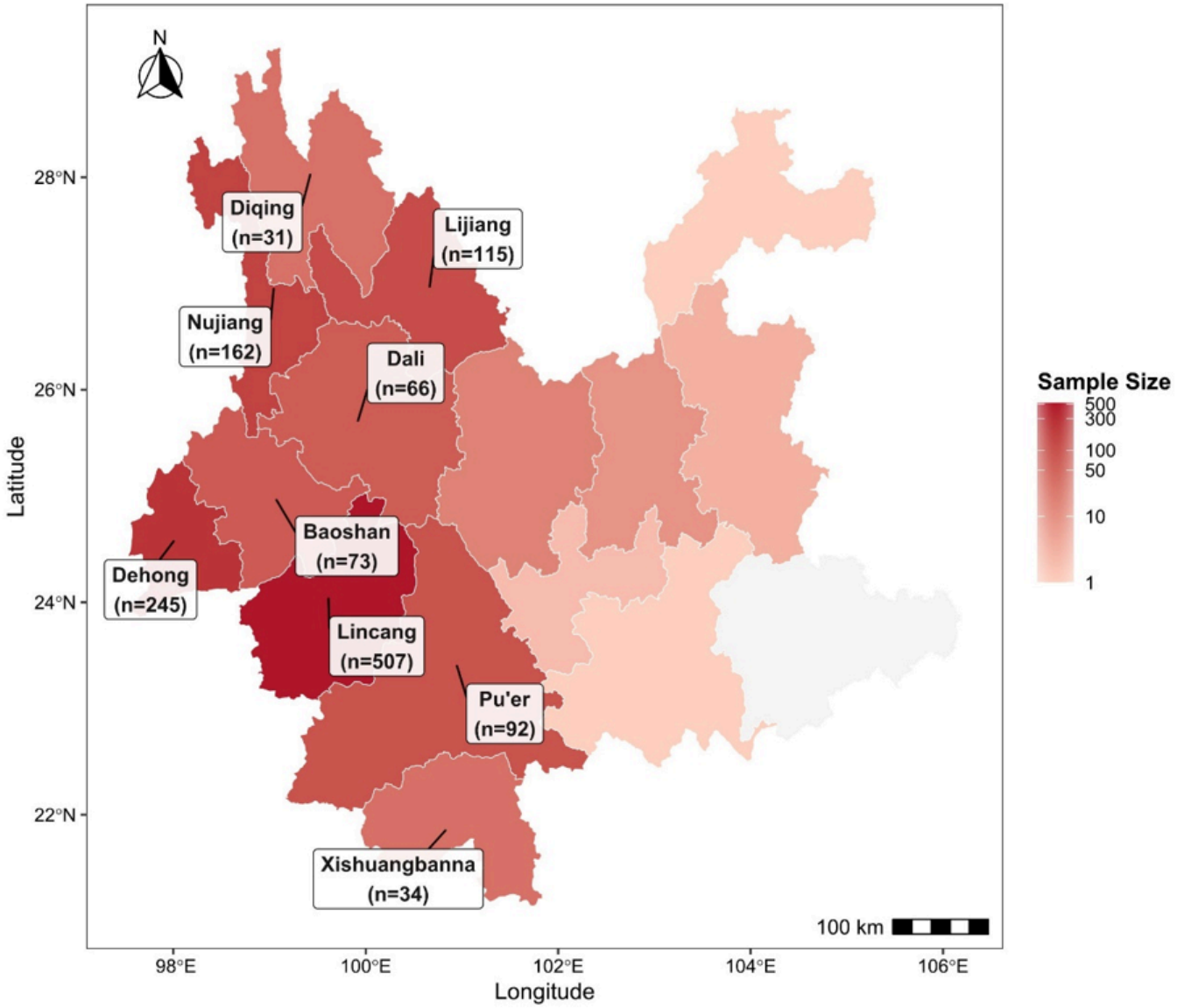


Figure 1

Geographic distribution of the study population.

