

Medication Literacy and Home Medication Behaviors Among Older Chinese Patients with Chronic Diseases: A National Cross-Sectional Study

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Purpose: To describe the status of home medication behaviors and medication literacy among older patients with chronic diseases in China and to identify factors influencing medication literacy levels to inform improvement strategies.

Patients and Methods: A national cross-sectional study was conducted from October 2022 to the end of June 2023 across 31 provinces using a multi-center, quota-based convenience sampling approach. Trained pharmacists collected data via face-to-face interviews using a validated Knowledge, Attitude, and Practice (KAP) questionnaire. Medication literacy was dichotomized into adequate (score ≥ 186) and inadequate (< 186). Multivariable logistic regression was employed to identify associated determinants.

Results: Among the 10,363 eligible participants, 48.31% demonstrated adequate medication literacy. Prevalent suboptimal home medication behaviors were observed: 57.05% failed to completely retain original medication packaging, and 74.25% could not fully understand package inserts. Through multivariable logistic regression, several key factors were identified as significant predictors of medication literacy. Higher educational attainment (college degree and above: OR = 2.185, 95% CI: 1.744 to 2.738) was identified as a strong predictor of adequate literacy. Conversely, discarding medication package inserts (OR = 0.697, 95% CI: 0.588 to 0.828) and the inability to comprehend package inserts (OR = 0.265, 95% CI: 0.226 to 0.311) were found to be negatively associated with literacy levels. Furthermore, 93.60% of the cohort reported the presence of somatic symptoms, which were frequently misattributed to normal aging rather than potentially modifiable medication-related causes.

Conclusion: Medication literacy among older Chinese adults with chronic diseases remains suboptimal, with nearly half failing to achieve adequate levels. Independent self-management is significantly associated with socioeconomic factors and specific behavioral gaps. A home-based pharmaceutical care system should be implemented to prioritize vulnerable groups, advocate for the retention of original packaging, and promote the development of simplified medication instructions.

Keywords: older patients, chronic diseases, medication literacy, home medication behavior, influencing factors

Introduction

By the mid-2030s, the global population aged 80 years and older is projected to reach 265 million, surpassing the number of infants, and by the late 2070s, the population aged 65 and above is expected to reach 2.2 billion, exceeding the number of children under 18.¹ By the end of 2024, individuals aged 60 and older in China accounted for 22.0% of the total population, a figure projected to reach 498 million by 2050.² With accelerating population aging, multimorbidity of chronic non-communicable diseases has become increasingly prevalent, and polypharmacy is commonplace. Evidence



indicates that the multimorbidity rate among Chinese adults aged 60 and older is 44.3%, with approximately 55% taking 5–9 medications daily and 14% taking more than 10.^{3,4} Older patients with chronic diseases typically require long-term multidrug regimens for disease control and management, making home medication the predominant scenario. However, declining cognitive and comprehension abilities in older adults, coupled with inadequate support from family members or caregivers, frequently result in medication errors at home, including missed doses, incorrect dosing, self-discontinuation, use of expired medications, and poor adherence.⁵ Adverse drug events are occurring frequently. Consequently, enhancing patients' self-management capacity regarding medication is essential to ensuring home medication safety.

The core of these independent management capabilities lies in medication literacy. Traditionally, patient competency has been evaluated through the lens of general health literacy. Health literacy is broadly defined as the cognitive and social skills that determine the ability of individuals to access, comprehend, and apply information to promote and maintain good health.⁶ While this overarching construct provides a foundational understanding of disease prevention and healthcare navigation, it is often insufficient to capture the specific complexities and acute risks associated with pharmacological therapy in the home setting. Consequently, medication literacy has emerged as a distinct and highly specialized construct. Unlike general health awareness, medication literacy demands rigorous and functionally driven competencies. It specifically denotes the capacity of an individual to safely obtain, comprehend, communicate, calculate, and process individualized medication information to execute informed pharmacological decisions.⁷ Furthermore, according to the Knowledge Attitude Practice conceptual framework, true medication literacy extends beyond mere cognitive understanding and willingness. It must manifest in tangible and daily care practices, formally conceptualized as home medication behaviors. Recognized by the World Health Organization as essential independent management actions that patients must adopt upon leaving healthcare facilities to ensure medication safety, these behaviors encompass the specific practical actions and physical management strategies employed by patients within their domestic environment to execute their prescribed therapeutic regimens.^{8–10} Under this theoretical framework, home medication behaviors represent the ultimate practice outcome, which is fundamentally dictated by the cognitive and functional foundation of medication literacy. In the context of older adults, critical physical home medication behaviors, such as retaining original medication packaging, comprehending complex package inserts, and accurately monitoring for adverse drug reactions, serve as direct functional indicators of their underlying medication literacy. Evaluation of these specific competencies provides an actionable reflection of the practical ability of a patient to prevent errors at the point of origin.

Numerous studies demonstrate that higher medication literacy in patients with chronic diseases is associated with greater medication adherence.^{11,12} Despite its critical importance, existing studies are frequently constrained by small, localized sample sizes or focus predominantly on theoretical knowledge, largely overlooking the crucial interplay between literacy and real-world physical medication behaviors in the home setting. To date, there is a paucity of large-scale, nationally representative evidence in China that systematically maps how specific home medication behaviors relate to overall medication literacy. Addressing this knowledge gap is imperative for transitioning from generalized health education to precise, behavior-targeted pharmaceutical care.

Therefore, this national cross-sectional study aimed to: (1) assess medication literacy levels among older patients with chronic diseases across China, (2) describe their specific home medication behaviors, and (3) identify the sociodemographic, clinical, and behavioral factors associated with medication literacy to inform targeted pharmaceutical interventions.

Materials and Methods

Study Design and Sampling Strategy

We conducted a nationwide, multi-center, quota-based convenience sampling cross-sectional study from October 2022 to the end of June 2023. To ensure geographic representation across mainland China, the study covered all 31 provincial-level administrative units. Within each province, a standardized hierarchical recruitment model was implemented. One tertiary hospital served as the primary coordinating center to train local community pharmacists. These trained pharmacists then recruited eligible older adults using convenience sampling at community outpatient clinics and

pharmacy consultation rooms. To balance geographic representation, we set a strict quota of approximately 350 valid cases per province.

