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Original Article

Traditional Chinese medicine-related pain-relief patterns and functional limitations among middle-aged and older Chinese adults with self-reported back, low-back, or neck pain: a cross-sectional CHARLS 2018 study with GBD 2023 context

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Abstract: Background: We examined traditional Chinese medicine (TCM)-related pain-relief patterns and their associations with functional limitation and outpatient utilization among Chinese adults with back, low back, or neck pain. Methods: This cross-sectional analysis included 8,351 adults aged 45 years or older from the 2018 China Health and Retirement Longitudinal Study. Survey-weighted logistic and modified Poisson models assessed associations with limitations in basic or instrumental daily activities and past-month outpatient use. As a secondary exploratory analysis, four models classified concurrent self-reported functional limitation using five-fold cross-validation. Global Burden of Disease Study 2023 estimates provided national context for 1990-2023. Results: Weighted prevalences of TCM-related use and functional limitation were 34.52% and 40.66%, respectively. Compared with no treatment, combined TCM-related and Western medication use was associated with functional limitation (odds ratio 1.51, 95% confidence interval 1.21-1.88) and outpatient utilization (prevalence ratio 1.99, 95% confidence interval 1.68-2.35). Use varied with education, insurance, and health status. Logistic regression achieved an out-of-fold area under the curve of 0.786; more complex models showed no clear improvement. Age-standardized prevalence and years lived with disability rates declined for low back pain but increased slightly for neck pain. Conclusion: Combined users reported more difficulties in daily activities and more outpatient contact. These findings describe concurrent associations and suggest areas for further assessment; they do not establish treatment effects or a clinical triage rule. The exploratory classification models have not been externally validated.

Keywords: Traditional Chinese medicine, low back pain, neck pain, functional limitation, outpatient utilization, burden of disease

Introduction

Back, low back, and neck pain are common musculoskeletal symptoms among middle-aged and older adults and remain a public health concern. The Global Burden of Disease Study (GBD) estimated that about 619 million people worldwide had low back pain and 203 million had neck pain in 2020. Both numbers are expected to rise with population growth and aging [1, 2]. For middle-aged and older adults with pain, daily functioning is an important aspect of health and a basis for understanding care needs alongside pain symptoms.

A study followed older adults living in the community over time. It found that pain at several sites or across the body was associated with

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later mobility problems and difficulties with daily activities [3]. These findings suggest that the pattern of pain may also be relevant to a person's ability to live independently. Basic activities of daily living (ADL) and instrumental activities of daily living (IADL) therefore provide important information for assessing functional needs in people with pain. Healthcare utilization reflects actual contact with the healthcare system. Examining utilization alongside functional status can provide a more comprehensive account of care needs and care-seeking behavior.

Chinese herbal medicine, acupuncture, professional massage, and Western medications are all used to relieve musculoskeletal pain in China. A previous study using data from the 2018 China Health and Retirement Longitudinal Study (CHARLS) described the use of these measures and found that treatment choices were associated with demographic, socioeconomic, and health behavior characteristics [4]. Building on this work, examining ADL/IADL difficulties and outpatient utilization across patterns of use among respondents with self-reported back, low back, or neck pain may clarify differences in functional and service needs. In addition, evaluating the classification of current functional limitation using demographic, health, and pain information may inform subsequent research on identifying care needs.

We therefore conducted a cross-sectional analysis of CHARLS 2018 data among respondents aged 45 years or older with self-reported back, low back, or neck pain. We described patterns of TCM-related pain-relief use and their associated factors, focusing on associations between these patterns, functional limitation, and outpatient utilization. As a secondary exploratory analysis, we compared regression and machine learning approaches for classifying concurrent self-reported ADL/IADL limitation. This comparison was not intended to establish a clinical risk-stratification tool or predict future functional decline. GBD 2023 estimates were used to describe long-term trends and age and sex distributions in the burden of low back pain and neck pain in China from 1990 to 2023, providing population-level context. This study aimed to provide population-based evidence to inform the identification of functional needs and the improvement of services for middle-aged and older adults with pain.

Materials and methods

Study design and reporting standards

This cross-sectional secondary analysis primarily used individual-level data from CHARLS 2018 (Wave 4), with GBD 2023 estimates for China providing contextual information. The study design and reporting followed the principles of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cross-sectional studies [5]. The machine learning analysis classified functional limitation at the same time point and was not prognostic. Its reporting drew on Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis (TRIPOD) requirements for transparent descriptions of the data, outcomes, candidate variables, and validation procedures [6].

CHARLS data source and study population

CHARLS is a national longitudinal survey of adults aged 45 years or older living in households in mainland China. At baseline, it used stratified, multistage sampling with probability proportional to population size, covering 28 provincial-level regions, 150 counties or districts, and 450 villages or communities. The fourth wave, conducted in 2018, included modules on health status and functioning, demographics, health insurance and healthcare utilization, socioeconomic circumstances, and survey weights.

Starting with 19,752 respondents in the 2018 health status and functioning module, we retained those with ascertainable age who were at least 45 years old and then selected respondents reporting pain in at least one of three sites: the back, low back, or neck. The final primary analysis sample comprised 8,351 respondents. Because CHARLS records self-reported pain sites rather than imaging findings or clinical diagnoses, we consistently describe the study population as respondents with self-reported back, low back, or neck pain.

Pain and pain-relief measures

Back, low back, and neck pain were coded separately from the CHARLS multiple-response

question on pain sites. Respondents reporting pain at any of these sites constituted the target population. The number of pain sites was calculated, ranging from 1 to 3, and pain combinations were further classified as single-site or multisite. This count describes the distribution of pain across the three selected sites; it is not a measure of pain intensity, duration, or chronicity, or a count of all painful sites in the body.

TCM-related pain-relief measures comprised Chinese herbal medicine, acupuncture, and professional massage; reporting any of these measures was classified as any TCM-related pain-relief use. Together with Western medication use and reports of no treatment or other measures, these responses were used to define five mutually exclusive patterns: no treatment, predominantly Western medications, TCM-related measures only, combined TCM-related measures and Western medications, and other or unclear. These categories represented self-reported patterns of pain-relief use, rather than standardized or study-assigned interventions. Information on dose, frequency, duration, and adherence was insufficient to characterize treatment regimens within each category. Combined use indicated that respondents reported both TCM-related measures and Western medications; it did not establish overlapping treatment periods or coordinated care between providers.

Primary outcome and other health variables

The primary outcome was any ADL/IADL limitation. This outcome captured self-reported difficulties in daily activities and was distinct from objective measures of physical performance, such as gait speed or the Short Physical Performance Battery (SPPB). Participants reporting difficulty were classified as having a limitation even if they could complete the activity independently. The measure did not identify the cause of these difficulties or attribute them to a specific pain site. ADL comprised six activities: dressing, bathing or showering, eating, getting into or out of bed, using the toilet, and maintaining bowel and bladder continence. IADL comprised five activities: doing housework, preparing hot meals, shopping for daily necessities, managing money, and taking medications. For each item, a response of 1 indicated no difficulty; responses of 2-4 indicated difficulty but being able to complete the activity, needing help, and being unable to complete the activity, respectively. The primary definition used available items: any valid response of 2-4 indicated limitation; respondents with at least one valid response and no reported limitation were classified as having no limitation; and respondents with no valid responses to any of the 11 items were assigned a missing outcome. To assess the influence of partially missing items, we recalculated the prevalence of functional limitation among respondents with complete responses to all 11 items. We also repeated the logistic regression analysis of treatment patterns and functional limitation in this group, using the same Model 3 covariates, individual weights, and community-clustered robust variance estimation as in the primary analysis.

Secondary health variables included poor or very poor self-rated health, nighttime sleep duration, and outpatient utilization in the previous month. Outpatient utilization was defined using CHARLS 2018 item ED001, which asked whether respondents had received outpatient care at a medical facility or through a visit from a health worker or doctor during the previous month, excluding hospitalization and physical examinations. Respondents answering “yes” were classified as having outpatient utilization, whereas those answering “no” were classified as having no outpatient utilization. This binary measure captured any outpatient contact and was not restricted to care for back, low back, or neck pain. Covariates were age, sex, educational attainment, marital or partnership status, any health insurance, number of pain sites, number of reported chronic conditions, number of valid chronic-condition responses, arthritis, self-rated health, and sleep duration.

Both chronic-condition measures were derived from 14 items on doctor-diagnosed conditions (da007_1_ through da007_14_): hypertension; dyslipidemia; diabetes or high blood sugar; cancer or malignant tumor; chronic lung disease; liver disease; heart disease; stroke; kidney disease; stomach or other digestive disease; emotional, nervous, or psychiatric problems; memory-related disease; arthritis or rheumatism; and asthma. The number of valid chronic-condition responses counted items coded 1 (“yes”) or 2 (“no”), with either response contributing one. Missing values and all

other codes were excluded from this count. The count could range from 0 to 14; zero indicated no valid responses in these items, not the absence of chronic conditions. The number of reported chronic conditions counted "yes" responses among the same items and was set to missing when none had a valid response. The valid-response count was included as a response-completeness covariate, distinct from the reported-condition count.

