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Article

Beyond geography: Cross-regional healthcare-seeking and hospitalization costs in Shandong, China

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Abstract: Cross-regional healthcare-seeking, defined as utilizing medical services beyond one's residential area, helps mitigate geographic disparities in health resources but may correlate with elevated financial burdens. As this practice grows in China, particularly in resource-diverse provinces like Shandong, its relationship with hospitalization costs remains insufficiently quantified. This study aims to measure the association between cross-regional care and hospitalization expenditures in Shandong Province, China. Analysis of 2.27 million hospitalizations showed that cross-regional care was associated with higher hospitalization costs but differed by types of cross-regional healthcare-seeking. Seeking care at primary or secondary hospitals within adjacent cities was correlated with reduced expenditures, reflecting proximity-oriented behavior. In contrast, treatment at interprovincial tertiary hospitals was associated with the largest cost increase, with expenditures 206% higher than those for local care. A portion of the association between cross-regional healthcare-seeking and hospitalization costs was transmitted through prolonged length of stay as an intermediary pathway, and this pattern was not evident for interprovincial tertiary care. These heterogeneous cost patterns in Shandong support the development of differentiated governance strategies tailored to these heterogeneous cost drivers.

Keywords: cross-regional healthcare-seeking; hospitalization costs; China; length of stay; health equity

1. Introduction

Cross-regional healthcare utilization refers to individuals seeking care outside their place of residence. This pattern, especially pronounced in resource-diverse provinces like Shandong, China, typically stems from the extreme geographic concentration of high-quality medical resources (Koylu et al., 2018). High-quality, high-tech resources remain predominantly clustered in major urban centers, making cross-regional care a practical strategy for accessing advanced treatments (Dong & Wang, 2024; Yuan et al., 2023). Recent government efforts in Shandong and nationwide have simplified reimbursement procedures and harmonized benefits for both local and non-local patients, further driving this utilization trend (Tian et al., 2025; Zhang & Zhang, 2022). However, this trend creates financial pressures within the provincial healthcare ecosystem: patients may face significantly higher direct medical costs and ancillary living expenses (e.g., travel, accommodation) when accessing higher-tier hospitals; simultaneously, the influx of cross-regional patients siphons off

patient volumes from local primary hospitals, leaving the former overwhelmed by excessive caseloads while the latter face operational sustainability challenges and existential crises (Li & Li, 2019; Wang et al., 2022; Zhao et al., 2024). Given Shandong's status as a populous province with a tiered medical system representative of many developing regions in China, a comprehensive understanding of the link between cross-regional utilization and hospitalization costs is therefore vital. It offers critical insights for informing policies that balance system efficiency with equity, not only for Shandong but for similar provinces navigating the tensions between resource concentration and patient mobility.

Several studies have compared hospitalization costs between cross-regional and regional healthcare utilization, but their findings require cautious extrapolation to China due to contextual differences. A study conducted in Poland revealed that the hospitalization costs for cross-regional healthcare utilization witnessed an annual increase from 2013 to 2017 (Tarkowski et al., 2019). Berta et al. (2021) went a step further by comparing the healthcare costs between regional patients and those seeking cross-regional healthcare in Italy. They found that the promotion of cross-regional healthcare utilization led to an increase in out-of-pocket costs for both regional and cross-regional patients. Notably, China's healthcare context differs substantially from those of these countries, which may shape distinct cost dynamics of cross-regional care. Unlike patient mobility in many international settings, primarily driven by gaps in insurance coverage or prolonged waiting times for medical services, cross-regional healthcare-seeking in China is shaped by severe geographic maldistribution of medical resources, instead of an insurance gap due to universal health coverage (UHC) (Chen et al., 2021; Dong & Wang, 2024). High-tech and high-quality services tend to be concentrated in high-level hospitals located in big cities (Li et al., 2018; Ren et al., 2023). A recent study by Yan et al. using the healthcare utilization data of Hefei residents in China reported that policies encouraging cross-regional healthcare utilization managed to reduce costs in China's top 100 hospitals but not in other hospitals (Yan et al., 2022). However, existing evidence in China remains scarce.

This study addresses critical research gaps by examining the association between cross-regional healthcare-seeking and hospitalization costs in Shandong, China, based on a large-scale dataset. We further explored potential explanatory factors to identify actionable strategies for curbing avoidable costs in cross-regional care. By bridging these evidence gaps of Shandong's healthcare ecosystem, this research contributes to promoting equitable healthcare access while supporting sustainable cost containment and system-efficient policies. It yields insights that are directly applicable to Shandong and highly relevant to other Chinese provinces facing similar challenges of resource concentration and patient mobility.