Participants and Data Collection

Participants were included if they: (1) were aged ≥ 60 years; (2) resided in one of the four major economic regions; (3) had at least one chronic disease (eg, hypertension, diabetes, hyperlipidemia, hyperuricemia, gout, asthma, and chronic obstructive pulmonary disease, etc.); (4) agreed to a home visit by a pharmacist; and (5) possessed adequate communication ability and cooperated throughout the interview.

Conversely, patients were strictly excluded if they: (1) had severe cognitive impairment, dementia, or psychiatric disorders preventing effective communication; (2) were entirely dependent on caregivers for medication administration with no personal involvement in their medication routine; (3) declined the in-home visit; or (4) provided incomplete questionnaire data during the survey.

Participating pharmacists were required to: (1) hold at least a junior professional title; (2) have ≥ 5 years of practical experience; and (3) have a background in community pharmacy services or medication consultation. Following informed consent, pharmacists conducted in-home visits lasting approximately 30 minutes, during which they physically reviewed the patients' home medicine cabinets and administered the structured questionnaire.

During the recruitment phase, pharmacists approached 12,318 potential participants. Initial screening excluded 964 individuals who did not meet the age criterion of 60 years or older, leaving 11,354 older adults for the home visits and initial surveys. Following data cleaning, we excluded an additional 991 records, specifically 568 with missing data exceeding 30% and 423 containing abnormal or illogical responses. A preliminary missing data analysis indicated that the demographic characteristics of the excluded participants did not differ significantly from the final cohort, suggesting the data were missing completely at random (MCAR). Ultimately, 10,363 valid cases were included in the analysis, yielding an effective response rate of 84.1% (10,363/12,318). The detailed STROBE participant flow is presented in [Figure 1](#).

Ethics Considerations

The study was approved by the Ethics Committee of Beijing Tiantan Hospital, Capital Medical University (KY2022-228-01). Written informed consent was obtained from all participants prior to their enrollment and the in-home physical audit. The research was conducted in full accordance with the ethical principles outlined in the Declaration of Helsinki.

Questionnaire Content and Variable Definitions

An expert panel developed the questionnaire utilizing the Knowledge, Attitude, and Practice (KAP) conceptual framework. An extensive literature search revealed that while existing tools adequately capture cognitive domains, they frequently overlook physical medication management behaviors at home. Consequently, multidisciplinary focus group discussions led our team to integrate objective home-based physical audits into the survey. The finalized instrument consisted of two primary components. First, pharmacists assessed sociodemographic and clinical variables, including age, gender, educational attainment, monthly income, residential status, employment, medical insurance type, the number of chronic diseases, and daily medication burden. Second, we utilized a 55 item Medication Literacy Scale to evaluate participants across knowledge, attitude, and practice dimensions. Crucially, this instrument explicitly operationalized home medication behaviors as practical actions assessed during the home visit, such as the retention of original packaging and the ability to comprehend package inserts. Drug Related Problems were defined in alignment with the Pharmaceutical Care Network Europe classification, encompassing actual or potential issues identified during the home audit, including self-reported adverse drug reactions, inappropriate storage, or symptom driven dose adjustments.

To clarify abstract concepts for older adults, critical metrics were mapped to concrete clinical scenarios. For example, comprehending disease specific targets required patients to accurately articulate their precise blood pressure, blood lipid, and blood glucose goals. Similarly, being fully aware of key package inserts was evaluated by the capacity of the patient to read and correctly comprehend at least 80% of the informational content within the inserts. This included identifying: (1) drug name and strength, (2) specific indications relevant to their condition, (3) exact dosage and timing, (4) major contraindications, (5) common adverse reactions to monitor, and (6) proper storage conditions. Furthermore, stronger

