The influence of cross-regional medical treatment on total medical expenses, medical insurance payments, and out-of-pocket expenses of patients with malignant tumors in Chinese low-income areas

Bokai Zhang1†, Haixin Wang1†, Hongyu Zhang1†, Guomei Tian2†, Ting Zhang1, Qi Shi1, Jian Liu1, Jinpeng Xu1, Jingchu Liu3, Qunhong Wu1 and Zheng Kang1*

Abstract

Background: In recent years, due to the increasing number of cross-regional medical patients, countries around the world have issued a series of policies or regulations to reduce their out-of-pocket burden. In this context, this study intended to explore the impact of the Spatio-temporal characteristics of cross-regional medical treatment on total medical expenses, medical insurance payments, and out-of-pocket expenses of patients with malignant tumors in low-income areas.

Methods: This study included 54,904 data of cross-provincial medical treatment of malignant tumor patients insured in Heilongjiang Province, China in 2020. Firstly, Microsoft Excel 2019 and ArcGIS 10.2 were applied to conduct a descriptive analysis of the Spatio-temporal characteristics of their cross-provincial medical treatment. Then, binary and multivariate logistic regression models were used to explore the specific impact of economic level and geographical distance of medical regions on total medical expenses, medical insurance payments, and out-of-pocket expenses.

Results: The number of cross-regional medical patients showed a gradual upward trend from February to December, and fell back in January. They were concentrated in regions with high economic level and short distance from the insured region, where were more likely to form the group with high out-of-pocket expenses (AOR = 3.620, \(P < 0.001\); AOR = 1.882, \(P < 0.001\)). While this possibility in middle-distance medical regions were less (AOR = 0.545, \(P < 0.001\)). Afterwards, two sensitivity analysis methods showed that the results were robust.

Conclusion: The number of cross-regional medical patients with malignant tumors in low-income areas is affected by seasonal factors, meanwhile, their total medical expenses, actual medical insurance payment levels, and out-of-pocket expenses are all affected by the economic level and geographical distance of medical regions. And the
Background

In recent years, there have been increasing studies on universal health coverage, and the coverage rate of medical insurance has also improved worldwide [1, 2]. However, there are still some differences in the payment level of medical insurance between countries or regions [3, 4]. This is related to the influence of local political, economic, demographic, and other factors on medical insurance policies, which makes it unable to achieve uniform financing and payment standards [5, 6]. When the insured goes beyond the insured region of medical treatment, their compensation policies will change, which may be the change of reimbursement catalogue or reimbursement ratio, or even they cannot get compensation. Therefore, this study introduced the concept of trans-regional medical treatment, that is, the insured go to regions other than the insured region for medical treatment, where the insured region refers to the maximum scope of the insured's medical insurance payment policies that will not change, which can be a city, province, state, or even a country, for example, the English National Health Service (NHS) [7]. In the European Union (EU) and China, although there are European Health Insurance Card (EHIC) and universal health insurance plan respectively, due to the differences in social health insurance policies between member states or provinces, neither of them is fully integrated [8–10]. Therefore, the cross-border medical treatment in Europe is similar to the trans-provincial medical treatment in China, both of which are common cross-regional medical treatments.

Since the twenty-first century, relevant survey results show that the demand for cross-regional medical treatment is increasing [11, 12]. There may be two reasons for this. On the one hand, with the global economic development, cultural integration, and climate change, more and more people choose to work, study or settle down in other regions. The concept of a global village has gradually become a reality, resulting in the continuous increase of population migration and mobility [13–16]. It is worth noting that, although both refer to the geographical or spatial movement of population between two regions, the former usually involves a permanent change in residence or nationality, which naturally leads to a change in the insured region [17]. The latter is related to China's household registration system, which generally refers to the separation of households, and their residence temporarily changes, but their household registration and insured region remain unchanged [18], such as migrant workers, office workers on business trips, and “migratory birds” population. According to the definition of cross-regional medical treatment in this study, people whose regions of residence are different from their insured regions form the first type of cross-regional medical treatment group when they seek medical treatment in their regions of residence, which can be called unplanned cross-regional medical treatment. On the other hand, due to the uneven distribution of medical resources and the increasing health needs of people, especially in the border areas or poor areas, where medical resources are relatively backward, people choose planned cross-regional medical treatment to seek better medical services [12, 19], such as medical travel and remote referral [20, 21], these fall into the second category known as planned cross-regional medical treatment.