2. Materials and Methods

2.1. Study population

This study cohort was sourced from the hospitalization datasets housed in the Cheeloo Lifespan Electronic Health Research Data Library (Cheeloo LEAD). A three-stage cluster random sampling approach was adopted to select a sample of 5 million residents across 136 counties in Shandong Province, a region with an overall

population of 101 million. To compile a comprehensive dataset for this cohort, researchers integrated electronic medical records, public health archives and social health insurance records. This integration allowed for the collection of diverse information, covering healthcare service utilization patterns, associated expenditure details and various influencing factors. The data integration process was executed by matching each participant's unique individual identification number and admission time points as core indexing criteria. Details regarding the study design and sampling procedure could be obtained from http://www.mhdata.sdu.edu.cn/cheeloolead.htm and in previously published studies (Du et al., 2021; Li et al., 2022; Zhao et al., 2022). Moreover, a detailed breakdown of the sampling workflow and the demographic traits of the study cohort is provided in Figure S1 of the Supplementary Materials. The study was approved by the Ethics Committee at Shandong University School of Public Health (No. Ll20220610).

We analyzed hospitalization records from 2015 to 2017 for the study cohort. The dataset included clinical and financial details such as the names and codes of diagnosed conditions, length of stay (LOS), and hospitalization costs. The addresses of each hospital were gathered from official registration records. Additionally, individual demographic information, permanent residence, and socioeconomic statuses of the patients were determined based on their public health records. The initial extraction yielded 2.27 million hospitalizations involving 1,172,425 unique individuals. After excluding the records that contain logical errors and missing values regarding hospitalization expenditure, the sample size was reduced to 1,608,846. To account for contextual influences, we linked each record to city-level indicators of healthcare capacity, economic development, and urban size, sourced from the *Shandong Statistical Yearbook* and China's 2014 Urban Size Classification Standards (General Office of the State Council, 2014). After further excluding the records with missing values on covariates related to cross-regional healthcare-seeking, the final sample size was 1,299,551.

2.2. Measurements

In China's city-based health governance system, cross-regional healthcare-seeking is defined as receiving inpatient care outside one's city of residence. Building upon this definition, specific types were identified by considering the hierarchical healthcare system and city scale. Hospitals were stratified into primary, secondary, and tertiary levels based on the hierarchical healthcare system. Primary hospitals are characterized by their large quantity yet relatively low technical capabilities. In contrast, tertiary hospitals are furnished with high-tech medical devices and staffed with high-level medical personnel. Moreover, tertiary hospitals are predominantly distributed in big cities with larger population sizes. Destination cities were categorized according to the State Council's 2014 Urban Scale Classification Standards: Type-II large cities (population under 3 million; e.g., Binzhou, Dongying), Type-I large cities within Shandong Province (population exceeding 3 million; e.g., Jinan, Qingdao), and major national centers outside the province (e.g., Beijing, Shanghai). Given that larger urban centers generally entail higher non-medical costs, such as accommodation and transportation (Zhang et al., 2022), we constructed five

mutually exclusive categories of cross-regional hospitalization by crossing hospital tier with city type: (i) care at primary or secondary facilities in Type-II or smaller cities; (ii) care at primary or secondary facilities in Type-I or larger cities within the province; (iii) care at tertiary hospitals in Type-II or smaller cities; (iv) care at tertiary hospitals in province-internal Type-I cities; and (v) care at tertiary hospitals in major cities outside the province.

The primary outcome of this study was total hospitalization cost, defined as the sum of all medical expenditures incurred during an inpatient stay, including charges for medications, surgical procedures, diagnostic tests, and other clinical services. To address the right-skewed distribution typical of healthcare cost data, we used the natural logarithm of total costs in all analytical models.

A set of variables was constructed to capture patient characteristics, residential context, healthcare setting, and clinical conditions. Individual attributes included age, sex, urban or rural residence, and season of hospital admission. At the city level, per capita GDP, hospital beds per 1,000 population, and health technicians per 1,000 population were used to reflect local socioeconomic status and healthcare resource availability. The healthcare delivery setting was characterized by the tier of the admitting hospital and the administrative scale of the destination city. Clinical conditions were represented by LOS and primary diagnosis, with diagnoses grouped into 21 categories according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10). Detailed variable definitions and category codes are provided in Supplementary Table S1.

