Original Paper

Age-Related Tibetan-Han Differences in Continuity of Care Among Insured Populations in High-Altitude Western China: Retrospective Longitudinal Observational Study

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Abstract

Background: Continuity of Care (CoC) is an important dimension of health system performance and health equity, reflecting whether individuals can maintain stable and coordinated care relationships over time, rather than merely gaining access to services. Although ethnic differences in CoC have been documented, most existing studies have examined average group differences and have paid limited attention to whether such differences vary across the life course. Claims-based analyses can provide a population-level approach to monitoring CoC and identifying age-specific equity gaps in routine health service use.

Objective: This study aimed to examine whether Tibetan-Han differences in CoC vary by age among insured populations in high-altitude western China and to assess whether these age-related patterns differ across outpatient, inpatient, chronic disease, and nonchronic disease care settings.

Methods: We used deidentified health insurance claims data from 3 major cities in high-altitude western China between January 1, 2021, and December 1, 2024. After data cleaning, we constructed a person-year dataset and restricted analyses to individuals with at least 3 annual health care encounters, yielding 850,469 person-years. The Bice-Boxerman CoC index was the primary outcome. Fixed-effects models with year and insurance-region fixed effects included ethnicity, age, age squared, and their interaction terms, adjusting for covariates derived from the Andersen behavioral model. SEs were clustered at the individual level. Subgroup analyses were conducted for outpatient, inpatient, chronic disease, and nonchronic disease samples.

Results: Mean CoC in the overall sample was 0.52 (SD 0.33). A significant nonlinear interaction between ethnicity and age was observed. Fixed-effects models showed a positive Tibetan coefficient (β=0.0582, P<.001), a negative ethnicity × age interaction (β=–0.0035, P<.001), and a significant ethnicity × age^2 interaction (P<.001). Outpatient results were similar. Inpatient analyses showed an overall disadvantage for Tibetans (β=–0.0795, P<.001) and a different age pattern. No significant age interaction was found in the chronic disease sample, whereas significant age heterogeneity remained in the nonchronic disease sample. Age-group analyses showed the largest Tibetan advantage at ages 20 to 25 and significantly lower continuity in most groups aged 35 to 75.

Conclusions: Ethnic differences in CoC were age-dependent and nonlinear rather than constant across age groups. Because the study covers 4 calendar years, these age-related associations may also reflect birth-cohort differences and should not be interpreted as within-person aging effects. Policies should pay greater attention to continuity barriers faced by middle-aged and older Tibetan populations.

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Keywords: ethnicity; age pattern; Continuity of Care; life-course inequality; Tibetan

Introduction

Health equity concerns not only whether different population groups can enter the health care system, but also whether they can continue to receive stable, coordinated, and high-quality care after entry. Ethnic health differences are not merely biological differences; rather, they reflect structural inequalities embedded in social determinants of health, resource allocation, and institutional access. Such inequalities are unlikely to be distributed evenly across age groups but may accumulate, intensify, attenuate, or even reverse as resources, institutional exposure, and health needs change over the life course [1,2]. Continuity of Care (CoC) is one key longitudinal dimension of this broader issue. As an important indicator of process quality, CoC has been associated with lower risk of mortality, hospitalization, and acute care use and therefore provides an important lens through which to assess whether health systems can transform episodic contacts into long-term, stable care relationships [3]. Ethnic health inequality may thus be reflected not only in whether people receive care at all, but also in whether care relationships can be sustained over time [4]. Prior studies have shown that higher CoC is generally associated with lower mortality, fewer emergency department visits and hospital admissions, and lower medical expenditures [5,6]. At the same time, ethnic minority groups are more likely to experience lower CoC [7].

CoC was initially regarded primarily as a core value of primary health care and was later conceptualized more broadly as the CoC relationships, information transfer, and management across time [8]. A review focusing on claims-based studies included 46 studies from North America, East Asia, and Europe and covered 14 types of continuity measures; of these, 39 reported a consistent association between higher continuity and lower health care use and costs [9]. A further critical review of the literature published between 2002 and 2022 showed that, among 160 included outcomes, most findings linked CoC to lower costs or more appropriate use of health care services [10]. A cohort study based on Medicare claims similarly found that more continuous and more regular patterns of primary care use were associated with greater Medicare savings and with fewer emergency department visits and hospitalizations [11]. At the same time, CoC is not evenly distributed across populations. Its level has been associated with age, sex, poverty, multimorbidity burden, and ethnic or racial background. Older individuals tend to have higher continuity, whereas ethnic minority groups and residents of more deprived areas are more likely to experience lower CoC [7,12,13]. However, in the existing literature, age and ethnicity have largely been treated as standard demographic covariates or examined only in terms of average differences, with limited attention to whether ethnic differences in CoC vary systematically across age. A large English primary care records study likewise found lower continuity in several ethnic minority groups, including among patients with multiple long-term conditions [7].

Theoretically, ethnic differences in CoC are unlikely to remain constant across age groups and may instead follow a more complex age pattern. Research on life-course inequality emphasizes that ethnicity should not be understood as a static demographic attribute, but rather as a social position embedded in social stratification, resource distribution, and institutional opportunity structures. The disadvantages arising from this position are therefore unlikely to be expressed uniformly across the life course; instead, they may gradually accumulate, intensify, attenuate, or reverse as institutional exposure, health needs, and dependence on care change over time [14]. Additionally, observed age differences may reflect not only cumulative disadvantage across the life course but also generational differences across birth cohorts in education, language, health systems, and broader social environments [15]. CoC may be especially sensitive to such age-related heterogeneity because maintaining repeated provider relationships becomes more dependent on the frequency of health care use, referral pathways, and the ability to navigate increasingly complex care as health needs change. Accordingly, the analyses describe age-related differences across person-years and cannot fully separate aging from birth-cohort processes. For a process-based quality indicator such as CoC, ethnic differences may therefore exhibit a complex age profile rather than a simple linear pattern. Accordingly, the key question is not merely whether CoC differences exist between ethnic groups, but how those differences vary with age. Recent English data also show that ethnic inequalities in multiple long-term conditions vary substantially by age, supporting an age-varying rather than constant pattern of ethnic inequality [16].