Descriptive and regression analyses

Continuous variables were summarized as means and standard deviations, and categorical variables as frequencies and percentages. Both unweighted proportions and proportions weighted using CHARLS individual cross-sectional weights were reported for pain-relief use. Binomial generalized linear models with a logit link were used for TCM-related use and functional limitation. Because outpatient utilization was a common binary outcome, modified Poisson regression with robust variance estimation was used to estimate prevalence ratios (PRs) [7]. All primary models incorporated normalized individual weights and community-clustered robust variance estimation.

Model 1 included age, sex, and number of pain sites. Model 2 additionally included education, marital or partnership status, and health insurance. Model 3 further included the number of reported chronic conditions, the number of valid chronic-condition responses, arthritis, self-rated health, sleep duration, and an indicator for missing sleep data. Although the CHARLS 2018 questionnaire included the 10-item Center for Epidemiologic Studies Depression Scale (CES-D-10), these scores were not included in the present regression models. The reported associations therefore account for the covariates listed above, without adjustment for depressive symptoms. Explicit missing categories were used for arthritis, self-rated health, and health insurance. Missing sleep duration was imputed using the sample median, with a missingness indicator included in the model. To avoid perfect collinearity, the pain-site count and its three component indicators were not entered into the same regression model. Multinomial logistic regression of treatment patterns used no treatment as the reference category, numerically coded outcomes, and community-clustered robust variance estimation. This model was unweighted and was used only as a supplementary analysis.

Cross-sectional classification of functional limitation

Candidate features included demographic characteristics, education, marital status, health insurance, number of pain sites, number of reported chronic conditions, number of valid chronic-condition responses, arthritis, self-rated health, sleep, and the different pain-relief measures. The number of valid chronic-condition responses measures questionnaire response completeness and is distinct from the number of reported chronic conditions. We compared standard logistic regression, least absolute shrinkage and selection operator (LASSO) logistic regression, random forest, and extreme gradient boosting (XGBoost) for classifying concurrent functional limitation. LASSO, random forest, and XGBoost were implemented using established algorithmic frameworks [8-10]. We used five-fold cross-validation stratified by outcome status, with random shuffling and a fixed random seed. In each iteration, models were fitted to four folds and evaluated on the remaining fold, so each participant received one out-of-fold prediction. Imputation, scaling, and categorical encoding were fitted within the training folds. This procedure provided internal validation only; no other CHARLS wave or independent cohort was used for external validation. Performance was assessed using the area under the receiver operating characteristic curve (AUC), the area under the precision-recall curve (PR-AUC), and the Brier score. The 95% confidence intervals (CIs) were obtained from 500 individual-level bootstrap resamples. Exploratory decision curve analysis compared model net benefit across probability thresholds with the conventional "treat all" and "treat none" reference strategies [11]. The displayed decision curve is for logistic regression. This analysis was not interpreted as evidence of demonstrated clinical benefit from using the models. SHapley Additive exPlanations (SHAP) was used to explain the XGBoost classification output, with global feature importance summarized using mean absolute SHAP values [12]. These values describe contributions to model output and do not establish causal effects or identify intervention targets.

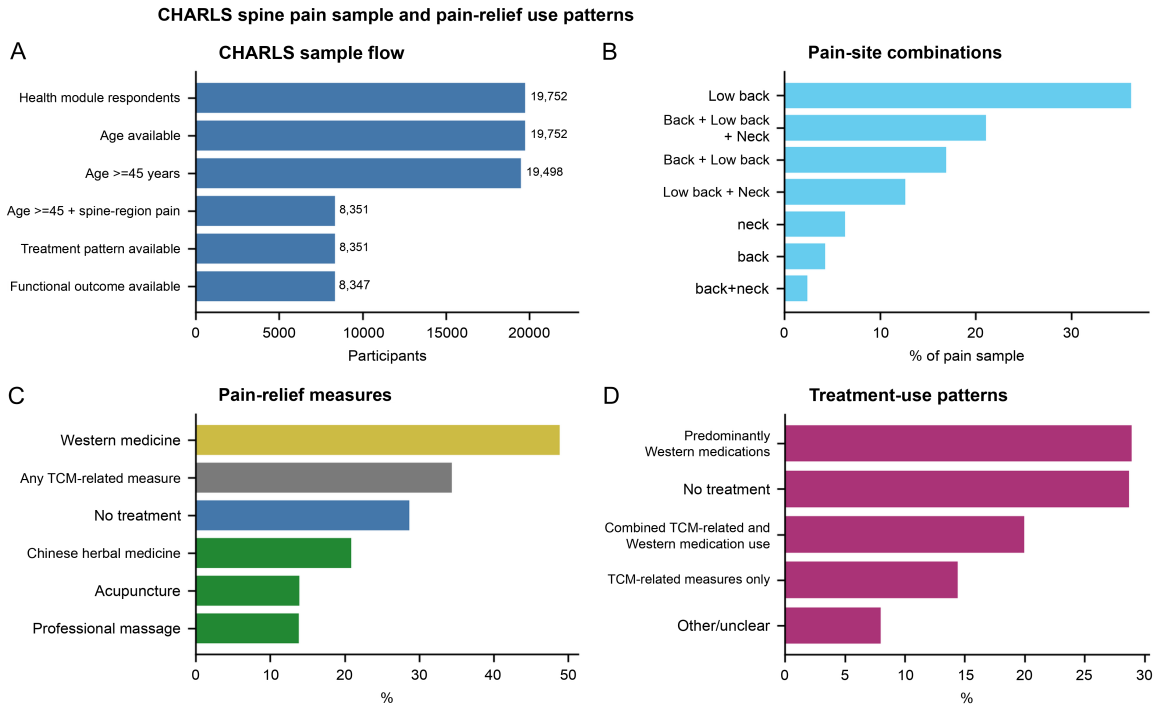


Figure 1. CHARLS sample selection, pain-site combinations, and use of pain-relief measures. (A) The image shows participant selection and sample sizes at each stage. (B) The image shows the proportions of participants with different combinations of back, low back, and neck pain. (C) The image shows the proportions reporting Western medications, any TCM-related measure, no treatment, Chinese herbal medicine, acupuncture, or professional massage. Respondents could report more than one pain-relief measure in (C). (D) The image shows the distribution of mutually exclusive patterns of pain-relief use. (B-D) The images present unweighted percentages using the primary analysis sample (n = 8,351) as the denominator. Abbreviations: CHARLS, China Health and Retirement Longitudinal Study; TCM, traditional Chinese medicine.

Disease burden context from GBD 2023

We obtained GBD 2023 estimates of low back pain and neck pain in China for 1990-2023 from the Institute for Health Metrics and Evaluation (IHME) GBD Results Tool. These estimates were analyzed separately to provide population-level context. They were not linked to individual CHARLS records or used to validate the CHARLS findings or classification models. We extracted prevalence and years lived with disability (YLD) counts and rates, with reporting focused on age-standardized rates. After combining the downloaded files, we removed rows that were identical across files when the source filename field was excluded. Before analysis, we checked each cause-measure-sex-age-year-metric combination for uniqueness and ordered the records by year using a stable sort.

We fitted a log-linear model, ln(rate) = alpha + beta × year, to the age-standardized rates. The estimated annual percentage change (EAPC) was calculated as (exp(beta) - 1) × 100%, with 95% CIs reported. We also described age-specific prevalence among adults aged 45 years or older and sex-specific age-standardized rates in 2023.

Software and statistical significance

Analyses were performed using Python 3.12.13. The main packages were pandas 3.0.3, NumPy 2.4.6, statsmodels 0.14.6, scikit-learn 1.9.0, XGBoost 3.3.0, and SHAP 0.52.0. All tests were two-sided, with $P<0.05$ considered statistically significant. Interpretation focused on effect estimates and their 95% CIs.