2.3. Statistical analysis

A recursive system model with three equations was constructed to examine the sequential associations among cross-regional healthcare-seeking behaviors, LOS and hospitalization costs for patients, which is characterized by unidirectional causal ordering and no bidirectional correlations between endogenous variables. (1) The first equation was employed to predict the association of each covariate with the presence of cross-regional healthcare-seeking. (2) The second equation was used to predict "length of stay", conditional on the first equation. (3) The third equation was further applied to predict whether cross-regional healthcare-seeking and the LOS would have an impact on hospitalization costs. The resulting recursive system model can be represented as follows:

$$\begin{cases} CH = \alpha_1 + \beta_{11i}\mathrm{age}_i + \beta_{12}\mathrm{male} + \beta_{13}\mathrm{urban} + \beta_{14j}ICD_j + \\ \qquad \beta_{15r}season_r + \beta_{16}GDP + \beta_{17}Beds + \beta_{18}HCP + \beta_{19}year_t \\ lnLOS = \alpha_2 + \beta_{2i}age_i + \beta_{22}male + \beta_{23}urban + \beta_{24j}ICD_j + \\ \qquad \beta_{25}season_r + \beta_{26p}HGrade_p + \beta_{27}private + \beta_{28q}CLevel_q + \\ \qquad \beta_{29}year_t + \varepsilon_{21}CH \\ lnHCost = \alpha_3 + \beta_{3i}age_i + \beta_{32}male + \beta_{33}urban + \beta_{34j}ICD_j + \\ \qquad \beta_{35}season_r + \beta_{36p}HGrade_p + \beta_{37}private + \beta_{38q}CLevel_q + \\ \qquad \beta_{39}year_t + \varepsilon_{31}CH + \varepsilon_{32}lnLOS \end{cases}$$

In the system of simultaneous equations, the three dependent variables *CH*,

lnLOS, and *lnHCost* represent the presence of cross-regional healthcare-seeking, LOS (log), and hospitalization cost (log), respectively. ICD_j is the *j*th disease category in the ICD-10 disease classification. $HGrade_p$ and *private* represent the level and ownership of the hospital. $CLevel_q$ is a categorical variable of city scale. The study period 2015–2017 was a transitional stage during which China's National Direct Settlement System was piloted and gradually promoted. To control for the potential confounding effects of this important institutional reform, we have included year fixed effects in all regression models to capture nationwide policy shocks and time-varying changes. We also conducted robustness checks by estimating regressions for each year separately. In addition, this study used a similar two-stage recursive system model to explore the impact path of types of cross-regional healthcare-seeking on hospitalization costs.

The model assumes a unidirectional path from cross-regional healthcare-seeking to LOS to hospitalization costs. Theoretically, if patients anticipated higher costs or longer LOS associated with cross-regional care, such expectations could drive their decision to seek care elsewhere, thereby creating a simultaneous relationship. To solve the bias, we conducted an additional sensitivity analysis to test whether the expectation of higher costs or longer treatment duration predicts cross-regional healthcare-seeking. Since actual LOS and costs are post-treatment outcomes unknown to patients' ex-ante, we constructed proxy variables for "expected treatment burden" at the diagnosis-category level. Our procedure was as follows:

Construction of Proxies: The study calculated the average LOS and average hospitalization costs for each specific diagnosis category observed in out-of-region hospitals. Crucially, the individual's own record was excluded from these calculations to avoid endogeneity.

Data Merging: The study merged these "expected" values back to the individual level based on each patient's diagnosis category.

Regression Analysis: The study fitted a logistic regression model with fixed effects, where the dependent variable was the binary choice of seeking cross-regional care (Yes/No). The model controlled for diagnosis categories (as fixed effects), along with individual demographics (age, sex, and insurance type) and year fixed effects. To account for potential correlation of errors within the same city, the study clustered standard errors at the city level.

Furthermore, to correct for potential sample selection bias arising from the fact that cross-regional healthcare-seeking is a self-selected behavior (i.e., not all patients with the potential need ultimately opt for such services), the study employed a two-stage Heckman Selection Model (HSM) to assess the association between cross-regional healthcare-seeking and hospitalization costs.

In the first stage (selection equation), a probit regression was performed to estimate the probability of patients engaging in cross-regional healthcare-seeking. Covariates included in this stage were carefully selected for their ability to directly predict care-seeking behavior while having no direct impact on hospitalization costs. To validate the model's stability, a sensitivity analysis was conducted: one covariate was excluded from the selection equation at a time, and the model was re-estimated. Results showed that the coefficients of the Inverse Mills Ratio (IMR), a metric quantifying potential selection bias, remained statistically significant ($p < 0.001$)

across all iterations, confirming the robustness of the selection equation.

In the second stage (outcome equation), the IMR (derived from the first-stage probability estimates) was incorporated into the linear regression model for hospitalization costs. This adjustment effectively mitigates unobserved selection bias, ensuring that the estimated association between cross-regional healthcare-seeking and hospitalization costs is not confounded by unmeasured factors that simultaneously influence both care-seeking decisions and cost outcomes (e.g., unmeasured family support for cross-regional travel).

Finally, we used 2021–2024 data from Weifang's "Three-Medical Integration Data Sharing Platform". This recent data could validate and supplement our findings, confirming their robustness. Weifang is a major prefecture-level city in Shandong Province with a permanent resident population of approximately 9.38 million (Shandong Provincial Bureau of Statistics, 2021). It ranks among the top-tier cities in the province by population size. This vast demographic base, coupled with its multi-tiered healthcare system, makes it an ideal case study for analyzing medical resource allocation and patient mobility.