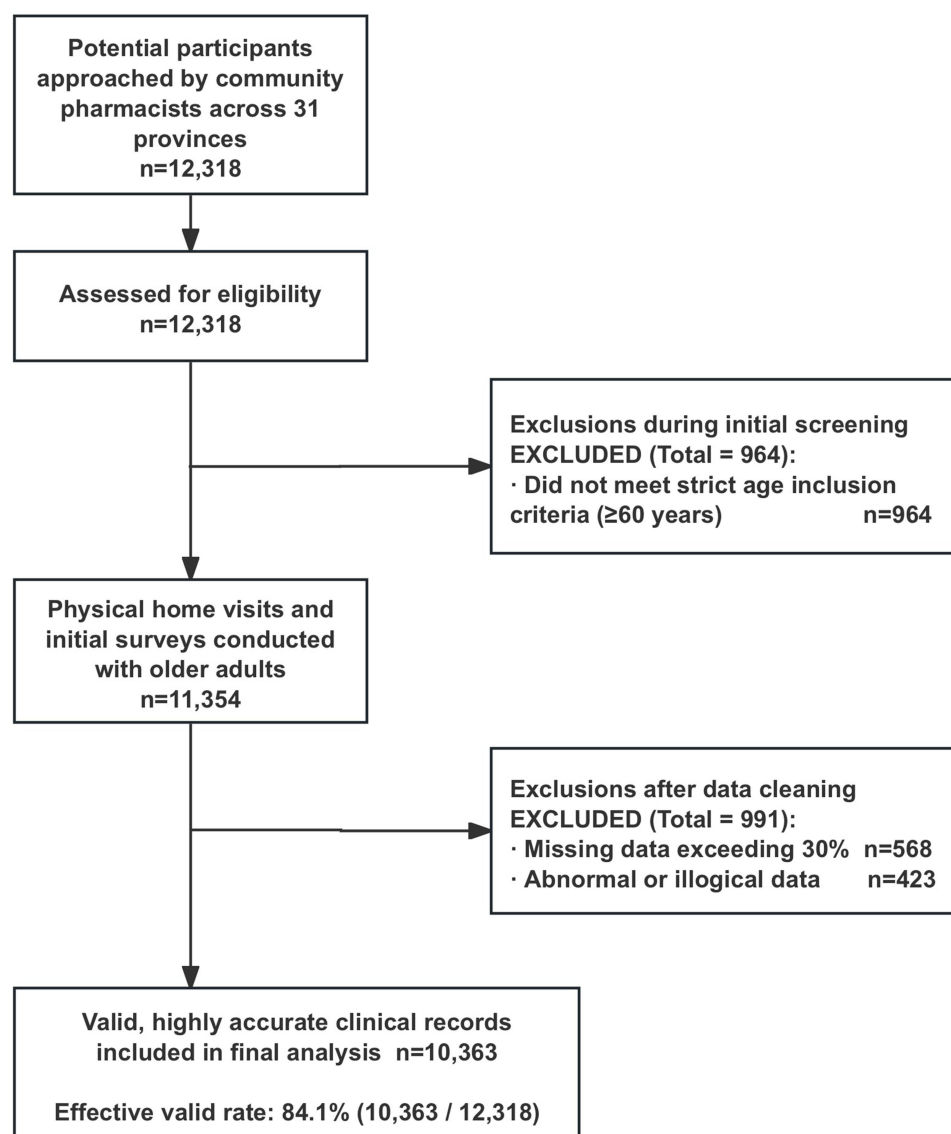


Figure 1 STROBE flow diagram of the participant recruitment and selection process. The flowchart details the stepwise screening of older adults with chronic diseases across 31 provinces in China. Specific reasons for exclusion during the initial approach and post-survey data cleaning, including age ineligibility (<60 years), missing data exceeding 30%, and abnormal or illogical responses, are outlined, yielding a final analytical cohort of 10,363 valid cases.

retention and comprehension of key medications were strictly operationalized as the physical practice of completely preserving both the original outer medication packaging and the accompanying package inserts. Items 1 to 26 and 33 to 55 were scored on a 1 to 5 Likert scale, while items 27 to 32 were dichotomous. The internal consistency Cronbach's alpha was 0.918, and confirmatory factor analysis demonstrated excellent model fit.

Justification of the Literacy Cut-off Score

In the absence of a universally established absolute clinical threshold for this specific scale, we dichotomized the medication literacy score using a data-driven approach combined with expert consensus. Specifically, the threshold was defined as the rounded sample mean of the overall KAP score from the final study cohort. A Delphi expert panel comprising clinical pharmacists subsequently validated this statistical benchmark. The panel concluded that dichotomizing at the population mean provides substantial clinical utility for public health interventions. Clinically, patients scoring below the cohort average typically exhibit observable deficits in independent self-management capacity, such as the inability to comprehend complex package inserts or identify warning signs requiring immediate medical attention.

Statistical Analysis

A priori power analysis determined the sample size. Assuming 90% power, a conservative 50% anticipated prevalence of adequate literacy, and a 1% margin of error, our target of over 10,000 cases was confirmed to be robustly powered. Data were analyzed using SPSS version 27.0. Descriptive statistics summarized frequencies and percentages. To perform comparisons between groups (adequate vs. inadequate literacy), Pearson's chi-square tests were utilized for categorical variables. We then constructed multivariable binary logistic regression using variables that demonstrated statistical significance ($p < 0.05$) in the univariate analysis to identify associated predictors. Medication literacy served as the dependent variable, with "inadequate literacy" coded as the reference category (0) and "adequate literacy" coded as (1).

Prior to regression analysis, multicollinearity among independent variables was assessed using the Variance Inflation Factor (VIF), applying a standard threshold of $VIF < 5.0$ to confirm the absence of severe multicollinearity. Predictors were incorporated into the model using the forced entry method (Enter). Model goodness of fit was evaluated using the omnibus likelihood ratio test and the Hosmer-Lemeshow test. Results of the regression analysis are presented as adjusted odds ratios (ORs) with their corresponding 95% confidence intervals (CIs). All statistical tests were two-sided, and a P -value < 0.05 was considered statistically significant.

In addition, to further validate the robustness of the findings, we conducted three sensitivity analyses. First, we performed a median-based sensitivity analysis by re-dichotomizing the cohort using the median score (185 points) as the cut-off value. Second, we constructed a multiple linear regression model treating the medication literacy score as a continuous dependent variable. Third, we conducted an exclusion analysis by removing small-province clusters.

Results

Participant Characteristics

After rigorous quality control and exclusion of incomplete or ineligible responses, 10,363 valid questionnaires were retained, corresponding to an effective response rate of 91.56%. Baseline demographic and clinical characteristics of the participants are presented in Table 1.

Table 1 Distribution of Basic Characteristics of Participants n (%)

Characteristics	Total N (%)	Medication Literacy		χ^2/t	P
		Adequate (n=5006)	Inadequate (n=5357)		
Gender					
Male	4752 (45.86)	2339 (49.2)	2413 (50.8)	2.942	0.086
Female	5611 (54.14)	2667 (47.5)	2944 (52.5)		
Age					
60~69	6122 (59.08)	3011 (49.2)	3111 (50.8)	10.781	0.005
70~79	2961 (28.57)	1430 (48.3)	1531 (51.7)		
≥80	1280 (12.35)	565 (44.1)	715 (55.9)		
Education level					
Primary school and below	3476 (33.54)	1079 (31.0)	2397 (69.0)	813.872	***
Junior high school	2708 (26.13)	1321 (48.8)	1387 (51.2)		
High school and secondary specialized school	3401 (32.82)	2017 (59.3)	1384 (40.7)		
College degree and above	778 (7.51)	589 (75.7)	189 (24.3)		
Smoking					
Yes	1405 (13.56)	635 (45.2)	770 (54.8)	6.299	0.012
No	8958 (86.44)	4317 (48.8)	4587 (51.2)		
Drinking					
Yes	1476	706 (47.8)	770 (52.2)	0.155	0.694
No	8887	4300 (48.4)	4587 (51.6)		

(Continued)

Table 1 (Continued).