Against this background, high-altitude western China provides a particularly important setting in which to examine ethnic differences in CoC. What matters here is not merely the geographic label of an “ethnic minority region,” but the more complex position of Tibetan patients within the health care system. On the one hand, they constitute the culturally and demographically predominant population in local Tibetan society; on the other hand, within China’s state-led system of modern biomedicine and Mandarin-dominated health communication, they may continue to face institutional, linguistic, and interactional barriers [17]. Previous studies have suggested that this tension is present in everyday medical practice. In high-altitude western China, traditional Tibetan medicine hospitals are often perceived by local residents as more accessible sites of care because they are more closely connected to local culture and can provide bilingual services in Tibetan and Mandarin. By contrast, western medicine hospitals more often rely on Mandarin and mainstream biomedical modes of communication, which may place older patients and those with lower levels of education at a disadvantage [18]. In caring for Tibetan patients, language communication, cultural understanding, and care sensitivity remain persistent challenges, suggesting that entry into higher-level hospitals does not automatically translate into stable and smooth care relationships [19]. At the same time, the supply of health resources and workforce capacity

in high-altitude western China and surrounding Tibetan areas continue to be constrained by geography and developmental conditions [20]. More importantly, patient-physician ethnic concordance has been shown to affect CoC, indicating that ethnicity operates not only at the level of the broader social context but also within patient-physician interactions and the organization of service delivery itself [3]. Against this backdrop, this study used health insurance claims data from 3 cities in high-altitude western China to reconstruct annual care patterns of insured individuals, examined age-related Tibetan-Han differences in CoC, and compared these patterns across outpatient, inpatient, chronic disease, and nonchronic disease populations.

Methods

Data Sources and Study Population

This study used deidentified health insurance claims data for insured populations in 3 major cities in high-altitude western China, covering the period from January 1, 2021, to December 1, 2024. High-altitude western China is the principal settlement area for the Tibetan population. According to the 2020 national population census, approximately 90% of the resident population was Tibetan, 8% was Han, and 2% belonged to other ethnic groups. The database integrates reimbursement records from China's 2 basic health insurance schemes, namely the Urban Employee Basic Medical Insurance (UEBMI) and the Urban and Rural Resident Basic Medical Insurance (URRBMI). These schemes reimburse eligible care received by enrolled populations through the social health insurance system, thereby allowing reimbursed encounters across medical institutions to be linked at the individual level. The database therefore constitutes a relatively comprehensive administrative health database for capturing health care use and care patterns among insured residents in the study cities [21].

Unlike single-hospital or single-city datasets, this database is based on encrypted personal identifiers and can continuously track reimbursed health care encounters across institutions, provinces, and years at the individual level, thereby allowing a more complete reconstruction of longitudinal care trajectories for the same insured person. Each claim record contains an encrypted personal identifier and information on sex, year of birth, ethnicity, residence type, employment status, insurance type, and the location of the medical institution. It also includes visit date, outpatient or inpatient status, principal diagnosis, medical expenditures, and surgical or operative procedure codes. Pharmacy reimbursement records were not included in the database.

We extracted all outpatient and inpatient claims recorded between 2021 and 2024, yielding 12,442,091 health care encounters. We then merged duplicate records generated for the same insured individual on the same date at the same medical institution. Records with missing ethnicity, outcome, or covariate information were removed, and the analysis was restricted to Tibetan and Han individuals. After excluding other ethnic groups, 7,156,141 encounter records remained. These records were then aggregated by encrypted personal identifier and calendar year to construct person-year observations, resulting in 2,131,720 person-years. Because CoC indices require repeated contacts and are unstable or minimally informative when based on very few encounters, we restricted the analytic sample to person-years with at least 3 health care encounters in a given year. This threshold was therefore an a priori inclusion criterion for the continuity analyses. The final dataset for the main analysis included 850,469 person-year observations.

Study Variables

Outcome Measures

The outcome of interest was CoC. Using claims data, we constructed continuity measures at the person-year level by taking all health care contacts of individual i in year t as the observation window and using the medical institution identifier that could be stably identified in the claims data as the provider unit; institution-level continuity was calculated for the main analyses covering 2021 to 2024 [22]. Institution-level continuity was selected as the primary outcome because institution identifiers were consistently available across the full study period and across care settings, permitting comparable longitudinal measurement. In supplementary analyses, we additionally reported physician-level continuity for 2021 to 2023, using physician identifiers in the claims data as the provider unit. However, because physician identifiers were coded within institutions and were not standardized across institutions, and because the corresponding variables were unavailable in 2024, these results were used only for robustness discussions. Higher values indicate more concentrated care and fewer provider handoffs or less fragmentation, and therefore reflect higher continuity [23].

The primary outcome was the Bice-Boxerman CoC index [24]. Let N_{it} denote the total number of visits made by individual i in year t, and n_{ijt} the number of visits to institution j. The CoC was defined as:

$$COC_{it}=\frac{\sum_j n_{ijt}^2 - N_{it}}{N_{it}(N_{it}-1)}$$

In addition to the CoC, we calculated the Herfindahl-Hirschman Index (HHI), usual provider of care (UPC), the Ejlertsson K index (K index), and sequential continuity (SECON) as alternative continuity measures. Their definitions, calculation procedures, and corresponding regression results are presented in Supplementary Text 1 in Multimedia Appendix 1.

Exposure

The main explanatory variable was ethnicity. Based on insurance registration records, Han individuals were coded as 0 and Tibetan individuals as 1. Accordingly, the ethnicity-related coefficients in the regression models represent differences in CoC for Tibetans relative to Han individuals. In the main analyses, we further interacted ethnicity with age

and age squared to assess whether ethnic differences varied nonlinearly with age.

Categorical Age Variable

Age was calculated from the year of birth and the year of health care use. In the main analyses, age was entered into the models as a continuous variable together with its squared term to identify nonlinear age patterns in ethnic differences in CoC. Specifically, the models included age, age squared, ethnicity × age, and ethnicity × age squared to evaluate whether ethnic differences changed with age in a curvilinear rather than a purely linear manner. The quadratic specification was chosen as a parsimonious primary model; to reduce dependence on this functional-form assumption, we also estimated age-group-specific models using 17 five-year categories.

To more intuitively visualize ethnic differences across life stages and corroborate the continuous-age results from the main analyses, we further constructed a categorical age variable by dividing age into 17 five-year groups: [0-5], (5-10],…, (75-80], and (80-110]. In supplementary analyses, ethnic differences were estimated separately within each age group to show their distribution across different stages of the life course. Because the sample size at the oldest ages was relatively limited, individuals aged 80 years and older were combined into a single group to avoid excessive sparsity in the oldest age category.

Covariates

Following the Andersen behavioral model [25], we organized the covariates into 3 domains. Predisposing factors included employment status (employed vs not employed), which was used to reflect socioeconomic position and potential differences in health behavior. Enabling factors included basic health insurance type (UEBMI vs URRBMI), hukou status (urban vs rural), and sex (male vs female). Need factors included 2 measures: the Elixhauser Comorbidity Index (ECI), which captures overall disease burden and health care need, and an indicator for the presence of any surgical or operative procedure codes.

Statistical Analyses

All statistical analyses were conducted in R (version 4.5.2; R Foundation for Statistical Computing). Data cleaning and variable construction were performed mainly using *tidyverse* packages (including *dplyr, tidyr, stringr*, and *lubridate*) and *data.table*; heterogeneous annual datasets were merged using *plyr*. Fixed-effects regressions were estimated primarily with the *fixest* package, using cluster-robust SEs at the individual level, and propensity score matching was implemented with *MatchIt*. Result processing and table output relied mainly on *broom, modelsummary,* and *tableone*. Figures were produced primarily with *ggplot2*, together with *patchwork, ggrepel,* and *ggsci* for layout and annotation.