A series of policies and regulations on cross-regional medical insurance payments have been issued to safeguard cross-regional patients’ right to equal access to medical security and relieve their pressure to pay medical expenses in advance. Typical examples include the Regulation (European Community) 883/2004 and the Directive 2011/24/EU of the European Parliament and the Council on the coordination of social security systems [22, 23], and the policy of direct settlement of cross-provincial social medical insurance [24]. They all divide the cross-regional medical treatment into planned and unplanned, and can realize the payment method of the instant medical insurance settlement, but there are differences in the provisions of the insured’s authorization, reimbursement scope, and reimbursement ratio. The advantage of the EU’s cross-border medical treatment policy is that emergency patients who do not plan to seek medical treatment can directly receive medical insurance payments without prior authorization. In addition, due to the different payment principles stipulated in Regulation 883/2004 and the Directive 2011/24, patients can choose the payment path that maximizes the medical insurance compensation according to the actual situation of the inflow country and outflow country reducing the differences in out-of-pocket expenditure caused by the differences in medical service price or reimbursement ratio between insured regions and regions of medical treatment [21].

Keywords: Cross-regional, Patient, Out-of-pocket expense, China
However, Chinese policies require that all patients seeking medical care across provinces obtain prior authorization for direct settlement, and unify requirements of medicare payments according to lists of medical insurance of regions of medical treatment and reimbursement rate of insured regions [21]. This has severe limitations, resulting in unavoidable treatment differences between patients in the same insured region due to different lists of medical insurance of regions of medical treatment [6]. In addition, due to widespread local protectionism, the health care sector has reduced the proportion of payments for some planned cross-regional medical treatment in an attempt to curb the outflow of patients, further exacerbating the differences [25, 26].

At present, the research on cross-regional medical insurance payment mainly focuses on the macro impact evaluation and corresponding countermeasures of existing policies or regulations, paying more attention to regional economic development, health system construction, medical service management and so on [19, 27–30]. Few studies have explored the practical impact of cross-regional medical treatment in the context of current policies from a patient perspective, especially their fairness of medical security and individual out-of-pocket expenses. At the same time, the study noted that malignant tumors may be one of the main diseases for cross-regional medical treatment. This is related to the high epidemiological burden of malignant tumors. On the one hand, the overall incidence of malignant tumors in the whole population is increasing. Previous studies have estimated there were 18.1 million new cancer cases worldwide in 2018 alone, and some studies also point out that the global incidence of cancer is expected to increase substantially over the next decades [31, 32]. On the other hand, according to the Global Burden of Disease Study 2019 (GBD 2019), the mortality rate and disability-adjusted life years (DALYs) of malignant tumors both rank first. Such critical diseases are well characterized by planned cross-regional medical treatment. In addition, malignant neoplasms pose a high disease economic burden, especially for patients in low-income areas, who are also an important group for cross-regional medical care [33–38]. Therefore, this study wants to explore the influence of the temporal and spatial characteristics of cross-regional medical treatment on the total medical expenses, medical insurance payments, and individual out-of-pocket expenses of patients with malignant tumors in low-income areas under the background of China’s current health care policies, providing strong evidence for improving the fairness of medical security for cross-regional medical patients and reducing their direct economic burden of disease.

Methods
Sample selection and data acquisition
To obtain more samples that meet the research conditions, the insured region should have the characteristics of less developed economy, large outflow population, and higher prevalence of malignant tumors. According to the ranking of per capita gross domestic product (PCGDP) and per capita disposable income (PCDI) of Chinese provinces in 2020 given by the National Bureau of Statistics (NBS), Heilongjiang Province (ranking second from the bottom) was an underdeveloped region with a low income level, and its population outflow was the most serious with the highest population loss rate in China, according to the results of the Seventh National Census. At the same time, Heilongjiang Province is located on the northern border of China, with poor weather conditions, relatively backward medical resources, and higher cancer burden [39, 40]. Therefore, Heilongjiang Province was selected as the research area.