Characteristics	Total N (%)	Medication Literacy		χ^2/t	P
		Adequate (n=5006)	Inadequate (n=5357)		
Living Situation					
Living alone	891 (8.60)	443 (49.7)	448 (50.3)	54.882	***
With spouse or caregiver	5941 (57.33)	3006 (50.6)	2935 (49.4)		
Living with children	3461 (33.40)	1543 (44.6)	1918 (55.4)		
Nursing home or other arrangements	70 (0.68)	14 (20.0)	56 (80.0)		
Monthly income/CNY					
<1000	2021 (19.50)	619 (30.6)	1402 (69.4)	607.041	***
1000~3000	2991 (28.86)	1268 (42.4)	1723 (57.6)		
3000~5000	3539 (34.15)	1891 (53.4)	1648 (46.6)		
5000~10,000	1604 (15.48)	1085 (67.6)	519 (32.4)		
>10,000	208 (2.01)	143 (68.8)	65 (32.4)		
Employment Status					
Retired at home	7454 (71.93)	3891 (52.2)	3563 (47.8)	291.998	***
Re-employed in the workforce	391 (3.77)	255 (65.2)	136 (34.8)		
Working in urban areas	2518 (24.30)	860 (34.2)	1658 (65.8)		
Reimbursement method					
Government funding or medical insurance	5597 (54.01)	3190 (57.0)	2407 (43.0)	373.254	***
Rural cooperative medical care	4463 (43.07)	1690 (37.9)	2773 (62.1)		
Self-payment	303 (2.92)	126 (41.6)	177 (58.4)		
Number of chronic diseases					
1	4028 (38.87)	1939 (48.1)	2089 (51.9)	9.576	0.008
2~3	5129 (49.49)	2435 (47.5)	2694 (52.5)		
4~	1206 (11.64)	632 (52.4)	574 (47.6)		
Number of medications ($\bar{x} \pm s$)	3.60±2.603	3.69±2.745	3.52±2.461	-3.382	***
Grouping by the number of medications					
≤2	3903 (37.66)	1868 (47.9)	2035 (52.1)	16.022	***
3~5	4791 (46.23)	2258 (47.1)	2533 (52.9)		
≥6	1669 (16.11)	880 (52.7)	789 (47.3)		
Retention of medication package inserts					
Retain	4006 (38.66)	2385 (59.5)	1621 (40.5)	330.124	***
Partially retain	4458 (43.02)	1849 (41.5)	2609 (58.5)		
Do not retain	1899 (18.32)	772 (40.7)	1127 (59.3)		
Retention of medication packaging					
Retain	4451 (42.95)	2508 (56.3)	1943 (43.7)	213.690	***
Partially retain	4730 (45.64)	1946 (41.1)	2784 (58.9)		
Do not retain	1182 (11.41)	552 (46.7)	630 (53.3)		
Awareness of disease control indicators					
Very clear	2559 (24.69)	1756 (68.6)	803 (31.4)	763.838	***
Know some	5852 (56.47)	2709 (46.3)	3134 (53.7)		
Do not know	1952 (18.84)	541 (27.7)	1411 (72.3)		
Awareness of each medication's indications					
Know all	2495 (24.08)	1669 (66.9)	826 (33.1)	760.772	***
Know most	4907 (47.35)	2449 (49.9)	2458 (50.1)		
Know few	2519 (24.31)	790 (31.4)	1729 (68.6)		
Know none	442 (4.27)	98 (22.2)	344 (77.8)		
Presence of physical discomfort symptoms					
Yes	9700 (93.60)	4616 (47.6)	5084 (52.4)	31.374	***
No	663 (6.40)	390 (58.8)	273 (41.2)		

(Continued)

Table 1 (Continued).

Characteristics	Total N (%)	Medication Literacy		χ^2/t	P
		Adequate (n=5006)	Inadequate (n=5357)		
Occurrence of ADR					
Yes, and can describe clearly	1848 (17.83)	1080 (58.4)	768 (41.6)	281.692	***
Yes, but cannot describe clearly	3681 (35.52)	1383 (37.6)	2298 (62.4)		
No	4834 (46.65)	2543 (52.6)	2291 (47.4)		
Ability to read and understand medication package inserts					
Fully capable	2668 (25.75)	1940 (72.7)	728 (27.3)	1277.995	***
Partially capable	5334 (51.47)	2540 (47.6)	2794 (52.4)		
Incapable	2361 (22.78)	526 (22.3)	1835 (77.7)		
DRPs					
Yes	3844 (37.09)	2163 (56.3)	1681 (43.7)	155.169	***
No	6519 (62.91)	2843 (43.6)	3676 (56.4)		

Note: ***Represents $P < 0.001$.

Abbreviations: ADR, adverse drug reactions; DRPs, drug-related problems.

Of the participants, 5611 (54.14%) were female and 4752 (45.86%) were male, with females predominating. The mean age was 69.07 ± 7.83 years, with the majority (65.78%) falling within the 60–69-year age group. More than half (59.67%) had completed junior high school education or less, and 90.73% lived with family members. Additionally, 82.51% reported a monthly income of less than 5000 CNY, 71.93% were retired, and 28.07% remained employed through rehiring or casual work. Multimorbidity (≥ 2 chronic diseases) was present in 61.13% of the cohort.

Assessment of Medication Literacy

In the present study, the mean medication literacy score among the 10,363 participants was 186.65 ± 27.70 (range: 79–275). Applying the data-driven methodology described earlier, we utilized the rounded sample mean of 186 as the clinical cut-off value. Consequently, participants scoring ≥ 186 were classified as having adequate medication literacy, whereas those scoring < 186 were considered to have inadequate medication literacy.

The mean number of prescribed medications per participant was 3.60 ± 2.603 . Patients with inadequate medication literacy took fewer medications on average (3.52 ± 2.461) compared with those with adequate medication literacy (3.69 ± 2.745 ; $t = -3.382$, $p < 0.001$).

Overall, 5006 participants (48.31%) demonstrated adequate medication literacy, with a mean score of 209.69 ± 17.51 , whereas 5357 participants (51.69%) exhibited inadequate medication literacy, with a mean score of 165.11 ± 15.42 (Table 2).

Home Medication Behaviors

Figure 2 presents the results on home medication knowledge and behaviors among older patients with chronic diseases. The results revealed that 62.34% of participants ($n=6460$) were taking three or more medications daily. Complete

Table 2 Results of KAP Questionnaire Scores on Medication Literacy

Group	Medication Literacy Knowledge	Drug Literacy Attitude	Medication Literacy Behavior	Total
Adequate Literacy Group (n=5006)	102.96 ± 11.62	36.20 ± 4.68	70.53 ± 8.71	209.69 ± 17.51
Inadequate Literacy group (n=5357)	77.33 ± 10.44	29.16 ± 4.10	58.62 ± 7.34	165.11 ± 15.42
Average	89.71 ± 16.90	32.56 ± 5.63	64.37 ± 9.99	186.65 ± 27.70

Note: KAP (Knowledge, Attitude, Practice).