This study used R 4.2.0 for the statistical analysis. The map of the sources and destinations of cross-regional healthcare-seeking was created using ArcMap 10.7 software. The significance level for all statistical analyses was set at 0.05.

3. Results

3.1. Statistical description of cross-regional healthcare-seeking in Shandong, China

Among the 2.27 million hospitalizations involving 1,172,425 patients, the mean age was 50.0 years (SD = 26.7), and 56.0% were female. **Tables 1** and S2 compare the characteristics of patients who received care within their region with those who sought cross-regional healthcare. Patients using cross-regional services tended to be younger, more likely to be male, and more frequently diagnosed with cancer. In addition, they also showed a stronger preference for tertiary and public hospitals. The spatial distribution of destination hospitals among cross-regional users (Figure S2) reveals that most patients resided in smaller cities but traveled to larger urban centers to access tertiary care, a pattern further illustrated in Figure S3. On average, hospitalization costs were higher for cross-regional healthcare users.

Table 1. Characteristics of Patients by Healthcare-Seeking Region.

Variables	No. (%)		*p*
	Local care *n* = 1,539,003	Cross-regional care *n* = 69,843	
Age group			
0–14 years old	187,032 (12.16)	7534 (10.79)	<0.001[a]
15–44 years old	357,708 (23.25)	18,267 (26.15)	
45–64 years old	493,927 (32.11)	28,409 (40.68)	
≥65 years old	499,574 (32.48)	15,633 (22.38)	
Male	672,688 (43.73)	34,195 (48.96)	<0.001[a]

Urban areas	763,206 (49.62)	28,417 (40.69)	<0.001[a]
Season			
Spring	421,435 (27.40)	19,299 (27.63)	<0.001[a]
Summer	398,679 (25.92)	19,137 (27.40)	
Autumn	353,828 (23.00)	15,746 (22.54)	
Winter	364,299 (23.68)	15,661 (22.42)	
The level of the hospitalized medical institutions			
Primary hospital	281,675 (18.31)	3696 (5.29)	<0.001[a]
Secondary hospital	548,949 (35.69)	9756 (13.97)	
Tertiary hospital	707,617 (46.00)	56,391 (80.74)	
Ownership of the hospitalized medical institutions			
Public hospital	1,401,174 (91.09)	67,148 (96.14)	<0.001[a]
Private hospital	137,067 (8.91)	2695 (3.86)	
City level			
Big cities	381,778 (24.81)	41,847 (59.92)	<0.001[a]
Small cities	1,157,225 (75.19)	27,996 (40.08)	
LOS (days), Median (IQR)	7 (7)	7 (8)	<0.001[b]
Hospitalization costs (CNY), Median (IQR)	4908.14 (6146.00)	10,193.15 (17073.75)	<0.001[b]
Per capita GDP, Mean (SD)	8.27 (3.51)	7.25 (4.05)	<0.001[c]
Hospital beds per 1000 population, Mean (SD)	5.66 (0.64)	5.39 (0.68)	<0.001[c]
Healthcare technicians per 1000 population, Mean (SD)	6.87 (1.16)	6.41 (1.06)	<0.001[c]

Abbreviations: ICD International Classification of Diseases, LOS length of stay, CNY Chinese Yuan, GDP Gross Domestic Product, IQR interquartile range, SD standard deviation.
Note: [a] *p* was obtained by χ^2 test; [b] *p* was obtained by Mann-Whitney U test; [c] *p* was obtained by One-Way ANOVA. Means and standard deviations for normally distributed variables, while frequencies and percentages for dichotomous variables, were described.

3.2. Associations between cross-regional healthcare-seeking and hospitalization costs

Table 2 shows that cross-regional healthcare-seeking was associated with 34% higher hospitalization costs (β = 0.34; 95% CI: 0.33 to 0.34). In the HSM results, cross-regional healthcare-seeking continued to be positively and significantly associated with hospitalization costs, but the effect size was stronger (β = 0.77; 95% CI: 0.73 to 0.80). Relative to regional care, hospitalization costs varied substantially across cross-regional healthcare-seeking patterns. Healthcare-seeking at primary or secondary hospitals in smaller (Type-II) cities was associated with 8.1% reduction in hospitalization costs (β = −0.08; 95% CI: −0.10, −0.07), demonstrating that convenience-driven complementary care did not increase expenditure. Conversely, hospitalization costs for care at province-external tertiary hospitals in major cities nearly tripled (β = 1.12; 95% CI: 1.10, 1.14). Intermediate cost increases emerged at: (1) province-internal Type-I city tertiary hospitals (β = 0.83; 95% CI: 0.82 to 0.84), and (2) primary or secondary hospitals in Type-I cities or larger (β = 0.65; 95% CI: 0.61 to 0.69), suggesting a clear cost gradient where higher-tier hospitals and major interprovincial destinations predicted disproportionate expenditure escalation. When

the results were stratified by year, the results continued (Supplementary Table S3). In addition, our reverse test found that expected burden, a strong proxy for clinical severity, did not predict cross-regional care-seeking. This supports the main results, suggesting that the associations are not fully attributable to unmeasured severity and the validity of the recursive system model (Supplementary Tables S4 and S5).