First, we constructed annual CoC measures from insurance claims records, with the CoC as the primary indicator. Descriptive statistics were reported for the overall sample, service-setting samples (outpatient and inpatient), and population-specific samples (chronic disease and nonchronic disease). Continuous variables were summarized as means and SDs, and categorical variables as frequencies and percentages. The main model was a linear regression with year and insurance-region fixed effects specified as follows:

$$CoC_{it} = \beta_1 Tibetan_i + \beta_2 Age_{it} + \beta_3 Age_{it}^2 + \beta_4 (Tibetan_i \times Age_{it}) + \beta_5 (Tibetan_i \times Age_{it}^2) + \gamma X_{it} + \delta_t + \mu_r + \varepsilon_{it}$$

$Y_{it} Ethnicity_i Age_{it} Age_{it}^2 X_{it} \lambda_t \delta_r \beta_4 \beta_5$In this model, the outcome denotes CoC for individual i in year t; ethnicity is coded Tibetan=1 and Han=0; age is entered continuously together with its squared term; the covariate set follows the Andersen model and includes sex, employment status, insurance type, hukou status, the ECI, chronic disease status, and the surgical or operative procedure indicator; and the model includes year fixed effects and insurance-region fixed effects. These are not individual fixed effects; therefore, the time-invariant ethnicity coefficient remains estimable. The ethnicity-by-age coefficients capture the linear and nonlinear age-varying components of Tibetan-Han differences. Accordingly, the main model focuses on how adjusted ethnic differences vary with age rather than on a single constant average difference.

To assess heterogeneity across service settings and health-need strata, we reestimated the above model separately in outpatient, inpatient, chronic disease, and nonchronic disease subsamples. For the outpatient and inpatient analyses, annual continuity measures were recalculated within each setting to ensure that they corresponded to the relevant service context. All regression models used cluster-robust SEs at the individual level to account for within-person correlation arising from repeated observations across years. Results are presented as point estimates with 95% CIs.

In supplementary robustness analyses, we reexamined the main findings in 4 ways. First, we replaced the CoC with the HHI, UPC, K index, and SECON and reestimated the same models with year and insurance-region fixed effects to assess whether the findings depended on a specific continuity measure. Second, we converted the CoC into binary outcomes for low continuity and high continuity and estimated logit models to assess how the ethnicity-by-age interactions affected the probability of falling in the lower or upper tails of the continuity distribution; low and high continuity were defined as values at or below the 25th percentile and at or above the 75th percentile of the annual CoC distribution, respectively. Third, among the 2021 to 2023 sample with available physician identifiers, we recalculated continuity at the physician level and repeated the main regression specification to test whether the findings depended on institution-level, rather than physician-level, continuity. Fourth, we estimated propensity scores using the main-study covariates and constructed a matched sample using 1:1 nearest-neighbor matching without replacement and a caliper of 0.2 times the SD of the logit of the propensity score. We then reestimated the main model in the matched sample to improve comparability between ethnic groups on observed characteristics. The age-group-specific analyses described below additionally provide a check that

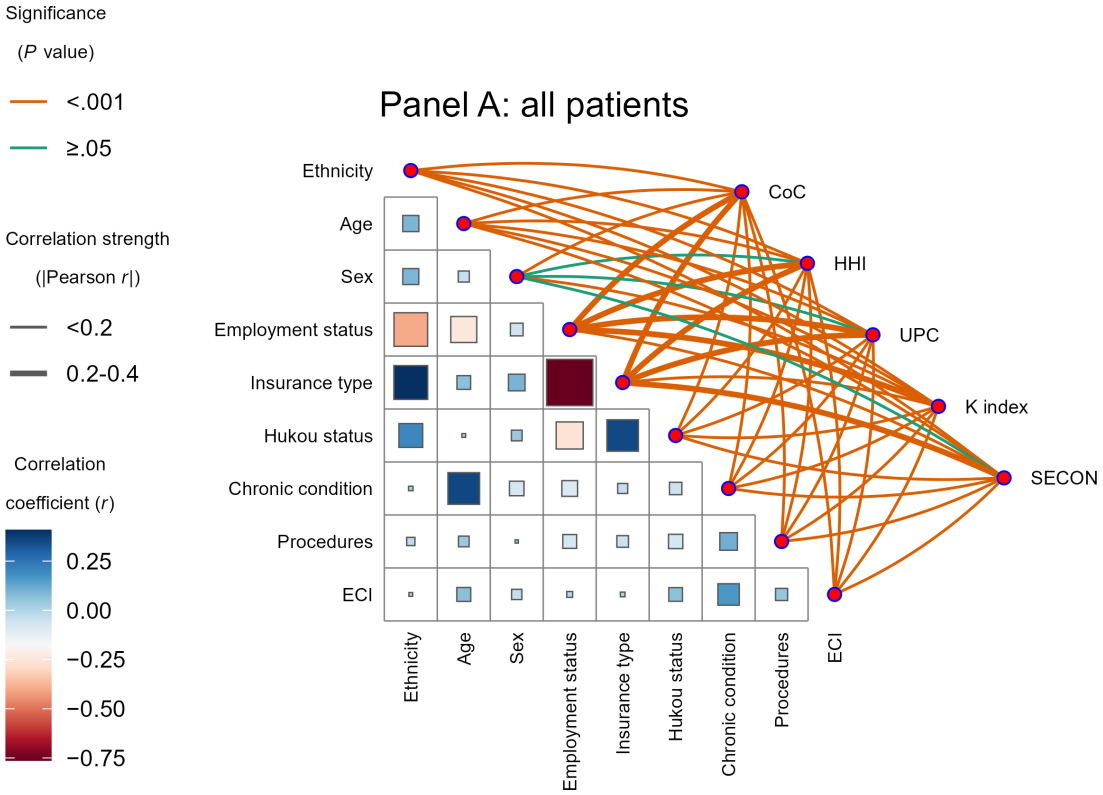
the substantive pattern is not driven solely by the quadratic age specification.

We additionally conducted reviewer-requested supplementary checks: complete age-group-specific parameter tables for all 5 continuity measures (Supplementary Tables 9A-9E in Multimedia Appendix 1); 2-tailed Welch *t* tests corresponding to the unadjusted Figure 1 comparisons (Supplementary Table 10 in Multimedia Appendix 1); COVID-period sensitivity analyses (Supplementary Tables 11-12 in Multimedia Appendix 1); natural cubic spline models (Supplementary Tables 13-14 and Supplementary Figure 8 in Multimedia Appendix 1); linear mixed-effects models (Supplementary Table 15 and Supplementary Tables 16A-16E in Multimedia Appendix 1); and additional model diagnostics and covariate-selection sensitivity analyses (Supplementary Tables 17-19 and Supplementary Figure 9 in Multimedia Appendix 1).