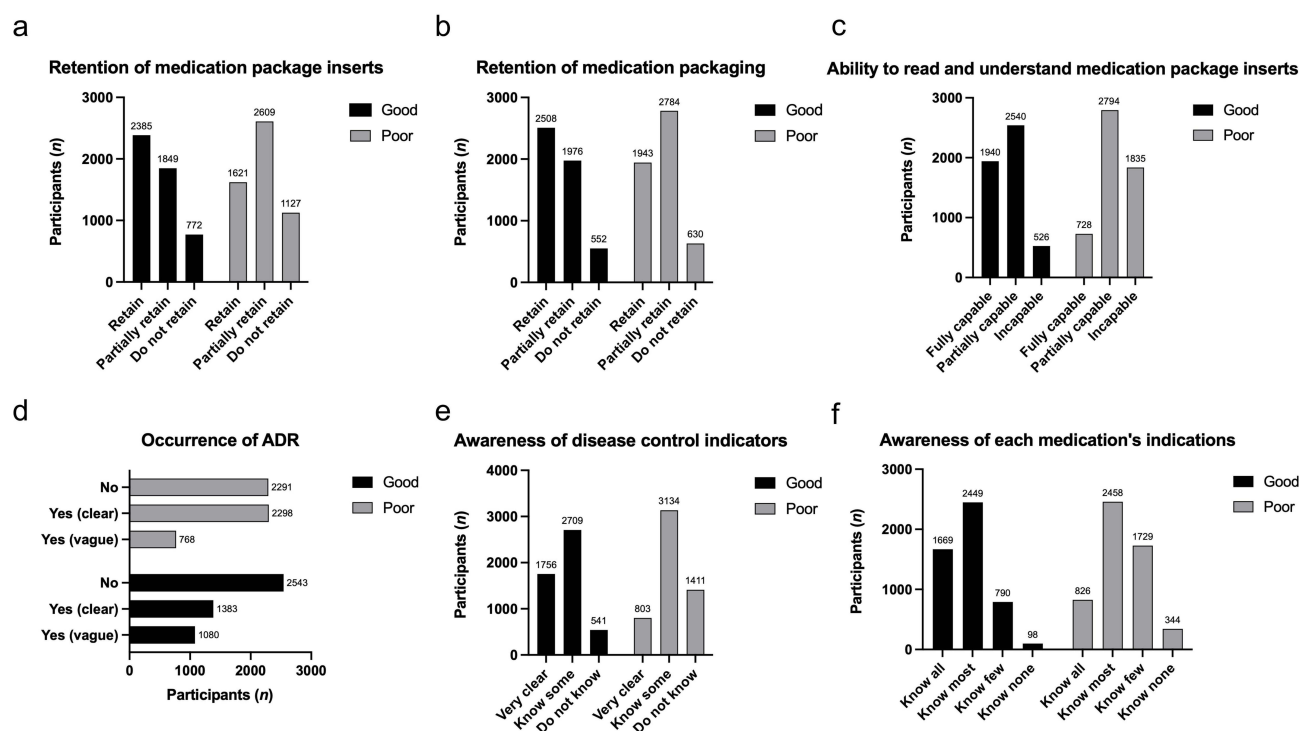


Figure 2 Investigation of home medication behaviors in older adults. (a) Survey on whether older adults retain medication package inserts. (b) Survey on whether older adults retain medication packaging. (c) Survey of the older adults' ability to read and comprehend medication package inserts. (d) Survey of the incidence of adverse drug reactions among older adults. (e) Survey of the older adults' awareness of disease control indicators. (f) Survey of the older adults' awareness of medication indications.

retention of original outer packaging was reported by only 42.95% of participants, and complete retention of package inserts by just 38.66%; both proportions were below 50%. Retention of package inserts ($\chi^2=330.124$, $p<0.001$) and outer packaging ($\chi^2=213.690$, $p<0.001$) differed significantly between the adequate and inadequate medication literacy groups.

Only 24.08% ($n=2495$) of participants reported being fully aware of their disease-specific control targets, whereas 71.43% knew the indications for at least half of their medications. Persistent physical discomfort was reported by 93.60% of the cohort. A history of adverse drug reactions (ADRs) was acknowledged by more than half (53.35%), among whom only 17.83% could describe the events clearly and 35.52% were unable to provide a clear description.

Notably, the ability to comprehend package inserts exerted a highly significant influence on medication literacy ($p<0.001$). Only 25.75% of participants reported full understanding of package inserts, whereas 51.47% had partial understanding and 22.78% reported no understanding.

Multivariable Logistic Regression Analysis

In the present study, participants were initially dichotomized into adequate and inadequate medication literacy groups based on their total scores. Univariate analyses revealed statistically significant between-group differences (all $P < 0.05$) across various sociodemographic and behavioral domains. These domains included education level, residential status, monthly income, employment status, medical insurance type, knowledge of disease control targets, retention and comprehension of package inserts, retention of outer packaging, awareness of medication indications, self-reported physical discomfort, and the presence of drug-related problems (DRPs) or adverse drug reactions (ADRs) (Table 1).

To identify the primary determinants underlying these differences, variables demonstrating statistical significance in the univariate analysis were entered into a multivariable binary logistic regression model. Inadequate medication literacy was designated as the reference category (coded 0), and adequate medication literacy was coded 1. The omnibus likelihood ratio test was highly significant ($\chi^2 = 2495.228$, $p < 0.001$), indicating strong overall explanatory power of the included covariates. The Hosmer-Lemeshow goodness-of-fit test yielded $\chi^2 = 6.619$ ($p = 0.578$), confirming excellent model calibration.

The regression analysis identified several key socioeconomic and behavioral factors associated with medication literacy. Compared to primary school or below, higher educational attainment was progressively associated with better medication literacy. College degrees or above (OR = 2.185, 95% CI: 1.744 to 2.738, $p < 0.001$), senior high school (OR = 1.457, 95% CI: 1.273 to 1.668, $p < 0.001$), and junior high school (OR = 1.193, 95% CI: 1.051 to 1.353, $p = 0.006$) all conferred significantly higher odds of adequate literacy. Conversely, institutional residence (OR = 0.247, 95% CI: 0.124 to 0.495, $p < 0.001$) and having the New Rural Cooperative Medical Scheme (OR = 0.789, 95% CI: 0.705 to 0.881, $p < 0.001$) were independently associated with lower literacy levels.

Behaviorally, the inability to retain and comprehend medication information emerged as a strong negative associate. Patients who discarded their package inserts (OR = 0.697, 95% CI: 0.588 to 0.828, $p < 0.001$) and those who reported a complete inability to understand the inserts (OR = 0.265, 95% CI: 0.226 to 0.311, $p < 0.001$) were significantly less likely to achieve adequate medication literacy. An inverse association was also observed between the presence of self-reported DRPs and literacy levels (OR = 0.734, 95% CI: 0.668 to 0.808, $p < 0.001$), potentially indicating reverse causality, where existing problems limit effective self-management. In the multivariable adjusted model, age group variations and outer packaging retention did not reach statistical significance. Detailed results are presented in Table 3.