Note: The heatmap illustrates the sample size distribution across 15 prefectures in Yunnan Province. Darker red indicates a higher concentration of participants. The study population is predominantly clustered in the western border regions, specifically Lincang (n=507), Dehong (n=245), and Nujiang (n=162), which correspond to the primary settlements of the "Directly-Entering-Socialism" ethnic minorities.

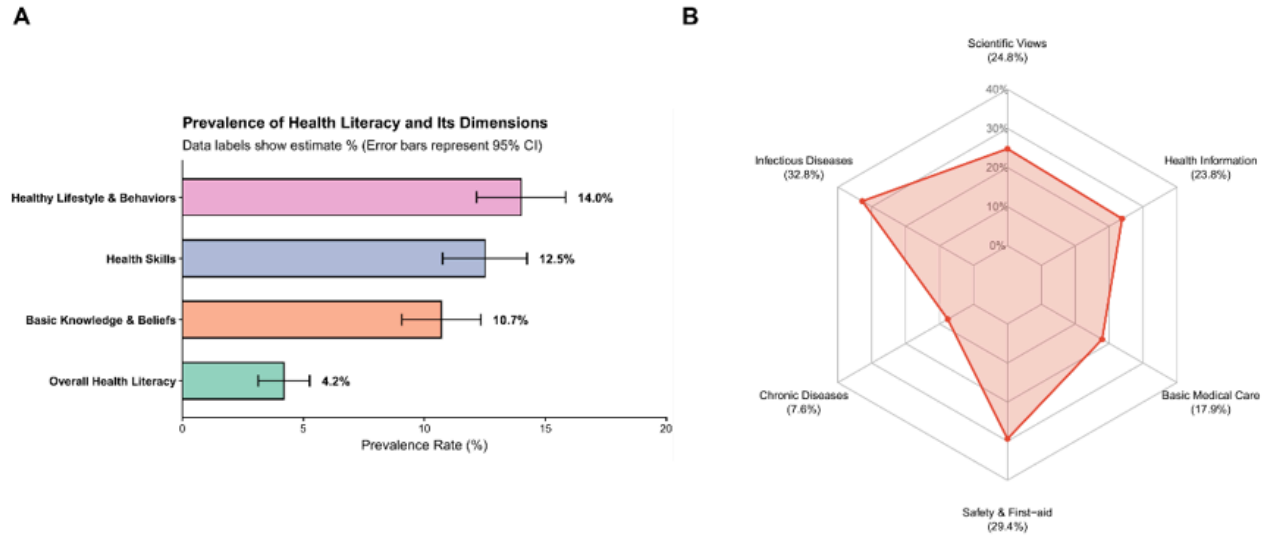


Figure 2

Prevalence of health literacy among "Directly-Entering-Socialism" ethnic minorities. (A) Overall health literacy and its three primary categories (with 95% CIs), identifying "Healthy Lifestyles and Behaviors" (4.2%) as the primary behavioral bottleneck. **(B)** Prevalence across six specific dimensions, contrasting higher proficiency in Infectious Disease Prevention with a critical deficit in "Chronic Disease Prevention" literacy (7.6%).