Results

Study sample and pain combinations

Of the 19,752 respondents in the health module, 19,498 were aged 45 years or older. Among them, 8,351 reported back, low back, or neck pain and were included in the primary analysis (**Figure 1**). The mean age was 62.24 years

Table 1. Characteristics of the CHARLS primary analysis sample overall and by treatment pattern

Characteristic	Overall	No treatment	Predominantly Western medications	TCM-related measures only	Combined use	Other or unclear
Age (years), mean (SD)	62.24 (10.05)	62.14 (9.97)	62.79 (10.31)	61.36 (9.80)	62.17 (9.82)	62.35 (10.23)
Sex: female, n (%)	5169 (61.9%)	1375 (57.4%)	1511 (62.5%)	748 (62.1%)	1117 (67.0%)	418 (62.6%)
Sex: male, n (%)	3182 (38.1%)	1022 (42.6%)	905 (37.5%)	456 (37.9%)	549 (33.0%)	250 (37.4%)
Education: college or higher, n (%)	111 (1.3%)	33 (1.4%)	11 (0.5%)	40 (3.3%)	13 (0.8%)	14 (2.1%)
Education: senior high/secondary vocational school, n (%)	702 (8.4%)	200 (8.3%)	148 (6.1%)	158 (13.1%)	112 (6.7%)	84 (12.6%)
Education: junior high school, n (%)	1577 (18.9%)	441 (18.4%)	415 (17.2%)	272 (22.6%)	298 (17.9%)	151 (22.6%)
Education: no formal/incomplete primary education, n (%)	4175 (50.0%)	1188 (49.6%)	1333 (55.2%)	485 (40.3%)	900 (54.0%)	269 (40.3%)
Education: primary school, n (%)	1786 (21.4%)	535 (22.3%)	509 (21.1%)	249 (20.7%)	343 (20.6%)	150 (22.5%)
Married or partnered, n (%)	6987 (83.7%)	2044 (85.3%)	2010 (83.2%)	1022 (84.9%)	1365 (81.9%)	546 (81.7%)
Any health insurance, n (%)	8114 (97.2%)	2325 (97.1%)	2345 (97.1%)	1167 (96.9%)	1631 (97.9%)	646 (96.9%)
Number of pain sites, mean (SD)	1.74 (0.78)	1.60 (0.72)	1.77 (0.80)	1.74 (0.77)	1.94 (0.82)	1.65 (0.78)
Number of chronic conditions, mean (SD)	0.93 (1.20)	0.78 (1.06)	0.95 (1.24)	0.94 (1.20)	1.11 (1.32)	0.90 (1.15)
Arthritis, n (%)	867 (18.7%)	184 (12.0%)	257 (20.2%)	130 (19.5%)	227 (30.0%)	69 (16.8%)
Poor/very poor self-rated health, n (%)	3113 (39.6%)	735 (32.1%)	962 (43.2%)	407 (35.6%)	824 (52.5%)	185 (29.5%)
Nighttime sleep duration (hours), mean (SD)	5.85 (2.11)	5.99 (2.08)	5.82 (2.13)	5.89 (2.00)	5.60 (2.20)	6.01 (2.03)
Any ADL/IADL limitation, n (%)	3481 (41.7%)	849 (35.4%)	1105 (45.8%)	430 (35.7%)	880 (52.9%)	217 (32.5%)

Note: Values are means (standard deviations) or n (%). Treatment patterns represent self-reported patterns of pain-relief use. Abbreviations: CHARLS, China Health and Retirement Longitudinal Study; TCM, traditional Chinese medicine; SD, standard deviation; ADL, activities of daily living; IADL, instrumental activities of daily living.

Table 2. Use of pain-relief measures

Pain-relief measure	n/N	Unweighted proportion (%)	CHARLS-weighted proportion (%)
Chinese herbal medicine	1746/8351	20.91	20.78
Acupuncture	1163/8351	13.93	13.75
Professional massage	1153/8351	13.81	14.18
Any TCM-related measure	2870/8351	34.37	34.52
Western medications	4082/8351	48.88	46.55
No treatment	2397/8351	28.70	28.87

Note: Weighted proportions use the CHARLS 2018 individual cross-sectional weights. Self-reported use does not indicate treatment effectiveness. Abbreviations: CHARLS, China Health and Retirement Longitudinal Study; TCM, traditional Chinese medicine. n/N denotes the number reporting use divided by the total sample size.

(standard deviation [SD] 10.05); 5,169 respondents (61.9%) were women, 6,987 (83.7%) were married or partnered, and 8,114 (97.2%) reported at least one type of health insurance (**Table 1**).

Pain confined to the low back was the most common pattern, reported by 3,028 respondents (36.26%). Pain at all three sites - the back, low back, and neck - was reported by 1,762 respondents (21.10%), followed by back and low back pain in 1,414 (16.93%) and low back and neck pain in 1,058 (12.67%). The mean number of pain sites was 1.74 (SD 0.78).

Patterns of TCM-related pain-relief use

The unweighted proportions using Chinese herbal medicine, acupuncture, and professional massage were 20.91%, 13.93%, and 13.81%, respectively; the corresponding weighted proportions were 20.78%, 13.75%, and 14.18%. Overall, 2,870 respondents used at least one TCM-related pain-relief measure, yielding an unweighted proportion of 34.37% and a weighted proportion of 34.52% (**Table 2**). The distribution of treatment patterns was 28.93% for predominantly Western medications, 28.70% for no treatment, 19.95% for combined TCM-related and Western medication use, 14.42% for TCM-related measures only, and 8.00% for other or unclear.

In the fully adjusted weighted model, TCM-related use showed a gradient by educational attainment. Compared with no formal education or incomplete primary education, the odds ratios (ORs) were 1.75 (95% CI: 1.11-2.76) for college education or higher, 1.39 (95% CI: 1.07-1.82) for senior high school or secondary vocational education, and 1.28 (95% CI: 1.05-1.57) for junior high school education. Respondents without health insurance had lower odds of use (OR 0.65, 95% CI: 0.46-0.91). Arthritis (OR 1.45, 95% CI: 1.12-1.90), poor or very poor self-rated health (OR 1.33, 95% CI: 1.16-1.53), and each additional pain site (OR 1.20, 95% CI: 1.10-1.31) were associated with greater odds of use (**Table 3**). Sex, marital status, number of chronic conditions, and sleep duration were not significantly associated with use in the fully adjusted model. The unweighted multinomial analysis is presented in Supplementary Table 1.

Functional limitation and outpatient utilization profiles

Functional status was ascertainable for 8,347 respondents, of whom 3,481 had functional limitation. The unweighted prevalence was 41.70%, and the weighted prevalence was 40.66%. The prevalences of ADL and IADL limitations were 33.13% and 33.57%, respectively. Among the 7,045 respondents with complete responses to all 11 items, 3,399 had functional limitation, corresponding to a prevalence of 48.25%.

Unadjusted functional profiles differed across treatment patterns (**Table 4**; **Figure 2**). The prevalence of any functional limitation was highest in the combined-use group (52.85%), followed by the predominantly Western medication group (45.76%). The corresponding prevalences were 35.71% in the TCM-related measures-only group and 35.43% in the no-treatment group. Outpatient utilization in the previous month was reported by 33.23% of the combined-use group, 24.77% of the TCM-related measures-only group, 21.55% of the

Table 3. Factors associated with any TCM-related pain-relief use in weighted analyses

Variable	Adjusted OR (95% CI)	*P* value	Analytic sample size
Female vs. male	1.10 (0.94-1.29)	0.229	7693
Education: college or higher vs. no formal/incomplete primary education	1.75 (1.11-2.76)	0.016	7693
Education: senior high/secondary vocational school vs. no formal/incomplete primary education	1.39 (1.07-1.82)	0.014	7693
Education: junior high school vs. no formal/incomplete primary education	1.28 (1.05-1.57)	0.014	7693
Education: primary school vs. no formal/incomplete primary education	1.14 (0.97-1.34)	0.111	7693
No health insurance vs. insured	0.65 (0.46-0.91)	0.014	7693
Arthritis: yes vs. no	1.45 (1.12-1.90)	0.006	7693
Poor/very poor vs. non-poor self-rated health	1.33 (1.16-1.53)	<0.001	7693
Age (per 1-year increase)	0.99 (0.98-1.00)	0.044	7693
Pain-site count (per 1-site increase)	1.20 (1.10-1.31)	<0.001	7693
Married/partnered: yes vs. no	0.92 (0.77-1.09)	0.326	7693
Reported chronic conditions (per 1-condition increase)	1.04 (0.98-1.11)	0.188	7693
Sleep duration (per 1-hour increase)	0.99 (0.96-1.02)	0.467	7693

Note: Model 3 used logistic regression with individual survey weights and community-clustered robust variance estimation. Missingness indicators and the number of valid chronic-condition responses were included as adjustment variables; their coefficients are not shown. Abbreviations: TCM, traditional Chinese medicine; OR, odds ratio; CI, confidence interval.

Table 4. Functional and health profiles by treatment pattern

Treatment pattern	Sample size	ADL limitation (%)	IADL limitation (%)	Any functional limitation (%)	Functional limitation among complete 11-item respondents (%)	Poor/very poor self-rated health (%)	Mean sleep duration (hours)	Outpatient utilization in the past month (%)
Combined use	1666	42.28	42.88	52.85	57.39	52.48	5.60	33.23
No treatment	2397	27.37	28.23	35.43	42.63	32.07	5.99	14.32
Other or unclear	668	24.54	24.44	32.53	38.83	29.51	6.01	18.74
TCM-related measures only	1204	28.05	29.24	35.71	42.38	35.61	5.89	24.77
Predominantly Western medications	2416	36.50	37.14	45.76	52.09	43.22	5.82	21.55

Note: The primary functional outcome was based on six ADL and five IADL items. Results among respondents with complete responses to all 11 items were used for sensitivity assessment. Abbreviations: TCM, traditional Chinese medicine; ADL, activities of daily living; IADL, instrumental activities of daily living.