Table 3 Comparison of Medication Literacy of the Older Adult with Different Characteristics

Variables		β	S.E.	Wald	p	OR	95% CI
Age (ref = 60~69)	70~79	0.082	0.054	2.294	0.130	1.085	0.976–1.206
	≥ 80	0.034	0.077	0.199	0.656	1.035	0.890–1.203
Education level (ref = Primary school and below)	Junior high school	0.176	0.064	7.474	0.006	1.193	1.051–1.353
	High school and secondary specialized school	0.377	0.069	29.837	***	1.457	1.273–1.668
	College degree and above	0.782	0.115	46.225	***	2.185	1.744–2.738
Smoking (ref = yes)		0.223	0.066	11.483	***	1.250	1.099–1.423
Living Situation (ref = Living alone)	With spouse or caregiver	−0.097	0.084	1.349	0.245	0.907	0.770–1.069
	Living with children	−0.103	0.087	1.387	0.239	0.902	0.760–1.071
	Nursing home or other arrangements	−1.398	0.354	15.584	***	0.247	0.124–0.495
Monthly income/CNY (ref = <1000)	1000~3000	−0.066	0.073	0.818	0.366	0.936	0.811–1.080
	3000~5000	−0.055	0.081	0.464	0.496	0.946	0.808–1.109
	5000~10,000	0.166	0.100	2.760	0.097	1.181	0.971–1.437
	>10,000	0.206	0.189	1.192	0.275	1.229	0.849–1.778
Employment Status (ref = Retired at home)	Re-employed in the workforce	0.040	0.124	0.102	0.749	1.040	0.816–1.327
	Working in urban areas	−0.128	0.063	4.100	0.043	0.880	0.777–0.996
Reimbursement method (ref = Government funding or medical insurance)	Rural cooperative medical care	−0.238	0.057	17.525	***	0.789	0.705–0.881
	Self-payment	0.028	0.139	0.040	0.841	1.028	0.783–1.350
Number of chronic diseases (ref = 1)	2~3	−0.079	0.052	2.382	0.123	0.924	0.835–1.022
	4~	0.014	0.081	0.030	0.863	1.014	0.865–1.190
Grouping by the number of medications (ref = ≤ 2)	3~5	−0.044	0.053	0.668	0.414	0.957	0.862–1.063
	≥ 6	0.102	0.075	1.857	0.173	1.107	0.956–1.282
Retention of medication package inserts (ref = Retain)	Partially retain	−0.270	0.069	15.358	***	0.764	0.667–0.874
	Do not retain	−0.360	0.087	17.055	***	0.697	0.588–0.828
Retention of medication packaging (ref = Retain)	Partially retain	−0.102	0.067	2.360	0.124	0.903	0.792–1.029
	Do not retain	0.116	0.100	1.352	0.245	1.123	0.924–1.365
Awareness of disease control indicators (ref = Very clear)	Know some	−0.295	0.058	26.275	***	0.744	0.665–0.833
	Do not know	−0.670	0.079	72.348	***	0.512	0.438–0.597
Awareness of each medication's indications (ref = Know all)	Know most	−0.297	0.058	25.755	***	0.743	0.663–0.833
	Know few	−0.475	0.072	43.430	***	0.622	0.540–0.716
	Know none	−0.644	0.139	21.597	***	0.525	0.400–0.689

(Continued)

Table 3 (Continued).

Variables		β	S.E.	Wald	<i>p</i>	OR	95% CI
Presence of physical discomfort symptoms (ref = yes)		0.126	0.094	1.795	0.180	1.134	0.943–1.364
Occurrence of ADR (ref = Yes, and can describe clearly)	Yes, but cannot describe clearly	−0.283	0.066	18.126	***	0.754	0.662–0.858
	No	0.077	0.063	1.480	0.224	1.080	0.954–1.223
Ability to read and understand medication package inserts (ref = Fully capable)	Partially capable	−0.607	0.058	107.927	***	0.545	0.486–0.611
	Incapable	−1.329	0.082	262.897	***	0.265	0.226–0.311
DRPs (ref = No)		−0.309	0.048	40.628	***	0.734	0.668–0.808

Notes: ***Represents $P < 0.001$. The multivariable logistic regression model was adjusted for province-level fixed effects to account for potential spatial clustering. The specific odds ratios for individual provinces are not displayed in this table. Inadequate medication literacy was the reference category for the dependent variable. S.E., standard error; OR, odds ratio; CI, confidence interval; ADR, adverse drug reactions; DRPs, drug-related problems.

Sensitivity Analyses

Three sensitivity analyses were conducted to verify the robustness of the primary model and address potential information loss from dichotomizing the literacy scores. When re-categorizing the cohort using the median score as the cut-off, the logistic regression results remained highly consistent: educational attainment, package insert retention, and insert comprehension persisted as strong independent predictors (all $p < 0.001$). Additionally, a multiple linear regression treating the total literacy score as a continuous outcome (Adjusted $R^2 = 0.253$, $F = 195.647$, $p < 0.001$) fully supported the primary findings. Specifically, inability to understand inserts ($\beta = -0.241$, $p < 0.001$), educational level ($\beta = 0.110$, $p < 0.001$), and the presence of DRPs ($\beta = -0.086$, $p < 0.001$) continued to be the most prominent influencing factors. Finally, an exclusion analysis omitting minor province clusters (final $n = 10,293$) did not alter the significance, directionality, or relative magnitude of the key predictors. Together, these results demonstrate the stability of our findings across alternative analytical approaches.

Discussion

Main Findings

Through face-to-face home audits and surveys, this study evaluated the medication-taking behaviors and medication literacy of 10,363 older patients with chronic diseases across 31 provinces in China. The findings revealed that medication literacy remains suboptimal, with only 48.31% of the cohort achieving adequate levels. Prevalent medication safety risks in the home setting are closely associated with suboptimal behaviors, notably the discarding of original medication packaging and the inability to comprehend package inserts. Furthermore, a vast majority of participants (93.60%) reported experiencing somatic symptoms, which were frequently misattributed to normal aging. Multivariable analysis identified higher educational attainment, retention of packaging, and comprehension of inserts as strong positive predictors of medication literacy, whereas institutional residence and lower socioeconomic status were negatively associated.