Table 2. Association between cross-regional healthcare-seeking and hospitalization costs.

Variables	Coefficient	95% CI
Association between cross-regional healthcare-seeking and hospitalization costs using recursive system model		
Cross-regional healthcare-seeking	0.338***	0.332, 0.343
Association between cross-regional healthcare-seeking and hospitalization costs using HSM		
Cross-regional healthcare-seeking	0.765***	0.729, 0.800
IMR	−0.184***	−0.201, −0.167
Association between different types of cross-regional healthcare-seeking and hospitalization costs		
Primary/secondary hospitals in Type-II cities or smaller	−0.084***	−0.099, −0.070
Primary/secondary hospitals in Type-I cities or larger	0.653***	0.614, 0.692
Tertiary hospitals in Type-II cities or smaller	0.486***	0.473, 0.498
Tertiary hospitals in province-internal Type-I cities	0.831***	0.822, 0.840
Tertiary hospitals in province-external major cities	1.120***	1.104, 1.135

Abbreviations: HSM Heckman Selection Model, IMR Inverse Mills Ratio, CI confidence interval.
Note: *** $p < 0.001$.

Figure 1 illustrates how LOS acted to connect cross-regional healthcare-seeking with hospitalization costs. **Tables 3** and S6 quantify the direct, indirect, and total association for the recursive system, with cross-regional care identified as the second strongest correlate of elevated costs, following LOS. In addition to its direct association, cross-regional care was also indirectly associated with increased costs by prolonging LOS. Crucially, LOS exhibited distinct co-variation patterns with costs across care-seeking scenarios: positive associations between LOS extension and higher costs were observed for care in Type-I or larger-city primary/secondary hospitals, Type-II or smaller-city tertiary hospitals, and province-internal Type-I city tertiary hospitals; conversely, shorter LOS was statistically associated with reduced costs for province-external major-city tertiary hospitals and Type-II or smaller-city primary/secondary hospitals, compared with regional care.