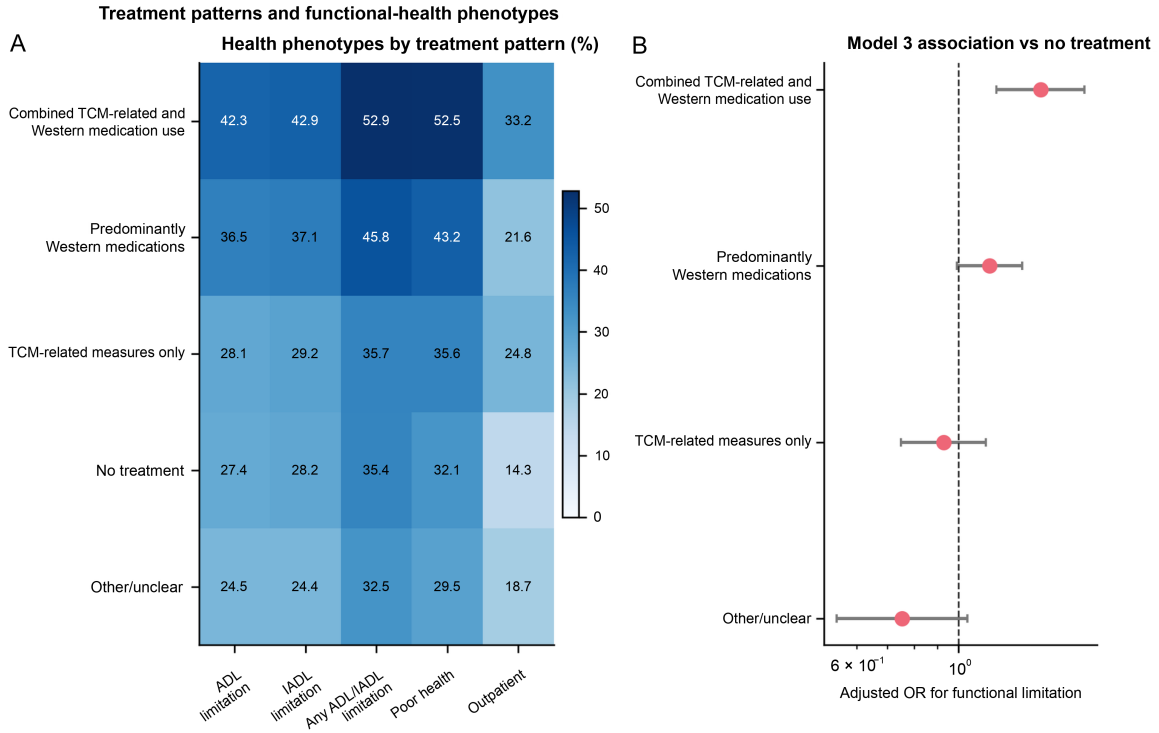


Figure 2. Patterns of pain-relief use and self-reported functional and health profiles. A. The image shows the unweighted percentages of participants with ADL limitation, IADL limitation, any ADL/IADL limitation, poor or very poor self-rated health, and outpatient utilization in the previous month across patterns of pain-relief use. Functional limitation refers to self-reported difficulty in daily activities. B. The image shows the adjusted ORs for any ADL/IADL limitation relative to no treatment from the fully adjusted, survey-weighted logistic regression model. Points represent ORs, and horizontal error bars represent 95% CIs. The dashed line indicates OR = 1. Abbreviations: ADL, activities of daily living; IADL, instrumental activities of daily living; OR, odds ratio; CI, confidence interval; TCM, traditional Chinese medicine.

predominantly Western medication group, and 14.32% of the no-treatment group.

After adjustment for demographic, socioeconomic, and health factors, combined use remained associated with functional limitation compared with no treatment (OR 1.51, 95% CI: 1.21-1.88, P<0.001). The ORs were 1.17 (95% CI: 0.99-1.38, P = 0.063) for predominantly Western medications, 0.93 (95% CI: 0.75-1.15, P = 0.487) for TCM-related measures only, and 0.75 (95% CI: 0.54-1.05, P = 0.091) for other or unclear patterns (**Table 5**).

The findings remained consistent when the analysis was repeated among 6,531 respondents with complete responses to all 11 ADL/IADL items and available data for the fully adjusted model. Relative to no treatment, the ORs were 1.42 (95% CI: 1.13-1.78, P = 0.002) for combined use, 0.91 (95% CI: 0.73-1.13, P = 0.408) for TCM-related measures only, 1.18 (95% CI: 0.99-1.40, P = 0.069) for predominantly Western medications, and 0.75 (95% CI: 0.55-1.03, P = 0.074) for other or unclear patterns (Supplementary Table 2). The associations of combined use and TCM-related measures only with functional limitation were similar in direction in the primary analysis and the analysis restricted to participants with complete responses to all 11 ADL/IADL items.

Modified Poisson regression indicated higher outpatient utilization across all treatment or other-measure patterns. Compared with no treatment, the PRs were 1.99 (95% CI: 1.68-2.35) for combined use, 1.67 (95% CI: 1.36-2.05) for TCM-related measures only, 1.35 (95% CI: 1.16-1.57) for predominantly Western medications, and 1.28 (95% CI: 1.00-1.65) for other or unclear patterns.

Performance of cross-sectional functional limitation classification

The classification analysis included 8,347 respondents. Logistic regression achieved an

Table 5. Weighted associations of treatment patterns with functional limitation and outpatient utilization

Outcome	Treatment pattern comparison	Effect measure	Adjusted estimate (95% CI)	*P* value	Analytic sample size
Any ADL/IADL limitation	Combined use vs. no treatment	OR	1.51 (1.21-1.88)	<0.001	7690
Any ADL/IADL limitation	Other or unclear vs. no treatment	OR	0.75 (0.54-1.05)	0.091	7690
Any ADL/IADL limitation	TCM-related measures only vs. no treatment	OR	0.93 (0.75-1.15)	0.487	7690
Any ADL/IADL limitation	Predominantly Western medications vs. no treatment	OR	1.17 (0.99-1.38)	0.063	7690
Outpatient utilization in the past month	Combined use vs. no treatment	PR	1.99 (1.68-2.35)	<0.001	7687
Outpatient utilization in the past month	Other or unclear vs. no treatment	PR	1.28 (1.00-1.65)	0.050	7687
Outpatient utilization in the past month	TCM-related measures only vs. no treatment	PR	1.67 (1.36-2.05)	<0.001	7687
Outpatient utilization in the past month	Predominantly Western medications vs. no treatment	PR	1.35 (1.16-1.57)	<0.001	7687

Note: Weighted logistic regression was used for functional limitation, and weighted modified Poisson regression was used for outpatient utilization to estimate PRs. All estimates represent cross-sectional associations. Abbreviations: TCM, traditional Chinese medicine; ADL, activities of daily living; IADL, instrumental activities of daily living; OR, odds ratio; PR, prevalence ratio; CI, confidence interval.

Table 6. Out-of-fold performance of cross-sectional functional limitation classification models

Model	Validation strategy	Sample size	AUC (95% CI)	PR-AUC (95% CI)	Brier score (95% CI)
Logistic	Out-of-fold predictions from 5-fold stratified cross-validation	8347	0.786 (0.776-0.796)	0.718 (0.703-0.735)	0.184 (0.180-0.188)
LASSO	Out-of-fold predictions from 5-fold stratified cross-validation	8347	0.786 (0.776-0.796)	0.718 (0.703-0.735)	0.185 (0.180-0.188)
XGBoost	Out-of-fold predictions from 5-fold stratified cross-validation	8347	0.786 (0.776-0.796)	0.717 (0.702-0.735)	0.185 (0.180-0.189)
Random Forest	Out-of-fold predictions from 5-fold stratified cross-validation	8347	0.783 (0.773-0.793)	0.710 (0.695-0.729)	0.187 (0.183-0.191)

Note: Performance was based on out-of-fold predictions from five-fold stratified cross-validation. The 95% CIs were obtained from 500 bootstrap resamples. This analysis assessed concurrent classification, not prognostic prediction. Abbreviations: AUC, area under the receiver operating characteristic curve; PR-AUC, area under the precision-recall curve; CI, confidence interval; LASSO, least absolute shrinkage and selection operator; XGBoost, extreme gradient boosting.