Comparison with Previous Studies and the Chinese Context

The adequate medication literacy rate of 48.31% observed in our cohort highlights a substantial need for targeted clinical interventions. When viewed alongside general health literacy rates, which frequently exceed 60% among older adults in developed nations, this statistical gap is highly illuminating.^{13,14} As established in the introduction, it is crucial to distinguish the highly specialized concept of medication literacy from broader health literacy. While adequate health literacy enables older adults to navigate medical systems and understand general lifestyle advice, it does not automatically ensure safe pharmacological execution. Medication literacy requires advanced cognitive and functional execution, including the ability to calculate exact dosages, interpret complex clinical instructions, and identify physical medication hazards in the domestic environment. The 48.31% adequacy rate in our study underscores that even when older adults possess general health awareness, translating that awareness into the rigorous and unforgiving practices required for home medication management remains a significant challenge. This disparity highlights the ongoing difficulties in healthcare resource allocation and the penetration of targeted pharmaceutical education in developing contexts.

Previous studies have also noted that individuals residing in eastern China demonstrate significantly higher medication literacy levels than those in central and western regions. This geographic disparity is driven chiefly by unequal healthcare resource distribution, variable penetration of health education programs, and disparate patient self-management capacities.^{15,16} Overall, medication literacy among older Chinese adults with chronic conditions remains suboptimal, leaving substantial room for improvement to enhance self-management and promote safer medication use in the home environment.¹⁷

Beyond systemic and regional factors, the specific cultural context of China profoundly influences home medication behaviors. Chinese older adults traditionally rely heavily on familial support for health management rather than independent proactive learning.¹⁸ Consequently, when minor somatic symptoms or early adverse drug reactions (ADRs) occur, there is a strong cultural tendency to attribute these issues exclusively to normal aging or seasonal changes rather than suspecting potentially modifiable medication errors. Among the 53.35% of participants in our study who had experienced ADRs, only 17.83% could describe the episode clearly. This cultural normalization of physical discomfort significantly delays corrective clinical action, leaving the remainder of adverse events unnoticed, unreported, and unmanaged in the domestic environment.

Explanatory Mechanisms for Key Determinants

Educational attainment and socioeconomic status emerged as significant predictors of medication literacy. Individuals with higher education levels exhibited a significantly greater proportion of adequate medication literacy, were more likely to possess a clear understanding of disease control targets and medication indications, and demonstrated superior comprehension of package inserts. These findings highlight the critical role of health education in facilitating the understanding and practical application of medical information. Interestingly, while age is traditionally considered a primary barrier to health literacy, it lost its statistical significance in our multivariable adjusted model. This loss of significance suggests profound generational disparities in educational opportunities in China. The lower medication literacy observed among older age groups in univariate analyses is likely driven by their historical lack of access to formal education rather than biological cognitive decline. This finding is highly encouraging, as it redefines medication literacy not as an irreversible consequence of aging, but as a modifiable socioeconomic deficit that can be mitigated through continuous, targeted health education.

Parallel to educational disparities, broader socioeconomic factors profoundly influenced literacy levels. Higher monthly income was consistently associated with greater medication literacy, a relationship likely linked to having better access to health information resources and the formation of stronger self-management capabilities. Conversely, lower-income groups displayed reduced literacy levels, potentially due to their socioeconomic disadvantages and restricted channels for obtaining reliable health information. For instance, older adults still engaged in urban employment exhibited lower literacy levels, which may be related to their lower average income and time constraints that hinder their ability to focus on medication management. Similarly, participants covered by rural cooperative medical insurance demonstrated significantly lower medication literacy compared to those with government funding or urban employee medical insurance. Economic levels are inherently linked to the type of medical insurance. Research indicates that compared to high-income populations, low- and middle-income groups perceive medical compensation as less equitable and rely more heavily on publicly financed health insurance.¹⁹ This underscores the necessity of prioritizing socioeconomically vulnerable populations.

Regarding home medication behaviors, the outer carton and package insert serve as the primary sources of medication information, containing critical identification details (active ingredients, strength, batch number, expiry date) and essential clinical guidance (dosage, contraindications, adverse reactions, storage conditions).²⁰ In this study, only 38.66% of participants completely retained their package inserts. Although the cross-sectional design precludes strict causal inferences, the positive association between retaining inserts and higher medication literacy is logically sound. The absence of these information sources, coupled with comprehension difficulties (only 25.75% of participants reported fully understanding the contents of the inserts), creates a dual deficit that markedly exacerbates medication-related uncertainty. Without the ability to perform pre-ingestion verification or rapidly trace information when symptoms occur, patients face significantly increased risks of treatment delays, dosing errors, ingestion of expired medications, and

incomplete adverse event reporting. Similarly, lacking clear awareness of individualized therapeutic targets (observed in 75.31% of participants) frequently leads to symptom-driven dose titration. This behavior can precipitate wide fluctuations in physiological parameters, thereby increasing the risk of acute cardiovascular and cerebrovascular events.²¹

Notably, older adults residing in nursing homes or institutions demonstrated significantly lower medication literacy than community-dwelling individuals. While the institutionalized subsample was small and warrants cautious interpretation, this negative association likely reflects the pervasive passivity of medication administration in residential care, which curtails active learning opportunities. A cross-sectional retrospective study conducted in Sweden, involving 1,260,843 community-dwelling older adults and 86,721 institutionalized older adults, found that 30% of those in institutions had been exposed to potentially inappropriate medications compared to 12% of community-dwelling individuals, further corroborating this hypothesis.²²

Furthermore, the multivariable regression revealed an inverse association between self-reported drug-related problems (DRPs) and medication literacy. Rather than a direct negative impact, this result more likely indicates reverse causality or a bidirectional reporting bias. Patients with higher medication literacy possess the vocabulary and awareness necessary to accurately identify and report DRPs, whereas those with lower literacy may experience DRPs but fail to recognize or clearly articulate them.

Practical Implications

The high prevalence of polypharmacy and the narrow therapeutic indices of many chronic disease medications mean that even minor deviations in home medication management carry the potential risk of precipitating severe adverse clinical events, including emergency hospitalization or organ damage.²³ Mitigating these risks requires a structural shift from generalized health education to targeted, home-based pharmaceutical care.