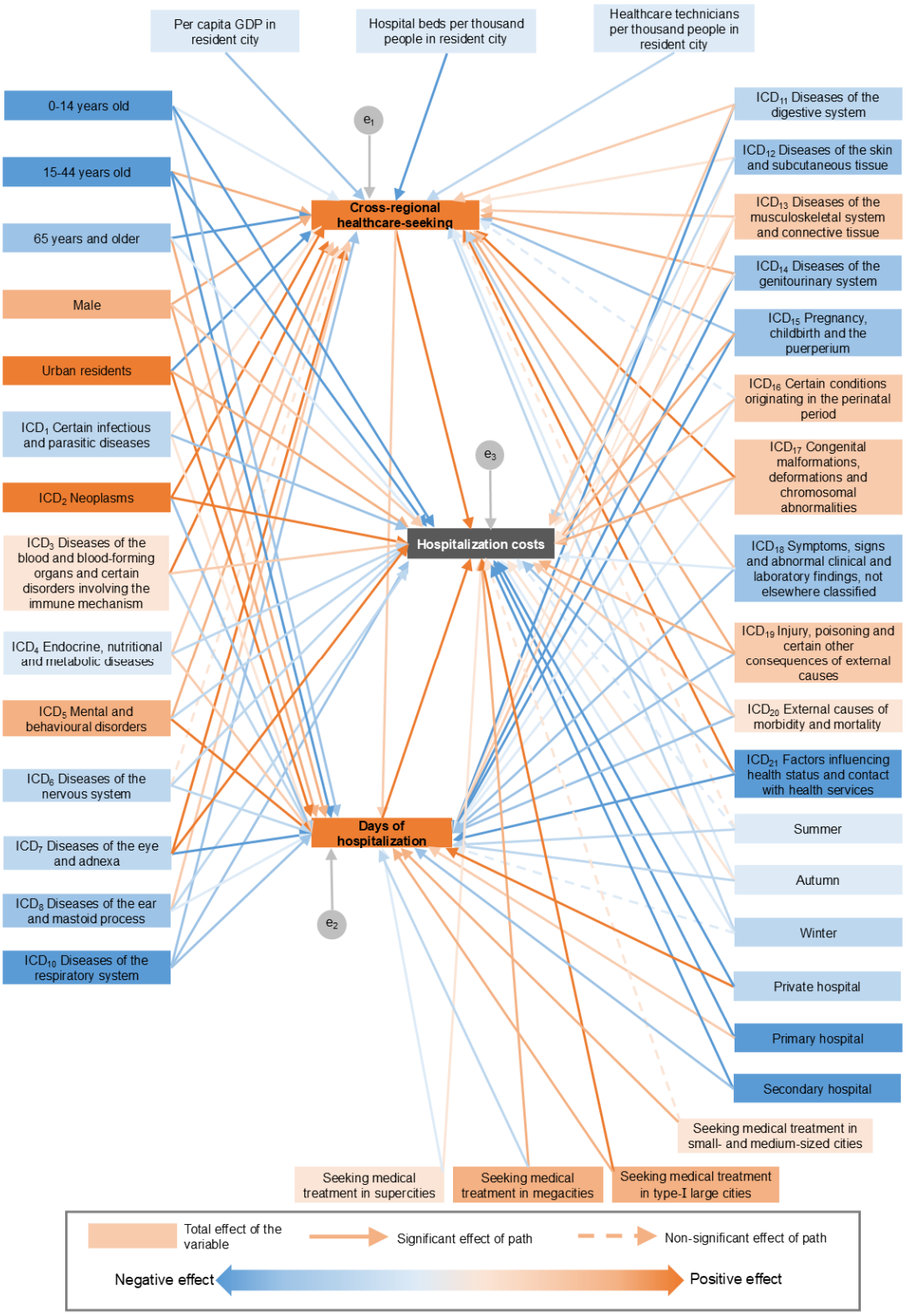

Figure 1. Path diagram of factors influencing hospitalization costs. Note: The color indicates the direction and magnitude of the effect. Specifically, orange represents a positive effect, indicating that the pathway is linked to higher values of the corresponding endogenous variable, while blue represents a negative effect. The darker the color, the larger the standardized coefficient of the pathway. The background color of the variable names indicates the total effect's direction and relative magnitude of that variable on hospitalization costs through all pathways.

Table 3. Direct, indirect, and total association of influencing factors on hospitalization costs.

Variables	Linking cross-regional healthcare-seeking to hospitalization costs				Linking types of cross-regional healthcare-seeking to hospitalization costs			
	Direct effect	Indirect effect	Total effect	Rank	Direct effect	Indirect effect	Total effect	Rank
Natural log of LOS	0.46	–	0.46	1	0.45	–	0.45	1
Cross-regional healthcare-seeking	0.069	0.0115	0.081	2	–	–	–	–
Tertiary hospitals in province-internal Type-I cities	–	–	–	–	0.113	0.013	0.126	3
Tertiary hospitals in province-external major cities	–	–	–	–	0.09	−0.0019	0.088	5
Tertiary hospitals in Type-II cities or smaller	–	–	–	–	0.049	0.0067	0.055	7
Primary/secondary hospitals in Type-I cities or larger	–	–	–	–	0.021	0.0034	0.024	13
Primary/secondary hospitals in Type-II cities or smaller	–	–	–	–	−0.01	−0.0007	−0.01	22

Abbreviations: LOS, length of stay.

3.3. Associations between cross-regional healthcare-seeking and hospitalization costs: evidence from Weifang city

Between 2021 and 2024, Weifang recorded 400,338 cross-regional inpatient visits and 7,531,310 local inpatient visits. Among cross-regional inpatients, 32.58% were aged ≥ 60 years old. Males accounted for 49.82% of cross-regional inpatient visits.

The LOS for cross-regional inpatients and local inpatients was 7.70 days (IQR: 7.10) and 9.32 days (IQR: 8.34), respectively. The median cost for cross-regional inpatients was CNY 20,776.61 (IQR: 24,576.55), higher than the local inpatients, with cross-regional costs approximately 2.7 times higher. This cost disparity aligns with the structural pattern identified in the 2015–2017 study (Table S7). After adjusting for potential confounders, cross-regional healthcare was significantly associated with higher hospitalization costs ($\beta = 0.367$, 95% CI: 0.358–0.389) (Table S8). Temporary cross-regional inpatients showed a clear preference for tertiary hospitals. It indicated that local high-quality care resources had a persistent gap, and patients sought medical services in resource-rich regions (Table S9). Descriptive statistics and regression analysis mutually validated the core findings. Resource-driven cross-regional healthcare-seeking and higher hospitalization costs show a close association.

4. Discussion

Based on 2.25 million hospitalization records from Shandong Province, China, this study reveals novel findings on the cost implications of cross-regional care. Particularly, patients seeking tertiary care in out-of-province metropolitan centers were associated with 34% higher levels of hospitalization costs overall, but with substantial heterogeneity across healthcare-seeking types in Shandong, China. Specifically, seeking tertiary care at out-of-province metropolitan centers was linked to the highest cost surge, higher than local care, while accessing primary or secondary hospitals in adjacent smaller cities was associated with an 8.1% cost reduction. Part of

the association between cross-regional healthcare-seeking and hospitalization costs was aligned with prolonged LOS as an intermediary link, with this pattern absent in interprovincial tertiary care.