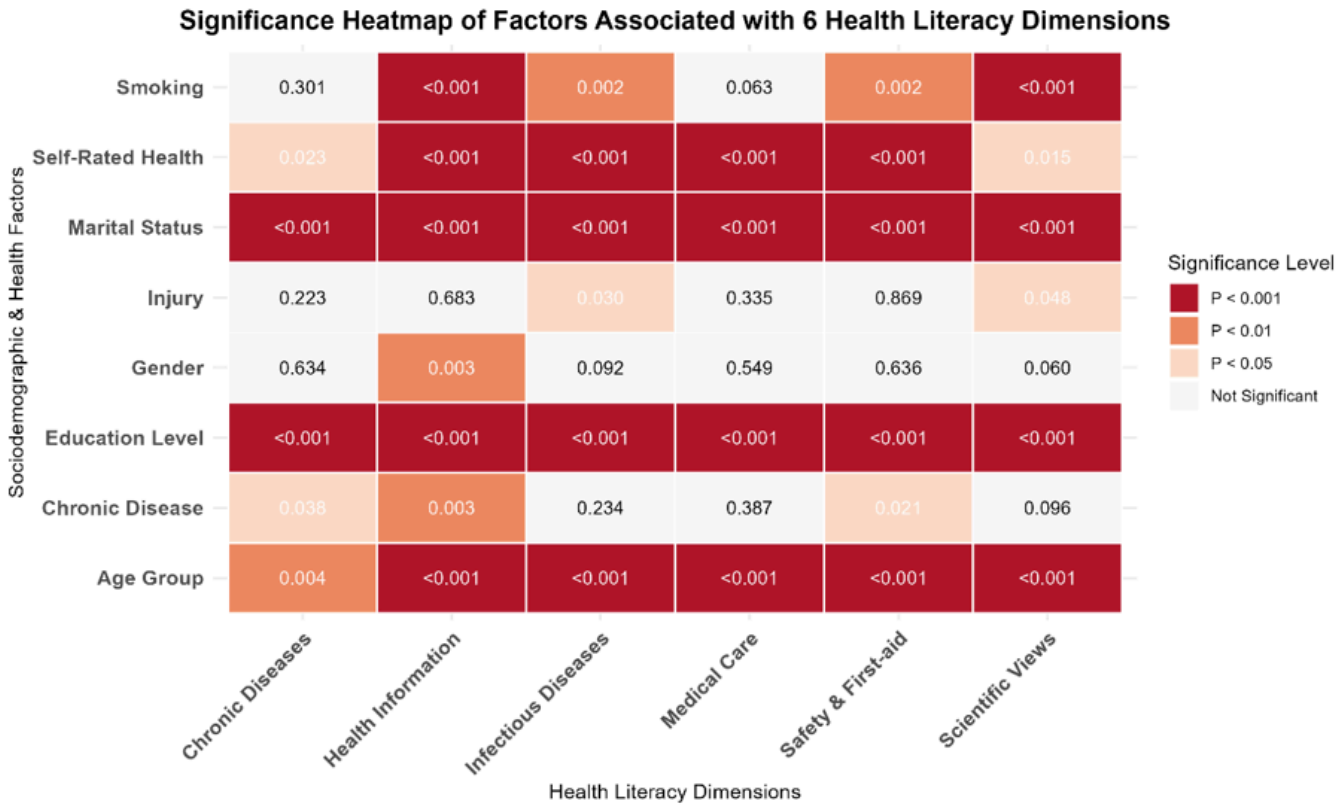


Figure 3

Significance heatmap of factors associated with the six specific health literacy dimensions. ***Note:*** *The heatmap visualizes the statistical significance (P-values derived from Chi-square tests) of various sociodemographic and health-related factors across the six problem-based dimensions. Darker red cells indicate a higher level of statistical significance (P < 0.001). While education level and age group universally determine all dimensions, behavioral factors (e.g., smoking) and health status (e.g., chronic disease) display dimension-specific associations.*