At the community level, health education programs could integrate brief screening tools to stratify patients by educational background. Engaging better-educated family members as peer educators is a practical approach to bridge existing knowledge gaps.²⁴ This effort can be further supported by regular community-based health lectures.²⁵ Furthermore, preserving and encouraging the autonomy of functionally independent older adults by combining structured health education with opportunities to exercise safe medication practices will significantly facilitate the development of medication literacy. Simultaneously, clinical practice must incorporate careful consideration of patients' socioeconomic circumstances. Providing enhanced health education support specifically tailored for low-income groups is essential to reduce medication-related health risks and alleviate the subsequent medical and financial burdens on both individuals and society.

Beyond educational initiatives, systemic changes to medication information delivery are necessary. We strongly advocate for proactively undertaking age-friendly reforms of package inserts while continuously emphasizing the critical importance of retaining the original leaflets. Specific adaptations should include enlarged typefaces and high-contrast printing to achieve optimal visual legibility. To enhance cognitive readability, inserts should be streamlined to feature only eight essential core elements (drug name, indications, dosage, contraindications, warnings, adverse reactions, storage, and expiry date). Additionally, incorporating QR codes that link to audio explanations or voice-assisted instructions can greatly accommodate users with visual or reading impairments. Medication information achieves genuine usability only when its complexity is carefully calibrated to the cognitive and sensory profiles of older adults. As the internet and artificial intelligence serve as increasingly important channels for accessing medication information, it is crucial to adapt these digital tools with simplified interfaces and voice-assisted features to better meet the specific needs of older patients.

Ultimately, establishing a comprehensive home-based pharmaceutical care system is imperative to intercept and mitigate medication errors at their point of origin. To provide actionable guidance for medical practitioners and ministries of health, we propose a detailed, five-phase framework for constructing this system, as outlined in [Box 1](#). This framework encompasses proactive patient identification, structured in-home physical audits, targeted interventions, continuous monitoring, and the necessary systemic infrastructure required for sustainable implementation.

Box 1 Proposed Framework for a Comprehensive Home-Based Pharmaceutical Care System

Phase 1: Proactive Patient Identification and Risk Stratification Primary care networks and community health centers should utilize electronic health records to flag high-risk individuals. Priority is given to older adults exhibiting polypharmacy (taking five or more daily medications), multimorbidity, recent hospital discharge, a history of adverse drug reactions, or identified socioeconomic vulnerabilities.

Phase 2: The In-Home Physical Audit Community pharmacists conduct a physical inventory of all medications in the home, including prescriptions, over-the-counter drugs, and herbal supplements. During this audit, pharmacists evaluate the physical storage conditions, identify expired or hoarded medications, and strictly verify whether patients have retained the original medication packaging and package inserts. Furthermore, pharmacists assess the patient's actual understanding of their medications by asking them to articulate their individualized disease-control targets and the specific indications for each drug.

Phase 3: Targeted Pharmacological and Educational Interventions Drug-related problems, including therapeutic duplication and improper dosing, are identified and resolved. Pharmacists recommend deprescribing potentially inappropriate medications to reduce the pill burden and actively enforce the retention of original medication cartons as a behavioral safeguard. For patients with low literacy, pharmacists utilize the teach-back method to ensure comprehension of the essential core elements of the medication, and expired medications are safely disposed of on-site to eliminate immediate hazards.

Phase 4: Multidisciplinary Integration and Continuous Monitoring Following the audit, pharmacists generate a structured home-visit report detailing identified drug-related problems and recommended regimen adjustments. This report is directly transmitted to the patient's primary care physician or specialist for collaborative action. Additionally, routine check-ins via phone or simplified digital platforms are implemented to monitor medication adherence, assess the occurrence of somatic symptoms, and prevent the misattribution of adverse reactions to normal aging.

Phase 5: Systemic and Policy Infrastructure To ensure the long-term viability of this system, ministries of health must establish national certification programs to train community pharmacists specifically in geriatric pharmacotherapy and home-visit communication protocols. Furthermore, home-based pharmaceutical care should be integrated into national or regional medical insurance schemes, shifting the compensation model from product-based dispensing fees to cognitive, service-based reimbursement.

Limitations

Several limitations warrant consideration. First, the cross-sectional design strictly precludes causal or temporal inferences between behaviors and literacy levels. Second, self-reported measures of DRPs and somatic symptoms are vulnerable to recall bias. Third, potential construct overlap exists between the behavioral predictors and the literacy outcome, which may inflate the observed statistical associations. Fourth, potentially confounding physiological factors (such as visual acuity, manual dexterity, and baseline cognitive decline) were neither assessed nor adjusted for. Finally, the lack of strict urban-rural stratification limits the detailed exploration of geographic disparities.

Future Directions

To establish causality and enhance validity, future research should employ multicenter longitudinal cohorts and integrate objective adherence measures, such as electronic pillboxes or smart blister packaging, to minimize reporting bias.

Conclusion

In conclusion, medication literacy among older Chinese adults with chronic conditions remains suboptimal, with approximately half of the population failing to achieve adequate levels. This literacy deficit is significantly associated with lower educational attainment and socioeconomically vulnerable statuses. Furthermore, inadequate literacy is closely linked to suboptimal physical home medication behaviors, specifically the discarding of original medication packaging and the inability to comprehend package inserts. Although institutional residence and the absence of packaging information strongly correlate with poorer literacy outcomes, the cross-sectional design of this study precludes definitive causal inferences. Given that these behavioral deficits and the cultural misattribution of adverse events to normal aging can precipitate severe clinical outcomes, a structural transition in healthcare delivery is imperative. Shifting from generalized health education to targeted, home-based pharmaceutical care, alongside age-friendly information reform and pharmacist-led physical audits, provides a critical strategy to enhance patient self-management and ensure medication safety at the point of origin.

Data Sharing Statement

The de-identified data that support the findings of this study are not publicly available due to restrictions imposed by the ethics committee to protect participant privacy.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Beijing Tiantan Hospital, Capital Medical University, with approval number KY2022-228-01. The study was conducted in full accordance with the ethical principles outlined in the Declaration of Helsinki. All participants were informed in detail about the study's purpose, procedures, risks, and benefits. Written informed consent was obtained from each participant prior to enrollment. Participation was entirely voluntary, and all respondents retained the right to withdraw from the study at any time without any negative consequences. Confidentiality of all collected data was strictly maintained throughout the research process.

Consent for Publication

Not applicable. This manuscript does not contain any individual person's data.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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