4.1. Cross-regional healthcare-seeking was associated with increasing hospitalization costs

Cross-regional healthcare-seeking was associated with an increase in the hospitalization costs within Shandong, China, ranking as the second strongest factor linked to higher hospitalization costs in this region. The results were generally in line with prior results obtained in Poland and non-top 100 hospitals of Hefei, China (Tarkowski et al., 2019; Yan et al., 2022). However, the results contrasted with the association found in Italy and the top 100 hospitals in Hefei, China (Fattore et al., 2014; Yan et al., 2022). The divergence in the results may be partly due to the specific composition of cross-regional flows in Shandong. A pivotal finding of this study identified high-tech tertiary care in out-of-province metropolitan hospitals as the most cost-intensive type of cross-regional care-seeking for Shandong residents. Patients utilizing such services were associated with higher hospitalization costs compared to those seeking regional care. Conversely, among Shandong patients, minimal cost differences emerged between regional and cross-regional care when patients accessed primary or secondary facilities in smaller cities.

Our study period (2015–2017) coincided with the implementation of China's National Direct Settlement System. We controlled for macro-level policy effects using year fixed effects. During this time, reforms mainly focused on simplifying cross-regional reimbursement and creating a relatively stable policy environment. This makes the 2015–2017 period well-suited for our analysis. In contrast, later years saw multiple overlapping policy changes, such as the introduction of DRG/DIP payment systems. This earlier stability allows us to isolate and examine the core patterns of cross-regional care. Furthermore, the fundamental drivers of cross-regional healthcare seeking remain unchanged. Recent policies have not resolved the geographic maldistribution of high-quality medical resources, which was identified in our study as the primary driver. These resources are still concentrated in tertiary hospitals in major cities. Therefore, the structural factors we describe likely remain relevant even under newer reforms, including prospective payment systems. We obtained similar results using 2021–2024 data from Weifang, which supports the reliability of our findings.

This observation aligns with the analytical framework developed by Laugesen and Vargas-Bustamante (2010), which are originally formulated in European contexts, but reveal distinct characteristics within the Shandong setting. As defined by the authors, the duplicative type refers to patients who choose cross-regional healthcare services that duplicate or supplement local care at the expense of higher costs, in order to access more intensive and high-technology medical treatment. This type of care has been consistently associated with substantial cost increases. This phenomenon is rather prevalent in China, driven by the unequal distribution of medical resources. High-intensity healthcare services tend to be concentrated in high-level hospitals located in major cities (Cai et al., 2019; Zhang et al., 2017). Tertiary hospitals, in particular, are

equipped with advanced medical devices and staffed by senior medical professionals, and they are predominantly distributed in large, populous cities (Sun & Luo, 2017; Zhang et al., 2015). While this is a national trend, the specific flow of Shandong patients toward hubs like Beijing, Jinan, and Qingdao exacerbates local cost pressures. For instance, Beijing is home to 81 tertiary hospitals, whereas some small cities within and surrounding Shandong may not have a single one (National Health Commission, 2018). This disparity motivates many Shandong patients to travel to large cities for tertiary care. Critically, tertiary hospitals in major cities also feature the highest service prices and the lowest medical insurance reimbursement rates (Li & Chen, 2023). Collectively, these factors mean that interprovincial cross-regional care at tertiary hospitals tends to be associated with the highest hospitalization costs for the Shandong healthcare system.

Notably, while Laugesen and Vargas-Bustamante's typology is groundbreaking, it lacks empirical evidence from countries with UHC. In their analytical framework, complementary care is defined as the utilization of nearby healthcare services when local care becomes inaccessible owing to limitations in local insurance coverage for such services (Laugesen & Vargas-Bustamante, 2010). By contrast, this scenario is rare in Shandong, China, a context characterized by the implementation of UHC. While Shandong patients do engage in cross-regional healthcare-seeking by accessing primary or secondary hospitals in adjacent cities, this behavior is associated with considerations of convenience-stemming from the closer geographic proximity of these facilities to their residences-rather than insurance-related barriers (Zhang et al., 2017). This form of cross-regional care in Shandong can enhance healthcare equity without increasing overall costs. Our study extends their typology by testing and refining its applicability in UHC systems, using Shandong as a representative case to develop context-specific estimations.