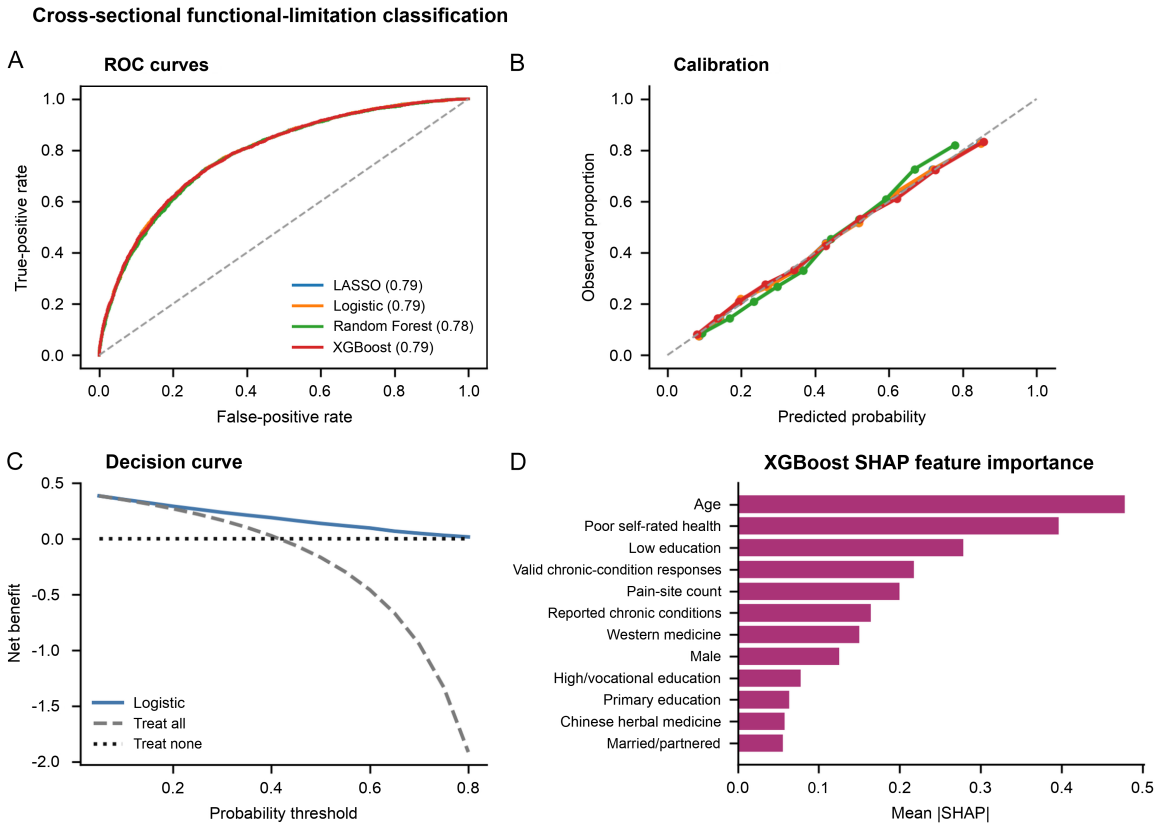


Figure 3. Cross-sectional classification of concurrent ADL/IADL limitation. A. The image shows out-of-fold ROC curves; B. The image shows calibration of out-of-fold probabilities; C. The image shows the exploratory decision curve for logistic regression, together with the "treat all" and "treat none" reference strategies. D. The image shows global feature importance for XGBoost, ranked by mean absolute SHAP values. "Valid chronic-condition responses" denotes the number of the 14 chronic-condition items with a valid "yes" or "no" response (possible range, 0-14) and measures response completeness; "Reported chronic conditions" denotes the number of "yes" responses among these items. SHAP values describe contributions to model output and do not establish causal effects. Abbreviations: ADL, activities of daily living; IADL, instrumental activities of daily living; ROC, receiver operating characteristic; AUC, area under the ROC curve; LASSO, least absolute shrinkage and selection operator; XGBoost, extreme gradient boosting; SHAP, SHapley Additive exPlanations.

out-of-fold AUC of 0.786 (95% CI: 0.776-0.796), a PR-AUC of 0.718 (95% CI: 0.703-0.735), and a Brier score of 0.184 (95% CI: 0.180-0.188). Both LASSO and XGBoost had an AUC of 0.786 after rounding, compared with 0.783 for random forest. Differences between models were small (**Table 6**; **Figure 3**).

Age, poor self-rated health, low education, number of pain sites, and chronic disease burden ranked highly by mean absolute SHAP value. The number of valid chronic-condition responses, a measure of response completeness, also contributed substantially to the XGBoost model output, indicating that the model used information on questionnaire response completeness. This SHAP finding should not be interpreted as evidence that the variable is a biological or clinical risk factor for functional limitation. More complex models showed no clear advantage in discrimination over standard logistic regression.

Burden of low back pain and neck pain in China in GBD 2023

The cleaned GBD dataset contained 21,420 rows, with no duplicate analysis keys, and all trends were ordered by year. From 1990 to 2023, the age-standardized prevalence of low back pain in China decreased from 6,636.60 to 4,929.78 per 100,000, a change of -25.72%. The EAPC was -0.543% per year (95% CI: -0.638 to -0.448). The age-standardized YLD

Table 7. GBD age-standardized trends in low back pain and neck pain in China, 1990-2023

Cause	Measure	1990 age-standardized rate (per 100,000)	2023 age-standardized rate (per 100,000)	Change, 1990-2023 (%)	EAPC (95% CI, %/year)	*P* value
Low back pain	Prevalence	6,636.60	4,929.78	-25.72	-0.543 (-0.638 to -0.448)	<0.001
Low back pain	YLD rate	740.83	551.92	-25.50	-0.539 (-0.634 to -0.444)	<0.001
Neck pain	Prevalence	2,479.65	2,504.27	0.99	0.119 (0.088 to 0.149)	<0.001
Neck pain	YLD rate	245.89	248.78	1.17	0.114 (0.088 to 0.141)	<0.001

Note: Rates are per 100,000 population. EAPCs were estimated by log-linear regression of age-standardized rates from 1990 to 2023. Abbreviations: GBD, Global Burden of Disease Study; YLD, years lived with disability; EAPC, estimated annual percentage change; CI, confidence interval.