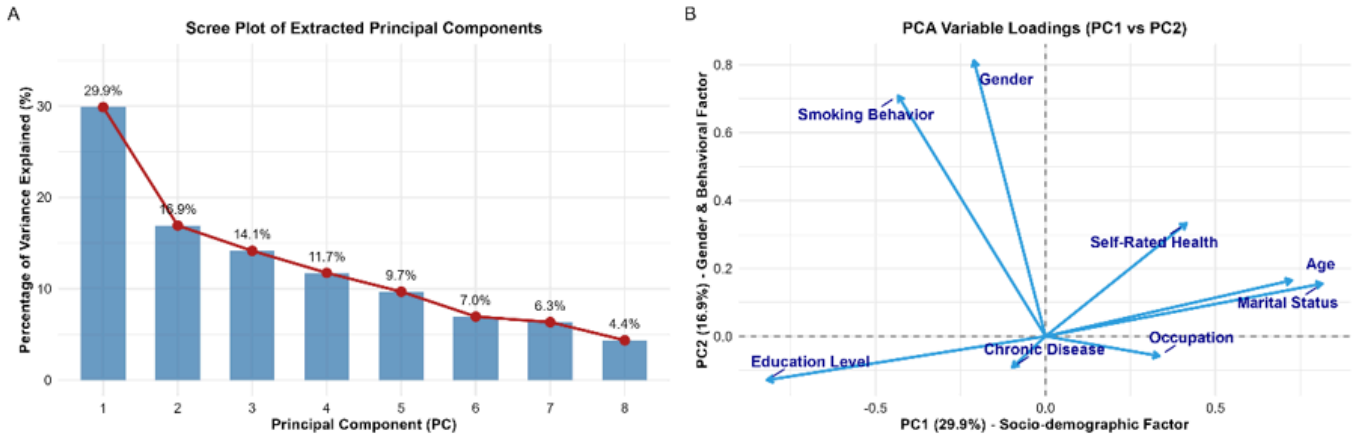


Figure 4

Principal Component Analysis (PCA) of sociodemographic and behavioral factors. (A) Scree plot showing three extracted components (eigenvalues >1) that cumulatively explain 60.93% of the total variance. **(B)** PCA variable loadings biplot (PC1 vs. PC2). PC1 represents a "Socio-demographic Factor" (primarily driven by education and age), while PC2 represents a "Gender & Behavioral Factor" (driven by gender and smoking).