4.2. LOS as a link between cross-regional healthcare-seeking and hospitalization costs

While shortening the LOS is widely considered a viable strategy for reducing hospitalization costs (Gonçalves-Bradley et al., 2017; Yin et al., 2019), this study empirically a heterogeneous association specific to the cross-regional landscape in Shandong. Our analysis reveals that LOS reduction was statistically linked to lower costs for cross-regional patients accessing primary or secondary hospitals in major metropolitan areas or provincial-level tertiary hospitals. In these settings, cross-regional patients exhibited significantly prolonged LOS compared to regional users, which directly contributed to their elevated hospitalization expenditures. However, LOS diverges for interprovincial tertiary care. Here, LOS did not explain the massive cost surge observed. Notably, cross-regional patients in these facilities recorded the shortest LOS among all cohorts, even shorter than regional users. This counterintuitive finding suggests that extreme financial and logistical burdens (e.g., non-reimbursable accommodation, familial separation, travel costs) may compel patients to aggressively minimize hospitalization duration despite severe conditions.

4.3. Policy implications

This study provides empirical evidence on the relationships among cross-regional healthcare-seeking, LOS, and hospitalization costs during the early stage of China's health insurance reform. While some policy directions, including hierarchical diagnosis and treatment, regional referral cooperation, and differentiated reimbursement policies, have been implemented in practice, this study proposes targeted refinements to optimize these existing frameworks based on our empirical findings on the heterogeneous drivers of cost and the paradoxical role of LOS.

First, current cross-regional policies often treat all cross-regional healthcare-seeking similarly, creating barriers even for efficient care-seeking in adjacent cities. Our analysis identifies that cross-regional care in adjacent primary/secondary facilities was driven by convenience and not associated with increasing cost, whereas interprovincial tertiary care is the primary cost driver. Accordingly, we propose the establishment of Cross-Border Municipal Health Zones, in which care received in adjacent regions is recognized as local care and eligible for zero-differential reimbursement.

Second, prospective payment system reforms universally incentivize shorter LOS to reduce costs. Crucially, our pre-reform data reveal a paradox: interprovincial patients in top-tier hospitals have the shortest LOS but the highest costs. Payment reforms should not penalize hospitals for longer stays. Instead, they should support transitional care coordination. For example, reforms could cover post-acute stabilization days. This approach mitigates the unintended consequence of current reforms, which risk prematurely discharging vulnerable mobile patients (Li et al., 2023; Rasooly et al., 2022).

4.4. Contributions and limitations

This study pioneers the exploration of the relationship between cross-regional care-seeking behavior and hospitalization costs in Shandong, China. It expands existing evidence on health services utilization within UHC systems. By identifying distinct cost patterns across different cross-regional healthcare-seeking, this research offers evidence-based insights for policymakers to optimize resource allocation, control undue cost escalation, and maintain equitable access to care.

However, our study has several limitations. First, the research area is confined to Shandong Province, China. As a result, when applying the findings to other populations, caution should be exercised. Notably, Shandong is a large province with a population of over 100 million, and its eastern-to-western gradient in economic development, sociodemographic structure, and health service resources resembles, to some degree, the national pattern of China. Nevertheless, Shandong is relatively economically advanced, with high household income and strong health system capacity. The observed patterns of cross-regional care, especially the magnitude of patient outflow and associated cost increases, may be more pronounced than in less developed provinces in central and western China. As such, the generalizability of our quantitative estimates to the national level is constrained, even though the underlying behavioral and systemic mechanisms may be broadly informative.

Second, although our sensitivity analyses (incorporated hospital-level factors and

disease type, reverse-causality tests and Heckman selection models) suggest that the observed associations are robust, we acknowledge that residual confounding by unmeasured disease severity or simultaneous decision-making processes cannot be entirely ruled out in this observational study.

Third, the study used 2015–2017 data, a stable period that helps isolate core patterns of cross-regional care. Comparative analysis with 2021–2024 regional data confirms key relationships persist. However, in the context of recent healthcare reforms, including prospective payment systems, the relationships among cross-regional healthcare-seeking, LOS, and costs may change. Therefore, the applicability of the conclusions to the current policy environment needs to be further verified using newer data. Finally, the mechanism analysis identifies statistical associations rather than strict causal mediation effects. Caution is needed when interpreting the pathway through LOS.

5. Conclusion

This pioneering study, leveraging 2.27 million hospitalizations in Shandong, China, reveals that cross-regional care-seeking was associated with increased hospitalization costs, with the steepest increases occurring among patients accessing tertiary care in out-of-province metropolitan centers. Our analysis uncovers a critical divergence in cost drivers: LOS variations partially explain costs for patients accessing primary/secondary facilities or provincial-level tertiary hospitals, where cross-regional patients often exhibit prolonged stays. Nevertheless, LOS does not account for the sharply higher costs in major interprovincial hospitals. Collectively, by proposing differentiated governance strategies tailored to these heterogeneous cost drivers, this study provides a strategic basis for reconciling equity and efficiency within China's cross-regional healthcare systems.

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