For diagnostics, we examined model fit, residuals-vs-fitted and normal Q-Q plots, variance inflation factors before and after centering age, and a post-LASSO reestimation of the primary model to assess sensitivity to covariate selection.

In addition to the main analyses using continuous age, we conducted supplementary analyses using 17 five-year age groups ([0-5], (5-10], …, (75-80], and (80-110]) and estimated Tibetan-Han differences in CoC separately within each group. The age-group-specific coefficients were further displayed in forest plots to illustrate the overall contour of age variation in ethnic differences.

Figure 1. Correlation structure between covariates and Continuity-of-Care (CoC) measures in the overall sample (panel A). The lower-left triangular matrix displays Pearson correlation coefficients among covariates. The network plot illustrates the correlations between covariates and the 5 CoC measures (CoC, Herfindahl-Hirschman Index [HHI], usual provider of care [UPC], the Ejlertsson K index [K index], and sequential continuity [SECON]). ECI: Elixhauser Comorbidity Index.



Ethical Considerations

Ethics approval for this study was granted by the Medical Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology (protocol numbers: [2022](S092)). All participants' information has been deidentified. The study was performed in accordance with the Declaration of Helsinki. The requirement for informed consent was waived by the Medical Ethics Committee because this study used deidentified administrative health insurance claims data.

Results

Characteristics

Table 1 presents the sample characteristics across the 5 analytic panels. The main analysis included 850,469 person-year observations, comprising 799,782 in the outpatient sample, 18,189 in the inpatient sample, 278,615 in the chronic disease sample, and 583,598 in the nonchronic disease sample. Ethnic composition was broadly similar across panels, with Tibetans accounting for approximately 88% to 89% and Han individuals for 11% to 12%.

Table 1. Sample characteristics and Continuity-of-Care (CoC) measures across study panels.[a]

Characteristic	Number (%) of person-years				
	Panel A (N=850,469)	Panel B (n=799,782)	Panel C (n=18,189)	Panel D (n=278,615)	Panel E (n=583,598)
Ethnicity, n (%)					
Tibetan	750,386 (88.2)	704,036 (88.0)	16,265 (89.4)	246,739 (88.6)	513,549 (88.0)
Han	100,083 (11.8)	95,746 (12.0)	1924 (10.6)	31,876 (11.4)	70,049 (12.0)
CoC, mean (SD)	0.52 (0.33)	0.54 (0.34)	0.45 (0.36)	0.52 (0.32)	0.52 (0.34)
HHI[b], mean (SD)	0.62 (0.26)	0.64 (0.26)	0.60 (0.26)	0.60 (0.26)	0.63 (0.26)
UPC[c], mean (SD)	0.70 (0.23)	0.71 (0.23)	0.66 (0.25)	0.69 (0.23)	0.70 (0.23)
K index[d], mean (SD)	0.68 (0.28)	0.69 (0.28)	0.55 (0.35)	0.72 (0.25)	0.66 (0.30)
SECON[e], mean (SD)	0.57(0.33)	0.59 (0.34)	0.49 (0.38)	0.58 (0.31)	0.57 (0.34)
Sex, n (%)					
Male	371,206 (43.6)	348,680 (43.6)	9601 (52.8)	136,678 (49.1)	240,123 (41.1)
Female	479,263 (56.4)	451,102 (56.4)	8588 (47.2)	141,937 (50.9)	343,475 (58.9)
Age group, n (%)					
(0,5)	23,072 (2.7)	20,736 (2.6)	610 (3.6)	740 (0.3)	22,332 (3.9)
(5,10)	22,286 (2.6)	21,081 (2.6)	219 (1.3)	927 (0.3)	21,359 (3.7)
(10,15)	13,154 (1.5)	12,124 (1.5)	172 (1.0)	969 (0.4)	12,185 (2.1)
(15,20)	9707 (1.1)	8585 (1.1)	222 (1.3)	1699 (0.6)	8008 (1.4)
(20,25)	30,895 (3.6)	29,430 (3.7)	259 (1.5)	3657 (1.3)	27,238 (4.7)
(25,30)	77,876 (9.2)	75,090 (9.4)	520 (3.0)	11,215 (4.1)	66,661 (11.6)
(30,35)	99,873 (11.7)	95,928 (12.0)	867 (5.1)	18,131 (6.6)	81,742 (14.2)
(35,40)	91,218 (10.7)	87,195 (10.9)	949 (5.6)	20,612 (7.5)	70,606 (12.3)
(40,45)	80,210 (9.4)	76,124 (9.5)	1182 (6.9)	22,673 (8.2)	57,537 (10.0)
(45,50)	76,007 (8.9)	71,573 (8.9)	1426 (8.3)	27,446 (10.0)	48561 (8.4)
(50,55)	78,136 (9.2)	73,107 (9.1)	1910 (11.2)	33,235 (12.1)	44,901 (7.8)
(55,60)	74,298 (8.7)	69,385 (8.7)	2148 (12.6)	36,065 (13.1)	38,233 (6.7)
(60,65)	64,604 (7.6)	60,148 (7.5)	2022 (11.8)	34,249 (12.4)	30,355 (5.3)
(65,70)	44,716 (5.3)	41,183 (5.1)	1745 (10.2)	25,763 (9.3)	18,953 (3.3)
(70,75)	33,019 (3.9)	30,102 (3.8)	1411 (8.3)	19,905 (7.2)	13,114 (2.3)
(75,80)	19,933 (2.3)	17,820 (2.2)	912 (5.3)	11,983 (4.3)	7950 (1.4)
(80,110)	11,465 (1.3)	10,171 (1.3)	518 (3.0)	6468 (2.3)	4997 (0.9)
Insurance type, n (%)					
UEBMI[f]	341,007 (40.1)	332,398 (41.6)	4023 (22.1)	119,135 (42.8)	229,116 (39.3)
URRBMI[g]	509,462 (59.9)	467,384 (58.4)	14,166 (77.9)	159,480 (57.2)	354,482 (60.7)
Residence type, n (%)					
Urban	592,869 (69.7)	565,961 (70.8)	11,852 (65.2)	204,779 (73.5)	397,627 (68.1)
Rural	257,600 (30.3)	233,821 (29.2)	6337 (34.8)	73,836 (26.5)	185,971 (31.9)
ECI[h], mean (SD)	0.20 (1.22)	0.18 (1.16)	1.52 (3.22)	0.49 (1.98)	0.06 (0.53)
Chronic disease, n (%)					
No	574,732 (67.6)	539,574 (67.5)	6256 (34.4)	—[i]	583,598 (100.0)
Yes	275,737 (32.4)	260,208 (32.5)	11,933 (65.6)	278,615 (100.0)	—
Surgery, mean (SD)	0.12 (0.81)	0.12 (0.80)	0.18 (0.75)	0.26 (1.25)	0.07 (0.52)