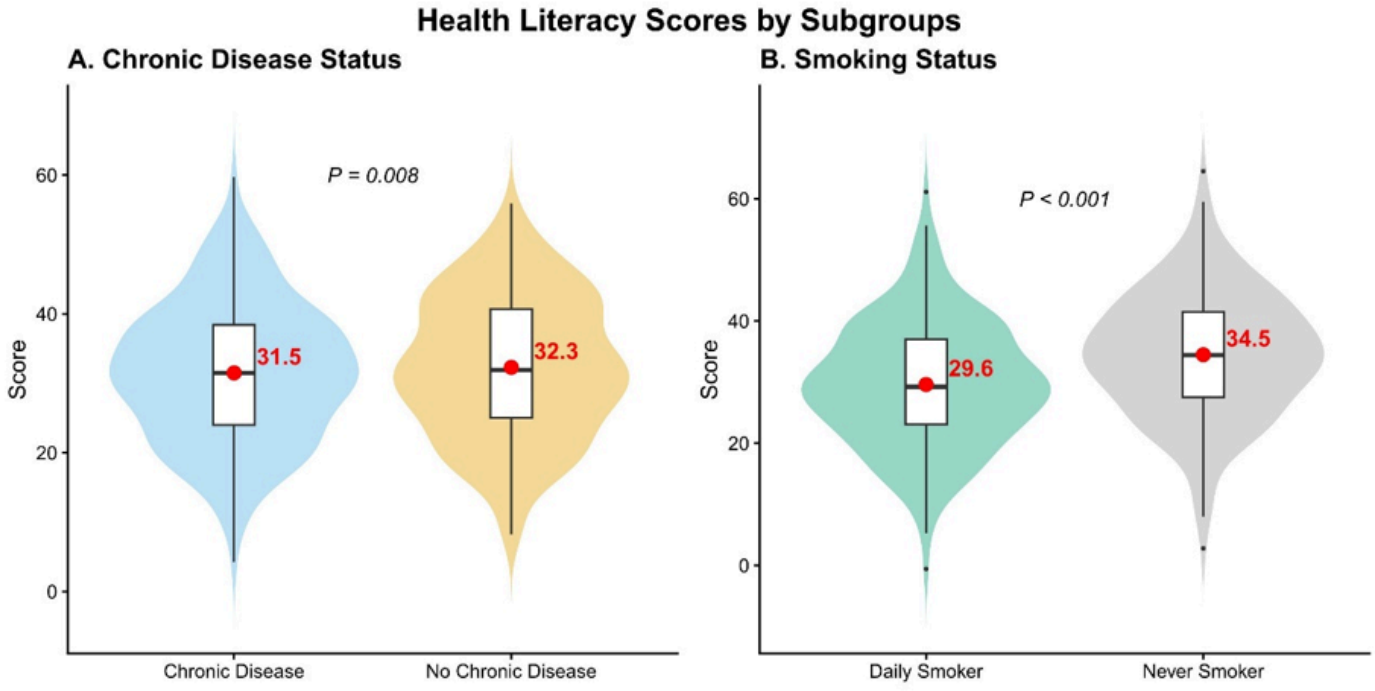


Figure 5

Disparities in health literacy scores by chronic disease status (A) and smoking behavior (B). ***Note:*** *Violin plots combined with boxplots show the distribution of scores. Red dots indicate mean values. Scores for participants without chronic diseases were significantly higher than for those with chronic diseases (P=0.008).*

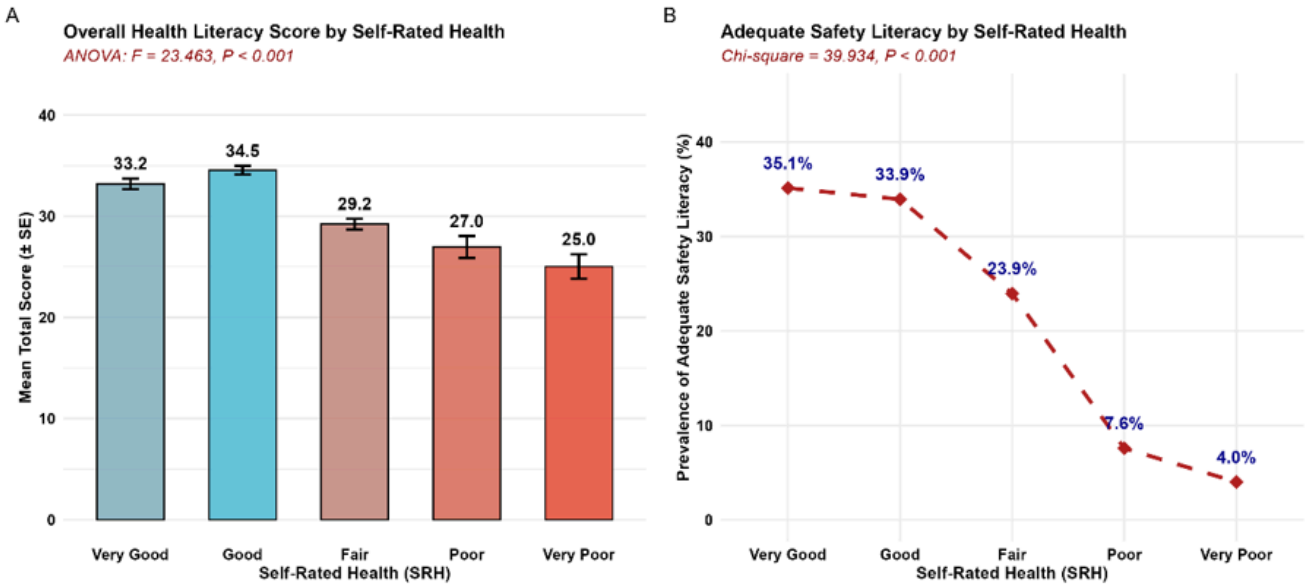


Figure 6

The impact of Self-Rated Health (SRH) on overall health literacy and specific safety literacy. ***Note:*** *(A) Overall health literacy scores strictly decline as self-rated health worsens (error bars represent SE). (B) The prevalence of adequate Safety & First-aid literacy drops precipitously from 35.1% to 4.0% alongside declining SRH, highlighting the "double burden" of physical and cognitive vulnerability.*

Supplementary Files

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