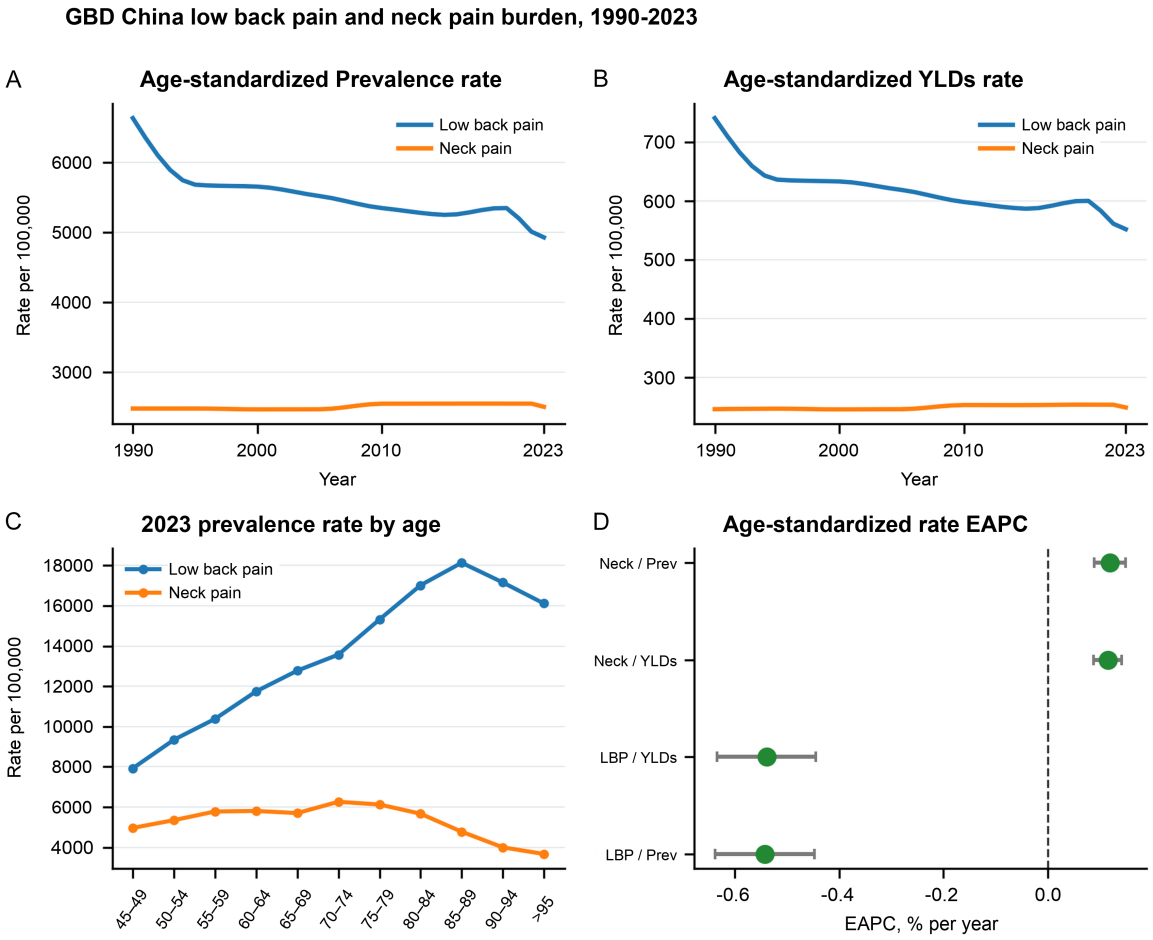


Figure 4. Burden of low back pain and neck pain in China, 1990-2023. (A) The image shows age-standardized prevalence rates by year; (B) The image shows age-standardized YLD rates by year; (C) The image shows age-specific prevalence rates by age group among adults aged 45 years or older in 2023; (D) The image shows EAPCs and 95% CIs for age-standardized prevalence and YLD rates. Rates in (A-C) are expressed per 100,000 population; EAPCs in (D) are expressed as % per year. Abbreviations: GBD, Global Burden of Disease Study; YLD, years lived with disability; EAPC, estimated annual percentage change; CI, confidence interval; LBP, low back pain; Prev, prevalence.

rate decreased from 740.83 to 551.92 per 100,000, with an EAPC of -0.539% per year (95% CI: -0.634 to -0.444) (**Table 7**; **Figure 4**).

The age-standardized prevalence of neck pain increased from 2,479.65 to 2,504.27 per 100,000, a change of 0.99%, with an EAPC of

0.119% per year (95% CI: 0.088-0.149). The age-standardized YLD rate increased from 245.89 to 248.78 per 100,000, with an EAPC of 0.114% per year (95% CI: 0.088-0.141). In 2023, age-standardized prevalence was higher in women than in men for both low back pain (5,857.1 vs. 3,991.7 per 100,000) and neck pain (2,905.2 vs. 2,110.3 per 100,000). Across age groups, low back pain prevalence was particularly high at ages 85-89 years, whereas neck pain prevalence was relatively high around ages 70-74 years.

Discussion

Using CHARLS 2018 data, this study described patterns of pain-relief use and their functional and healthcare utilization profiles among Chinese adults aged 45 years or older with self-reported back, low back, or neck pain. GBD 2023 estimates provided national disease burden context. Approximately one-third of participants used TCM-related pain-relief measures, and about four in ten had at least one limitation in daily activities. Use was associated with education, health insurance coverage, and health status. Combined users had a higher prevalence of functional limitation and outpatient utilization. For classifying current functional limitation, more complex models showed no clear improvement in discrimination over standard logistic regression. Meanwhile, although the age-standardized burden of low back pain in China declined, the corresponding measures for neck pain increased slightly. These findings suggest that pain management for middle-aged and older adults should address pain-relief use, maintenance of function, and healthcare needs together. Differences between use patterns should be interpreted in the context of disease burden and care-seeking behavior and cannot directly establish comparative treatment effectiveness.

Patterns of pain-relief use and associated factors

The weighted proportion of TCM-related pain-relief use was 34.52% among Chinese adults aged 45 years or older with back, low back, or neck pain. These measures were therefore common in this group. Chinese herbal medicine was more common than acupuncture or professional massage, consistent with Mei et al.'s analysis of the same CHARLS 2018 data [4]. Because that study used the same survey wave, this comparison does not provide independent replication. One possible explanation is that herbal medicine is easier to obtain and use, whereas acupuncture and professional massage depend more on healthcare facilities and trained practitioners. We did not measure travel distance, costs, or service availability, so this explanation remains untested. Based on the unweighted, mutually exclusive categories, approximately 58% of TCM-related users also reported Western medication use. Previous survey research documented patients' willingness to use TCM for chronic conditions and rehabilitation [13]. The longstanding coexistence of TCM and Western medicine in China's healthcare system also provides context for this pattern [14]. However, reporting both types of measures does not establish concurrent use, coordinated care, or therapeutic benefit from their combination.

Participants with arthritis, poorer self-rated health, or more pain sites were more likely to report TCM-related use. Liu et al. linked TCM use to chronic disease-related needs [15], and Yang et al. associated Chinese herbal medicine use with pain and activity difficulties among people with arthritis [16]. The number of chronic conditions showed no clear association after full adjustment, perhaps because a simple count does not distinguish disease type, severity, or duration. Use generally increased with education level, while uninsured participants had lower odds of use. Similar findings from Shanghai [17] suggest that treatment choices reflect both health needs and access to care. Symptoms may prompt people to seek care, but health information, the ability to navigate services, and financial coverage may also shape their choices.

Differences in functional limitation and outpatient utilization

Functional limitation was a substantial health burden among middle-aged and older Chinese adults with back, low back, or neck pain: approximately four in ten participants had at least one ADL or IADL limitation, and approximately one-third had ADL limitations and one-third had IADL limitations. These findings show that self-reported difficulties in daily activities were common among participants with back, low

back, or neck pain. A previous review linked multisite pain to poorer physical and psychosocial functioning in older adults [18]. In a longitudinal study, Eggermont et al. associated multisite or widespread pain with subsequent mobility and daily activity limitations [3], while a systematic review reported associations between chronic musculoskeletal pain and later functional decline [19]. Our cross-sectional analysis describes concurrent pain and functional difficulties and does not establish that pain caused these difficulties. These findings support assessing daily functioning as part of care for middle-aged and older adults with pain.

Treatment patterns had distinct functional and healthcare utilization profiles. The combined-use group had the highest unadjusted prevalence of functional limitation and remained associated with higher odds of limitation after adjustment for demographic, socioeconomic, and health factors (OR = 1.51, 95% CI: 1.21-1.88). The direction of the association and the overall findings were similar among respondents with complete responses to all 11 ADL/IADL items (OR = 1.42, 95% CI: 1.13-1.78). In contrast, adjusted differences between the predominantly Western medication, TCM-related measures-only, or other or unclear groups and the no-treatment group did not meet conventional thresholds for statistical significance. The combined-use group reported more daily activity difficulties and outpatient contact, but these observations do not establish why participants selected multiple measures. Differences in pain severity, depressive symptoms, and other unmeasured factors may contribute to the observed associations. Confounding by indication and reverse causation may partly explain this association. People with more severe illness, greater functional difficulties, or more complex clinical circumstances are more likely to receive more intensive or diverse treatments and also to experience unfavorable functional outcomes. More complex treatment and poorer outcomes may therefore coexist in observational data. As Kyriacou and Lewis noted, the clinical indications that determine treatment selection may themselves affect outcomes in nonrandomized studies [20]. One plausible, but untested, explanation is that persistent symptoms, more pain sites, or insufficient benefit from previous single-modality treatment prompt some patients to add TCM-related measures to Western medications or vice versa.

China's use of both TCM and Western medicine may also help explain this pattern. Survey research found that many Chinese patients see TCM as part of their cultural background. They often view it as a complement to Western treatment for chronic or severe illness, rather than as a choice that excludes Western treatment [13]. In a systematic review, Chung et al. found differences in whether patients told Western medicine practitioners about their TCM use. Patients also differed in their awareness of the possible risks of Chinese herbal medicine [21]. Our analysis also linked poorer self-rated health, arthritis, and more pain sites to greater TCM-related use. Combined users may have more health needs and be more likely to seek care or use different services. These factors may help explain their higher use of outpatient care. Clinicians could assess pain, daily functioning, chronic conditions, and medication use in this group. They should also ask about the combined use of Chinese herbal medicine, over-the-counter pain medicines, and prescription drugs. These steps may improve communication between providers and across specialties.

The prevalence of functional limitation in the TCM-related measures-only group was close to that in the no-treatment group, with an adjusted OR of 0.93 (95% CI: 0.75-1.15), whereas the PR for outpatient utilization was 1.67 (95% CI: 1.36-2.05). This does not establish equivalence between TCM-related measures and no treatment. Rather, no clear difference in the odds of functional limitation was observed under the sample and model conditions of this study; treatment effectiveness cannot be inferred from this finding. Functional limitation and outpatient utilization capture different dimensions. The former primarily describes current ability to perform daily activities, whereas the latter is also influenced by health beliefs, cultural acceptability, previous healthcare experiences, accessibility, and service preferences. A study of older adults in Shanghai associated TCM use with education, health conditions, social connections, and contact with healthcare professionals [17]. Another study of Chinese adults with chronic conditions associated TCM use with poorer self-rated health,

comorbidity, and previous visit frequency [22]. In addition, acupuncture and professional massage usually require contact with service providers, which may increase the likelihood of outpatient visits or other healthcare contacts.