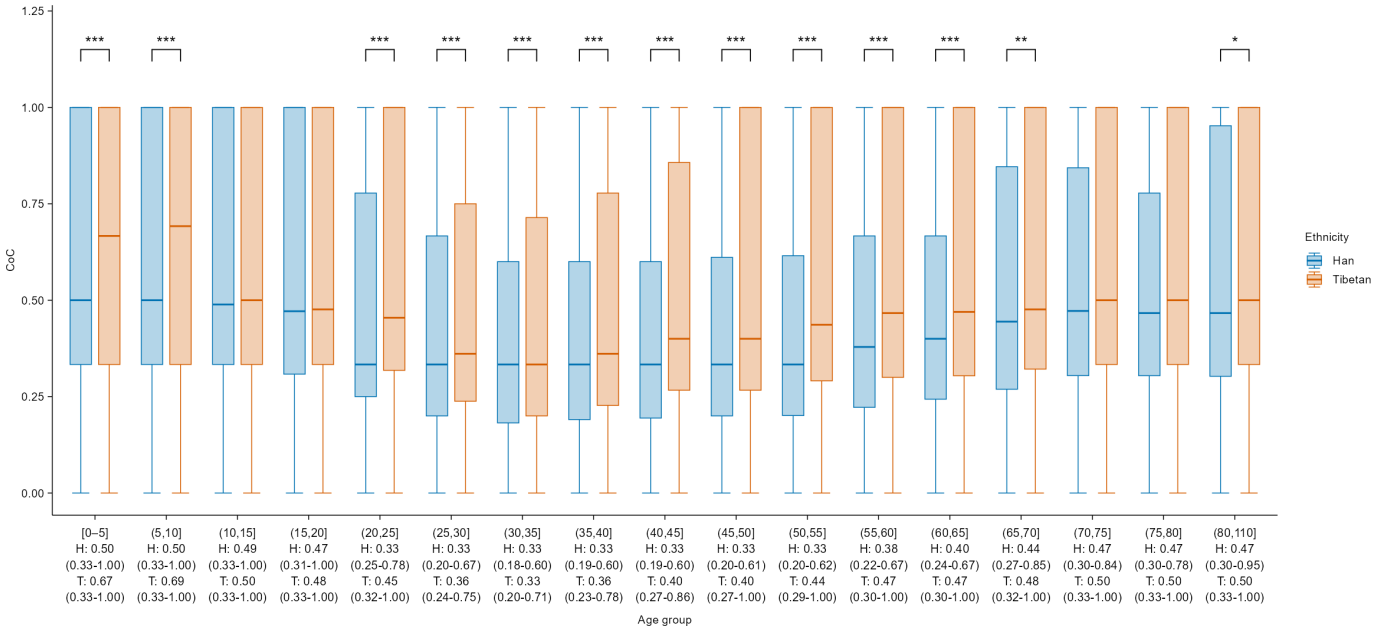
[a]Panel A includes all patients. Panel B includes outpatient visits. Panel C includes inpatient admissions. Panel D includes patients with chronic conditions. Panel E includes patients without chronic conditions.
[b]HHI: Herfindahl-Hirschman Index.
[c]UPC: usual provider of care.
[d]K index: Ejlertsson K index.
[e]SECON: sequential continuity.
[f]UEBMI: Urban Employee Basic Medical Insurance.
[g]URRBMI: Urban and Rural Resident Basic Medical Insurance.
[h]ECI: Elixhauser Comorbidity Index.
[i]Not applicable.

In the overall sample, the mean for CoC was 0.52 (SD 0.33); the corresponding values for the HHI, UPC, K index, and SECON were 0.62 (SD 0.26), 0.70 (SD 0.23), 0.68 (SD 0.28), and 0.57 (SD 0.33), respectively. Continuity levels varied across panels, with the inpatient sample showing the lowest overall continuity and the outpatient and chronic disease samples showing relatively higher levels. In the overall sample, 56.4% (479,263/850,469) of observations were female patients, and the age distribution was concentrated mainly in adulthood, whereas the inpatient and chronic disease samples were more heavily weighted toward middle-aged and older adults. Overall, 59.9% (509,462/850,469) were enrolled in URRBMI, and 69.7% (592,869/850,469) were urban residents. As expected, the ECI was substantially higher in the inpatient and chronic disease samples than in the overall and nonchronic disease samples, indicating a greater disease burden in these panels.

Correlation Structure and Age-Stratified Descriptive Patterns

Figure 2 shows that in the overall sample, most covariates selected on the basis of the Andersen model were significantly associated with the 5 continuity measures, supporting their inclusion in subsequent multivariable analyses. Correlations among covariates were generally weak to moderate, although employment status, insurance type, and hukou status were more strongly correlated with one another. Figure 1 further illustrates the unadjusted age-group-specific distributions of CoC by ethnicity in the overall sample. In both ethnic groups, CoC followed a clear nonlinear pattern across age, with relatively high levels in childhood, a decline from young adulthood to midlife, and a subsequent increase in older age. Descriptively, Tibetans had higher median CoC than Han individuals in most age groups, with more pronounced differences at ages 0 to 10, 20 to 70, and 80 years or older; by contrast, ethnic differences were smaller or not statistically significant in some age groups, such as ages 10 to 20 and 75 to 80 years. Corresponding results for the outpatient, inpatient, chronic disease, and nonchronic disease panels are presented in Supplementary Figures 1-2 in Multimedia Appendix 1.

Figure 2. Age-group-specific distribution of Continuity of Care (CoC) by ethnicity in the overall sample. The horizontal line within each box indicates the median; the lower and upper bounds of the box indicate the 25th and 75th percentiles, respectively; and the whiskers indicate the distribution range. Brackets and asterisks above each age group denote between-group comparisons for Han and Tibetan individuals within the same age group. *P<.05; **P<.01; ***P<.001. H: Han; T: Tibetan. Values below each age group: median (IQR). Asterisks: two-sided Welch t tests (*P <.05, **P <.01, ***P <.001).



Main Regression Results

Table 2 shows a significant nonlinear interaction between ethnicity and age in the overall sample. The main effect of Tibetan ethnicity was positive, whereas the interaction terms between ethnicity and age and between ethnicity and age squared were negative and positive, respectively. This pattern indicates that the adjusted continuity difference for Tibetans relative to Han individuals varied curvilinearly with age: the relative advantage observed at younger ages gradually weakened and later shifted to a disadvantage, although this disadvantage did not increase in a purely linear fashion. Estimates from the outpatient sample were highly consistent with those from the overall sample, whereas the inpatient sample showed a more direct Tibetan disadvantage and a more complex age pattern. Interaction terms were generally weaker in the chronic disease sample, suggesting a less stable age pattern, while the nonchronic disease sample broadly preserved the same direction of change as the overall sample. Because CoC ranges from 0 to 1, these coefficients represent absolute differences in the continuity score; given the very large sample, statistical significance should be interpreted

together with the magnitude and consistency of the estimates rather than as evidence of clinical importance by itself. Taken together, the main models indicate that Tibetan-Han differences in CoC were age-dependent and nonlinear, rather than representing a single constant average effect. Additional robustness results are presented in Supplementary Tables 1-8 in Multimedia Appendix 1.

Additional supplementary analyses were consistent with the main interpretation. Complete age-group-specific coefficients, SEs, *t* statistics, *P* values, and 95% CIs for CoC, HHI, UPC, K index, and SECON are reported in Supplementary Tables 9A-9E in Multimedia Appendix 1. The 2-tailed Welch *t* tests confirmed that Figure 1 significance annotations corresponded to the unadjusted between-ethnicity comparisons. COVID-period sensitivity analyses did not indicate that the main age-varying pattern was driven solely by a single study year. Natural cubic spline and mixed-effects models yielded broadly consistent age-specific patterns. Model diagnostics showed residual patterns expected for a bounded 0 to 1 outcome, while centered-age variance inflation factors indicated that the largest multicollinearity was concentrated in the polynomial age terms and their ethnicity interactions rather than the control variables. A post-LASSO reestimation retained all controls except hukou and produced nearly unchanged focal ethnicity-by-age estimates (Supplementary Tables 17-19 and Supplementary Figure 9 in Multimedia Appendix 1).

Table 2. Regression estimates for the annual Bice-Boxerman Continuity of Care (CoC) index with year and insurance-region fixed effects (FE)[a].

Term	Overall (Panel A)	Outpatient (Panel B)	Inpatient (Panel C)	Chronic (Panel D)	Nonchronic (Panel E)
Ethnicity (Tibetan=1)	0.0582[b] (0.0074)	0.0472[b] (0.0078)	–0.0795[b] (0.0226)	0.0141 (0.0147)	–0.0064 (0.0064)
Age	–0.0017[b] (0.0004)	–0.0031[b] (0.0004)	–0.0026[c] (0.0013)	–0.0023[b] (0.0006)	–0.0038[b] (0.0003)
Age squared	0.0000[b] (0.0000)	0.0000[b] (0.0000)	0.0000[c] (0.0000)	0.0000[b] (0.0000)	0.0000[b] (0.0000)
Ethnicity × age	–0.0035[b] (0.0004)	–0.0030[b] (0.0004)	0.0031[c] (0.0013)	–0.0005 (0.0006)	–0.0012[b] (0.0003)
Ethnicity × age squared	0.0000[b] (0.0000)	0.0000[b] (0.0000)	–0.0000[c] (0.0000)	–0.0000 (0.0000)	0.0000[d] (0.0000)
Controls	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Insurance-region FE	Yes	Yes	Yes	Yes	Yes
N	850,469	799,782	18,189	278,615	583,598
R-squared	0.0996	0.1293	0.0216	0.1074	0.1032

[a]This table reports linear regression estimates for annual CoC with year and insurance-region FEs. Panels A-E correspond to the overall sample, outpatient sample, inpatient sample, chronic disease sample, and nonchronic disease sample, respectively. Coefficients are unstandardized absolute differences on the 0 to 1 CoC scale; values in parentheses are cluster-robust SEs. The key explanatory variables include ethnicity (Tibetan=1 and Han=0), age, age squared, and their interaction terms. Covariates include sex, employment status, insurance type, residence type, Elixhauser Comorbidity Index (ECI), chronic disease status, and surgical or operative procedure indicators. SEs are clustered at the individual level. All analyses are restricted to person-years with at least 3 annual encounters. Higher CoC values indicate higher continuity.

[b]*P*<.001.

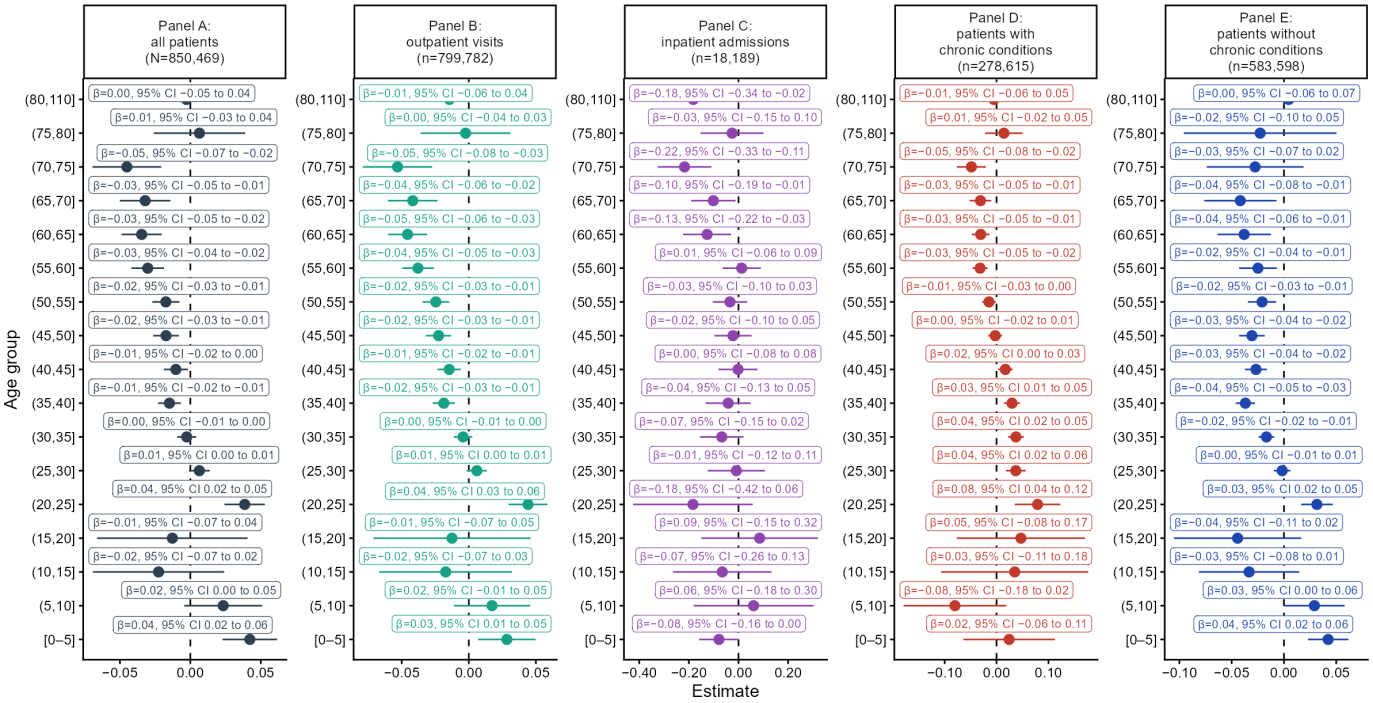
[c]*P*<.05.