The no-treatment group also needs attention. This group had the lowest use of outpatient care in the previous month. However, 35.43% had at least one functional limitation. Some people with daily difficulties had therefore not used the pain-relief measures covered by the survey. The reasons for reporting no treatment may differ. Some people may have mild symptoms and choose rest or care at home. Others may see pain as a normal part of aging or expect little benefit from treatment. Cost, transport, or limited access to services may also prevent people from seeking care. We therefore cannot assume that everyone in this group had unmet healthcare needs. Previous CHARLS research estimated that approximately 13% of middle-aged and older Chinese adults had unmet healthcare needs. The most common reason for not using outpatient services was the perception that the condition was not serious enough to require treatment, followed by reasons including financial difficulty. People with functional limitation and multimorbidity were more likely to have unmet needs [23].

Cross-sectional classification of functional limitation

We compared four modeling approaches - standard logistic regression, LASSO, random forest, and XGBoost - with out-of-fold AUCs ranging from 0.783 to 0.786. More complex models showed no clear gain in discrimination over logistic regression. This finding is consistent with previous clinical prediction research suggesting that machine learning does not necessarily outperform logistic regression when predictors are few and consist mainly of structured demographic and clinical information [24, 25]. Similar performance does not demonstrate the absence of nonlinear relationships or interactions; it indicates only that the more complex models offered no clear improvement in discrimination with the current feature set and internal validation framework. Given the similar internal performance, logistic regression provides a transparent and interpretable reference model for further research [26]. These findings do not establish that any of the models is ready for clinical screening.

In the global SHAP analysis of XGBoost, age, self-rated health, education-related features, number of pain sites, and chronic disease burden had relatively large mean absolute SHAP values and were major sources of information for classifying current functional limitation. This pattern is broadly consistent with previous research. Self-rated health integrates pain, illness, mood, fatigue, and personal assessments of functional ability; poorer self-rated health has been shown to identify older adults who subsequently experience IADL decline [27]. The number of pain sites may also capture overall burden. Multisite pain has been associated with unfavorable ADL/IADL trajectories and may affect independent living through activity limitations, activity avoidance, and reduced physical activity [28]. Previous CHARLS research linked higher education and better socioeconomic circumstances in adulthood to fewer functional limitations [29]. Education-related features also contributed substantially to classification in our study, although the direction and mechanisms of these associations require other analyses. Education may reflect not only schooling but also socioeconomic circumstances across the life course, health literacy, occupational physical demands, preventive service use, and access to rehabilitation resources. Multiple chronic conditions may jointly restrict function through accumulating symptoms, treatment burden, medication use, and declining physiological reserve [30]. The substantial contribution of valid chronic-condition responses indicates that XGBoost used information on response completeness as well as the recorded health characteristics. This count does not measure response accuracy, and SHAP values alone cannot establish why completeness was informative or how model performance would change after removing the variable. Performance in settings with different response patterns remains untested.

Population-level burden of low back pain and neck pain in China

The CHARLS analyses described functional difficulties and associated characteristics at the

individual level among middle-aged and older adults with spinal pain. To provide population health context, we used GBD estimates to examine long-term trends and age and sex distributions in the burden of low back pain and neck pain in China. This analysis adds national disease burden information but does not externally validate the CHARLS associations or classification models. GBD 2023 estimates showed divergent age-standardized trends between 1990 and 2023: low back pain prevalence and YLD rates decreased by approximately one-quarter, whereas the corresponding neck pain measures changed little overall and increased slightly. The decline in low back pain was broadly consistent with a previous GBD 2021 analysis, which also reported reductions in China's age-standardized prevalence and YLD rates from 1990 to 2020 [1]. Similarly, Xia et al.'s GBD 2019 analysis found only small changes in age-standardized neck pain prevalence and YLD rates in China between 1990 and 2019, consistent with the persistent burden observed here [31]. Long-term trends thus differ by pain site, and improvements in age-standardized low back pain measures do not imply parallel reductions in neck pain or overall pain management needs. Changes in age-standardized rates must also be distinguished from changes in case numbers. Case numbers and healthcare needs additionally depend on population size, age structure, and patients' functional status. The previous Chinese neck pain study illustrates this distinction: despite limited change in age-standardized prevalence, estimated case numbers increased from approximately 37.9 million in 1990 to 68 million in 2019 [31]. Global low back pain research likewise identifies population growth and aging as important drivers of future increases in case numbers. As China's population ages, demand for primary care pain management and rehabilitation may therefore persist even if age-standardized rates improve.

The age and sex distributions identify groups that warrant particular attention. In 2023, age-standardized prevalence among women was approximately 1.47 times that among men for low back pain and 1.38 times that among men for neck pain. Among the age groups presented, low back pain prevalence peaked at ages 85-89 years, whereas neck pain prevalence was relatively high around ages 70-74 years. These findings align with previous reports of higher prevalence among women, a pronounced low back pain burden at advanced ages (World Health Organization, Low back pain fact sheet, 2023; https://www.who.int/news-room/fact-sheets/detail/low-back-pain; accessed September 19, 2026), and frequent neck pain in middle and older age [2]. Women constituted 61.9% of the CHARLS pain sample, and age and sex contributed to concurrent classification. However, the sample's sex composition does not estimate sex-specific population prevalence, and mean absolute SHAP values do not establish the direction of an association. Together, these findings suggest that assessment of middle-aged and older adults with pain should consider age, sex, and functional needs, with particular attention to older women's assessment and service needs. Several biological and psychosocial factors may underlie these age and sex differences. In a longitudinal study of community-dwelling Chinese women, Huang et al. found that muscle and joint pain became more common across the menopausal transition and was associated with poorer health, higher body mass index, anxiety, and depression [32]. However, our study did not directly test these mechanisms and cannot determine their relative contributions. The CHARLS findings on multisite pain add individual-level information to the GBD results. In our sample, 21.10% reported pain in the back, low back, and neck, indicating that clinical needs may extend across anatomical sites. Previous longitudinal research linked multisite or widespread pain in older adults to subsequent mobility difficulties and functional decline, supporting joint assessment of symptom distribution and daily functioning [3]. The GBD estimates describe the population-level burden of low back pain and neck pain in China, while the CHARLS analysis identifies differences in functional limitation and outpatient contact across self-reported pain-relief use patterns. These separate analyses provide complementary perspectives, but they cannot establish how population-level YLD estimates relate to functional difficulties in individual CHARLS participants or quantify the combined disability burden of low back pain and neck pain within individuals. The CHARLS findings support including the maintenance of independent living among pain management goals.

Clinical and public health implications

Reported use of multiple pain-relief measures may prompt clinicians to ask about difficulties in daily activities and patterns of healthcare contact. This study does not provide a validated rule for prioritizing patients. Decisions about rehabilitation, referral, or treatment should rely on direct assessment of pain, daily functioning, mood, and medication use, with objective physical performance assessment when clinically indicated. For combined users, clinicians should review Chinese herbal medicine, prescription drugs, and over-the-counter pain medicines. They should also improve communication between providers. For patients who meet the criteria for chronic primary low back pain, World Health Organization (WHO) guidance supports individualized education, exercise, and other appropriate interventions within coordinated care. This approach considers physical, psychological, and social needs [33]. In DeBar et al.'s randomized trial of 800 patients aged 65 years or older with chronic low back pain, adding acupuncture to usual care improved back pain-related functioning. The benefit over usual care alone remained evident at 12 months, providing trial evidence to inform treatment choices for suitable older patients [34]. The WHO recommendations and this trial concern defined clinical populations and interventions that differ from the self-reported pain and use categories in our study. They therefore provide clinical context but do not establish the effectiveness of the combined-use pattern observed here.

The associations with education and insurance make access to pain care relevant to service planning. Primary care services could offer more accessible health education, community rehabilitation advice, and regular follow-up for middle-aged and older adults. Local needs assessments should consider cost, transport, and service availability, particularly for people with functional difficulties and limited resources. China's Guiding Opinions on Healthcare Security Supporting the Preservation, Innovation and Development of Traditional Chinese Medicine call for eligible primary care TCM providers to enter designated health insurance networks. The policy also encourages coverage of appropriate TCM techniques with established effectiveness and distinctive benefits (National Healthcare Security Administration and National Administration of Traditional Chinese Medicine, 2021; https://www.nhsa.gov.cn/art/2021/12/31/art_53_7720.html; accessed September 19, 2026). Service evaluations should track functional change, continuity of care, patient costs, and treatment safety to guide resource allocation and payment. These priorities concern identifying care needs and matching services to them; the present associations do not establish which treatments are more effective.