[d]*P*<.01.

Age-Stratified Regression Results

Figure 3 reports the Tibetan-Han differences in CoC within each age group after adjustment for sex, employment status, insurance type, residence type, the ECI, and the surgical or operative procedure indicator, with insurance-region and year fixed effects included. In the overall sample (panel A), a clear pattern of age heterogeneity was observed. Ethnic differences were close to 0 or slightly positive in childhood, and the largest positive difference appeared in the 20 to 25-year age group. Thereafter, the difference gradually diminished and became negative overall after age 35, reaching statistical significance in most age groups between 35 and 75 years. The largest negative difference was observed in the 70 to 75-year age group. Among individuals aged 80 years and older, the estimate again approached 0 and the CI crossed the null. The age profile in the outpatient sample (panel B) closely mirrored that of the overall sample, suggesting that the overall findings were driven primarily by outpatient continuity. By contrast, in the inpatient sample (panel C), point estimates were generally closer to 0 and CIs were substantially wider, indicating that ethnic differences in the inpatient setting were weaker overall and were estimated with lower precision; relatively stable negative differences were observed only at older ages. In the chronic disease sample (panel D), more pronounced positive differences were observed between ages 20 and 45, after which the estimates gradually turned negative, reaching statistical significance in multiple age groups after age 55. In the nonchronic disease sample (panel E), ethnic differences were small in childhood but predominantly negative between ages 30 and 70, suggesting that among individuals without chronic disease, the continuity disadvantage for Tibetans relative to Han individuals was concentrated mainly in adulthood and early old age. Results based on alternative continuity measures and physician-level continuity were broadly consistent with the pattern shown in Figure 3; these findings are presented in Supplementary Figures 3-7 in Multimedia Appendix 1.

Figure 3. Adjusted Tibetan-Han differences in Continuity of Care (CoC) across age groups. Point estimates are regression coefficients (β) representing the adjusted absolute difference in CoC between Tibetan and Han individuals within each age group. Horizontal lines indicate 95% CIs, and the vertical dashed line marks β=0. Labels report β and the corresponding 95% CI. Models adjust for sex, employment status, insurance type, residence type, Elixhauser Comorbidity Index (ECI), and surgical/operative procedure indicators, with year and insurance-region fixed effects and individual-level cluster-robust SEs. Panels A-E correspond to the overall, outpatient, inpatient, chronic disease, and nonchronic disease samples, respectively.



Discussion

Principal Findings

Using national health insurance claims data for insured populations in high-altitude western China from 2021 to 2024, this study examined Tibetan-Han differences in CoC from the perspective of process quality and investigated how these differences varied with age. By constructing continuity measures at the person-year level and estimating multivariable models that adjusted for covariates derived from the Andersen behavioral model, as well as insurance-region and year fixed effects, we found that although Tibetans showed higher continuity than Han individuals in descriptive comparisons across most age groups, this apparent advantage did not persist after adjustment. Rather than reflecting a constant average difference, Tibetan-Han differences in continuity followed a pronounced nonlinear age pattern. In the overall and outpatient samples, Tibetans showed relatively higher continuity at younger ages, but this advantage gradually weakened and turned into a disadvantage in adulthood. Differences in the inpatient sample were weaker and less precise, whereas the chronic disease and nonchronic disease samples showed varying degrees of age heterogeneity. Findings based on alternative continuity measures, physician-level continuity, matched-sample analyses, and age-group-specific models were broadly consistent with this main pattern. These findings describe age-related associations across person-years; because the observation window spans only 4 years, they cannot distinguish within-person aging effects from birth-cohort differences. Overall, the absolute differences were modest on the 0 to 1 CoC scale, so their importance is best interpreted at the population and health-system level rather than as a clinically validated threshold for individual patients. Moreover, unadjusted and adjusted differences do not capture the same level of effect: the former is closer to an overall difference shaped by group composition and service organization, whereas the latter is closer to a conditional ethnic difference under more comparable circumstances [26].

Our findings extend the discussion of health equity in Tibetan settings from the question of whether services are used to the process dimension of whether care can be continuously maintained. Equity and quality are not 2 separate goals, but jointly constitute health-system performance; examining continuity is, in essence, an assessment of whether the health care system can transform fragmented encounters into stable longitudinal care relationships [27,28]. Previous research has already suggested that CoC is not evenly distributed across ethnic groups. A study based on general practice records in England found that, even after adjustment for demographic characteristics, long-term conditions, and consultation frequency, several ethnic minority groups still had lower continuity than White patients [7]. Our earlier study in high-altitude western China likewise showed that patient-physician ethnic concordance could improve CoC, yet Tibetan patients remained disadvantaged overall [3]. These international and claims-based findings provide a useful comparison, but they do not establish the mechanisms underlying the present age pattern. Two mechanisms may be relevant hypotheses. The first is generational or birth-cohort difference: the observed age

pattern may not be driven entirely by age itself but may also partly reflect historical differences across birth cohorts in educational opportunity, Mandarin proficiency, institutional exposure, and health care accessibility.

Research on health disparities across the life course has repeatedly emphasized that age effects are often intertwined with cohort processes; thus, the lower continuity observed among older Tibetan patients may indicate not only age-related differences in care patterns but also that older cohorts entered the health care system under markedly different historical conditions [14,29]. A second possible mechanism is cumulative disadvantage. If ethnicity-related disadvantage becomes more visible as long-term care needs, chronic disease management, system navigation, and cross-institutional coordination become more demanding, then the relatively high crude continuity observed at younger ages may represent concentrated care under lower levels of need, whereas the shift toward disadvantage in adulthood may reflect growing difficulties in sustaining care relationships [30]. Evidence from older adults with a migration background also suggests lower personal CoC, implying that continuity itself may be one dimension through which ethnic inequality varies across age groups [31]. These mechanisms are plausible interpretations rather than effects directly tested in the present claims data.

The stratified results further suggest that Tibetan-Han differences in continuity were concentrated primarily in outpatient care, where relationships are more longitudinal, rather than being evenly distributed across all service settings. The close alignment between the outpatient and overall samples indicates that the age pattern identified in this study is more reflective of long-term follow-up and stable outpatient relationships [32]. By contrast, the inpatient findings should be interpreted more cautiously. Inpatient care is more acute and event-driven by nature and is therefore less suitable than outpatient care for capturing the relational meaning of continuity. Additionally, the inpatient sample in this study was substantially smaller, making the inpatient panel more appropriate as directional evidence than as a basis for interpretation at the same level of strength as the overall or outpatient analyses. The chronic disease sample also warrants careful reading. In the age-stratified figures, this group showed a pattern in which Tibetans had relatively higher continuity at younger ages but lower continuity at older ages; however, the continuous-age quadratic model was not statistically significant overall. One possible explanation is that chronic disease care is more structured through repeated follow-up and standardized management pathways, which may reduce variation attributable to ethnicity; family doctor and standardized diabetes and hypertension management programs have been shown to improve continuity or strengthen long-term care coordination [33]. This explanation remains a hypothesis because referral pathways and program participation were not directly measured in the claims data. Recent Chinese evidence further suggests that family doctor enrollment can shift chronic disease care toward community health centers, while evidence from high-altitude western China documents continuing constraints in the general-practice workforce and training capacity [33,34].

In the Tibetan context, this age-dependent ethnic difference in continuity deserves particular attention because it may reflect the tension between local social centrality and incorporation into the state health system. Tibetans are the demographic majority in local society, yet high-altitude western China continues to face longstanding constraints related to geographic dispersion, high altitude, shortages of health personnel, and limited primary care capacity, all of which can make regular follow-up, referral coordination, and long-term care more difficult. Previous studies have shown that the supply of general practitioners and training opportunities in high-altitude western China and in surrounding Tibetan areas remain insufficient, that the primary health care system is relatively fragile, and that continuity and coordination themselves are weak points in ongoing health-system reform [34,35]. Although Tibetans are the local majority, they may still encounter communication, cultural, and institutional barriers within China's state-led system of modern biomedicine and Mandarin-dominated health communication. In high-altitude western China, traditional Tibetan medicine hospitals receive higher ratings in primary care experience because they are more closely aligned with local culture and language environments, while cross-cultural nursing studies have likewise shown that language barriers, insufficient cultural understanding, and limited care sensitivity remain persistent challenges in clinical interactions with Tibetan patients [18,19]. These contextual factors offer plausible explanations for the observed age pattern, but the present claims data did not directly measure language proficiency, cultural preference, referral experience, geographic accessibility, or provider availability. The observed differences may therefore also reflect health care-seeking behavior, health beliefs, geographic accessibility, or provider supply, and should not be attributed to any single mechanism. Comparable evidence from First Nations populations in Australia, Canada, and Aotearoa New Zealand identifies culturally appropriate care, communication, trusting relationships, and coordination across services as important determinants of continuity [36].

The contribution of this study lies in showing that Tibetan-Han differences in CoC vary by age and service setting, shifting attention from average differences toward age-specific process quality. From a policy perspective, the findings support monitoring continuity alongside access, especially for middle-aged and older insured populations in the study cities. Potential responses include strengthening long-term outpatient management, cross-institutional coordination, primary care and referral capacity, physician workforce planning, culturally competent and bilingual services, and integrated chronic disease management. These implications should be understood as system-level priorities suggested by the observed patterns rather than interventions whose causal effects were tested in this study.

Limitations

This study has several limitations. First, the continuity measures were constructed from claims data and therefore reflect the concentration and stability of realized health care contacts over time, rather than directly capturing underlying clinical need, unmet need, motivations for care-seeking, interpersonal continuity, relational trust, communication quality, informational continuity, or patient satisfaction. High measured continuity is also not necessarily advantageous in every clinical context, because appropriate multidisciplinary care may require visits to multiple providers. Accordingly, what we identify is claims-based organizational continuity within the insured health care system, rather than the full multidimensional concept of continuity or direct evidence of any single mechanism. Second, although we used insurance claims to trace cross-institutional, cross-regional, and cross-year care patterns among insured individuals registered in high-altitude western China, and adjusted for observed covariates as well as insurance-region and year fixed effects, this study remains observational and cannot causally identify the specific mechanisms underlying ethnic differences. Important potential confounders were unavailable, including education, household income, health literacy, language proficiency, marital status, occupation, transportation access, distance to health care facilities, and patient preferences; residual confounding may therefore remain. Third, restricting analyses to person-years with at least 3 encounters may underrepresent healthier individuals, younger adults, and people with limited health care use, so the findings apply most directly to insured person-years with repeated health care contact. Fourth, the age pattern observed here may reflect both age-related differences and generational differences across birth cohorts in education, language adaptation, historical experience, and institutional exposure; the 4-year observation window cannot strictly separate age effects from cohort effects. Fifth, health care use and provider choice may have been affected by COVID-19-related disruptions during 2021 to 2024. Year fixed effects account for common annual shocks, but localized changes were not directly measured and may contribute to residual confounding. Sixth, the available claims variables used in this analysis did not permit separate continuity estimates for traditional Tibetan medicine versus Western medicine care, so the study cannot determine whether continuity was partly maintained through one medical system or the other. The database also does not include pharmacy claims or health care contacts paid entirely outside the insurance system. Finally, the study population was drawn from insured residents in 3 major cities in high-altitude western China. Although this provides relatively strong internal validity, caution is needed when generalizing these findings to all of high-altitude western China, uninsured populations, rural areas not represented by these cities, or other ethnic minority settings.

Conclusions

This study, based on health insurance claims data from insured populations in 3 cities in high-altitude western China between 2021 and 2024, shows that Tibetan-Han differences in CoC varied by age and were nonlinear rather than representing a constant average difference. In the overall and outpatient settings, Tibetans exhibited relatively higher continuity at younger ages, but this advantage gradually weakened and later shifted to a disadvantage in adulthood; the inpatient, chronic disease, and nonchronic disease populations showed different age-related patterns. Because age and birth cohort cannot be fully separated in this 4-year observational dataset, these findings should be interpreted as age-related associations rather than within-person aging trajectories. The observed effect sizes were modest on the 0 to 1 CoC scale but may still be relevant for population-level equity monitoring. Assessments of health equity in the study setting should therefore consider continuity alongside health care access and service use. Policy efforts may prioritize long-term outpatient management, cross-institutional coordination, primary care capacity, and culturally and linguistically appropriate services for middle-aged and older Tibetan populations, while recognizing that the mechanisms underlying the observed differences were not directly measured.

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Data Availability

The study data and related documents are available from the corresponding author, Professor TY, upon reasonable request via email at yeting@hust.edu.cn.

Authors' Contributions

CJ conceived the study, conducted the analyses, interpreted the data, and drafted the manuscript. JM contributed to data curation, the literature review, and manuscript drafting. WC contributed to study design, interpretation of the results, and manuscript revision. TY conceived and supervised the study, acquired funding, and critically revised the manuscript. XZ contributed to manuscript revision.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Systematic review and meta-analysis of generative AI–based interventions in behavioral medicine.
[DOCX File (Microsoft Word File), 2020 KB-Multimedia Appendix 1]

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Abbreviations

CoC: Continuity of Care
ECI: Elixhauser Comorbidity Index
HHI: Herfindahl-Hirschman Index
index: Ejlertsson K index
SECON: sequential continuity
UEBMI: Urban Employee Basic Medical Insurance
UPC: usual provider of care

URRBMI: Urban and Rural Resident Basic Medical Insurance

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