Limitations

The cross-sectional CHARLS analysis cannot establish the temporal relationships among pain-relief use, functional difficulties, and outpatient utilization or determine the effects of pain-relief measures on either outcome. The greater functional burden among combined users may reflect confounding by indication and reverse causation, as people with more severe pain or functional difficulties may seek several measures. This analysis did not include pain intensity assessed using a numerical rating scale (NRS), pain duration, or classification of pain as acute or chronic. Gait speed and the Short Physical Performance Battery (SPPB) were not included, so the functional findings concern self-reported activity difficulties rather than objectively measured physical performance. Unmeasured pain characteristics, limited information on prior treatment response and treatment timing, and the omission of CES-D-10 depressive symptom scores may leave residual confounding. Nighttime sleep duration and self-rated health do not substitute for an assessment of depressive symptoms. We therefore cannot determine whether the associations of pain-relief use with functional limitation and outpatient utilization would persist after adjustment for depressive symptoms or establish the direction or magnitude of bias arising from their omission. Pain, pain-relief use, and ADL/IADL difficulties were self-reported and are susceptible to recall error and misclassification. Pain reports do not confirm clinical diagnoses, and treatment categories lack detail on dose, frequency, duration, and adherence. Combined use does not necessarily indicate coordinated TCM and Western care. ADL/IADL difficulties measure overall function, while outpatient visits may

reflect other health needs and differences in provider contact required by each measure. Similar results in the complete-item sensitivity analysis do not rule out bias from nonrandom missing data or sample selection.

Our models classify functional limitations present at the time of the survey. We have not tested how well they predict future limitations or work in other populations. Internal cross-validation cannot replace testing in independent populations or other survey waves. The models are exploratory tools for concurrent classification and are not ready for direct clinical screening. Internal performance and decision curves do not demonstrate benefit from using them to guide patient care. The contribution of the number of valid chronic-condition responses to the XGBoost output suggests sensitivity to response availability and missing-data patterns. Including this covariate does not eliminate bias from nonrandom missingness or residual confounding. Its SHAP contribution alone does not quantify the change in discrimination that would follow its removal, and its relevance may vary across survey procedures and healthcare settings. SHAP values cannot establish cause and effect or show which factors should be targets for intervention. GBD estimates depend on source data quality and model assumptions. These estimates also remain uncertain. Differences between GBD and CHARLS in years, age ranges, pain definitions, and outcomes, together with the absence of individual-level linkage, limit GBD to contextual interpretation: YLDs cannot be equated with ADL/IADL difficulties, and burden trends cannot be attributed to particular pain-relief measures. Generalizability beyond the Chinese adults aged 45 years or older with pain studied here, including to hospitalized or institutionalized populations and other healthcare settings, requires validation. Longitudinal follow-up, detailed pain and treatment data, and independent validation are needed to clarify relationships between treatment choices, functional change, and service use.

Conclusion

TCM-related pain-relief use was common among Chinese adults aged 45 years or older with self-reported back, low back, or neck pain. Use varied with socioeconomic circumstances and health status. Combined use was associated with self-reported ADL/IADL limitation and outpatient utilization after adjustment for the included covariates. These findings describe concurrent patterns; unmeasured pain characteristics and depressive symptoms limit their interpretation. The secondary classification analysis showed similar internal discrimination across models but did not establish clinical utility or performance in other populations. The GBD estimates provide separate national context for the continuing burden of low back and neck pain in China. The CHARLS study was approved by the Ethics Review Committee of Peking University (approval number: IRB0000-1052-11015).

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Disclosure of conflict of interest

None.

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Supplementary Table 1. Unweighted multinomial logistic regression with no treatment as the reference category

Treatment pattern (reference: no treatment)	Variable	RRR (95% CI)	*P* value	Analytic sample size
Predominantly Western medications	Female vs. male	1.15 (1.01-1.30)	0.029	7683
Predominantly Western medications	Education: college or higher vs. no formal/incomplete primary education	0.36 (0.17-0.74)	0.006	7683
Predominantly Western medications	Education: senior high/secondary vocational school vs. no formal/incomplete primary education	0.81 (0.64-1.02)	0.070	7683
Predominantly Western medications	Education: junior high school vs. no formal/incomplete primary education	0.98 (0.82-1.17)	0.861	7683
Predominantly Western medications	Education: primary school vs. no formal/incomplete primary education	0.95 (0.82-1.10)	0.473	7683
Predominantly Western medications	No health insurance vs. insured	0.87 (0.61-1.23)	0.431	7683
Predominantly Western medications	Arthritis: yes vs. no	1.73 (1.41-2.13)	<0.001	7683
Predominantly Western medications	Poor/very poor vs. non-poor self-rated health	1.40 (1.23-1.59)	<0.001	7683
Predominantly Western medications	Age (per 1-year increase)	1.00 (0.99-1.00)	0.396	7683
Predominantly Western medications	Pain-site count (per 1-site increase)	1.22 (1.13-1.31)	<0.001	7683
Predominantly Western medications	Married/partnered: yes vs. no	0.97 (0.83-1.14)	0.738	7683
Predominantly Western medications	Sleep duration (per 1-hour increase)	0.99 (0.96-1.02)	0.509	7683
TCM-related measures only	Female vs. male	1.32 (1.13-1.54)	<0.001	7683
TCM-related measures only	Education: college or higher vs. no formal/incomplete primary education	3.56 (2.11-6.02)	<0.001	7683
TCM-related measures only	Education: senior high/secondary vocational school vs. no formal/incomplete primary education	2.34 (1.78-3.08)	<0.001	7683
TCM-related measures only	Education: junior high school vs. no formal/incomplete primary education	1.75 (1.39-2.21)	<0.001	7683
TCM-related measures only	Education: primary school vs. no formal/incomplete primary education	1.28 (1.02-1.59)	0.030	7683
TCM-related measures only	No health insurance vs. insured	1.13 (0.66-1.94)	0.658	7683
TCM-related measures only	Arthritis: yes vs. no	1.75 (1.36-2.25)	<0.001	7683
TCM-related measures only	Poor/very poor vs. non-poor self-rated health	1.17 (1.00-1.38)	0.052	7683
TCM-related measures only	Age (per 1-year increase)	0.99 (0.98-1.00)	0.192	7683
TCM-related measures only	Pain-site count (per 1-site increase)	1.18 (1.08-1.30)	<0.001	7683
TCM-related measures only	Married/partnered: yes vs. no	0.93 (0.73-1.19)	0.575	7683
TCM-related measures only	Sleep duration (per 1-hour increase)	1.00 (0.96-1.04)	0.871	7683
Combined use	Female vs. male	1.31 (1.15-1.50)	<0.001	7683
Combined use	Education: college or higher vs. no formal/incomplete primary education	0.72 (0.39-1.33)	0.295	7683
Combined use	Education: senior high/secondary vocational school vs. no formal/incomplete primary education	1.03 (0.79-1.35)	0.806	7683
Combined use	Education: junior high school vs. no formal/incomplete primary education	1.13 (0.93-1.37)	0.216	7683
Combined use	Education: primary school vs. no formal/incomplete primary education	0.99 (0.83-1.19)	0.945	7683
Combined use	No health insurance vs. insured	0.62 (0.44-0.88)	0.008	7683

Combined use	Arthritis: yes vs. no	2.75 (2.22-3.41)	<0.001	7683
Combined use	Poor/very poor vs. non-poor self-rated health	1.89 (1.63-2.19)	<0.001	7683
Combined use	Age (per 1-year increase)	0.99 (0.98-1.00)	0.002	7683
Combined use	Pain-site count (per 1-site increase)	1.48 (1.36-1.61)	<0.001	7683
Combined use	Married/partnered: yes vs. no	0.86 (0.72-1.04)	0.112	7683
Combined use	Sleep duration (per 1-hour increase)	0.97 (0.93-1.00)	0.068	7683

Note: Relative risk ratios (RRRs) and 95% CIs are reported. Community-clustered robust variance estimation was used. This was an unweighted supplementary analysis; coefficients for missingness adjustment variables are not shown. Abbreviations: TCM, traditional Chinese medicine; CI, confidence interval.

Supplementary Table 2. Sensitivity analysis among respondents with complete responses to all 11 ADL/IADL items

Sensitivity analysis	Treatment pattern comparison	Adjusted OR (95% CI)	*P* value	Analytic sample size
Complete responses to all 11 ADL/IADL items	Combined use vs. no treatment	1.42 (1.13-1.78)	0.002	6531
Complete responses to all 11 ADL/IADL items	Other or unclear vs. no treatment	0.75 (0.55-1.03)	0.074	6531
Complete responses to all 11 ADL/IADL items	TCM-related measures only vs. no treatment	0.91 (0.73-1.13)	0.408	6531
Complete responses to all 11 ADL/IADL items	Predominantly Western medications vs. no treatment	1.18 (0.99-1.40)	0.069	6531

Note: Weighted logistic regression was repeated among respondents with complete responses to all 11 ADL/IADL items, using the same Model 3 covariates, individual weights, and community-clustered robust variance estimation as in the primary analysis. Abbreviations: TCM, traditional Chinese medicine; ADL, activities of daily living; IADL, instrumental activities of daily living; OR, odds ratio; CI, confidence interval.