By 2020, Heilongjiang Province had fully realized the direct online reimbursement of hospitalization expenses of authorized cross-provincial patients. For patients without the authorization of medical insurance agencies, they need to return to the insured region for manual reimbursement. For patients without the authorization of medical insurance agencies, they need to return to the insured region for manual reimbursement, whose payment scope is consistent with that of local medical treatment, and the reimbursement ratio is reduced by about 20%. Their medical insurance treatment is naturally very low, and will not change due to the difference in medical treatment regions. This is related to controlling unreasonable medical treatment behavior to maintain the balance of medical insurance funds [41]. With the continuous improvement of the direct settlement system of cross-provincial medical treatment, this kind of population will gradually decrease. At the same time, considering the relatively low cancer survival rate in China [42], cross-sectional studies should be conducted to ensure the timeliness of data and reduce sample mixing. Therefore, this study applied to the Heilongjiang Medical Security Service Center for detailed data of cross-provincial direct settlement of medical expenses of insured malignant tumor patients in Heilongjiang Province in 2020 and promised to protect the privacy of patients, and the data was only used for this study. Finally, 54,904 valid data were obtained.
Variable selection and setting

In the database used in this study, the expense part includes the total medical expense and its composition, the amount of various medical insurance payments and out-of-pocket expenses of patients. From the perspective of patients, they do not pay attention to the specific composition of medical expenses or the proportion of medical insurance reimbursement stipulated by policies, but pay more attention to the actual level of medicare payments and the personal out-of-pocket amount that can directly affect their economic burden of disease. Therefore, this study selected three indicators as dependent variables: total medical expenses, actual medical insurance payment level (total medicare payments divided by total medical expenses) and personal out-of-pocket expenses. The first two variables were divided into three grades of low, middle and high according to trisection, which not only met the requirements of statistics but also intuitively showed the relative degree of themselves. The third variable referred to the concept of the group with high medical expenditure in the research on the concentration of medical expenditure, and defined the patients with the top 10% of out-of-pocket expenses as the group with high out-of-pocket expenses [43].

The independent variable of this study was the basic attribute of cross-regional medical regions, which was divided into economic levels and geographical distances from the insured region (divided into three grades based on the nationwide rankings), which are the deep-seated factors affecting population mobility and medical level [44, 45]. Since the database contains little personal information about patients in addition to the above expense information, age (divided into the elderly and non-elderly) and insurance type (divided into urban workers and urban and rural residents) which were known to have a greater impact on the dependent variable were selected as control variables in this study [46, 47]. At the same time, one of the independent variables was controlled and the other was analyzed separately to further reduce factor interference.

Statistical method

This study first applied Microsoft Office Excel 2019 and ArcGIS 10.2 to conduct a descriptive analysis of the temporal and spatial characteristics of the respondents’ cross-provincial medical regions, and then binary and multivariate logistic regression analysis was used to explore respectively the specific impact of economic level and geographical distance of cross-provincial medical regions.

Results

Temporal characters of cross-regional medical treatment in patients with malignant tumors

From 2018 to 2020, the total number of instant medical insurance settlements of cross-provincial medical treatment in Heilongjiang Province had kept increasing, among which the proportion of malignant tumor patients had also kept increasing, reaching 30.0% in 2020, an increase of 11.3 percentage points compared with 2019 (Fig. 1). Patients with malignant tumors have become the main group of cross-provincial medical insurance payments. In 2020, the number of them showed a gradual upward trend from February to December, and fell back in January, with a maximum difference of 5253. The variation trend of total medical expense per time was
basically the same as that of average medical insurance payment per time, but the former changed more obviously from month to month with a slight increase in general, while the latter was relatively stable (Fig. 2).

Spatial characters of cross-regional medical treatment in patients with malignant tumors

In 2020, the cross-provincial medical treatment regions of malignant tumor patients in Heilongjiang Province were mainly distributed in Northeast, North China and southeast coastal areas of China (Fig. 3). In this study, the top 10 regions with the number of patients accounting for 93.3% of total sample were selected to investigate their PCGDPs and distances from insured region among 30 provinces and autonomous regions except Heilongjiang Province and Taiwan Province in China (Table 1), and very 10 rankings were divided into a scale. The results showed that cross-regional medical patients were concentrated in regions with higher economic level and closer to insured region (Fig. 4).

Analysis of the influence of economic levels and distances from the insured region of cross-regional medical regions

In order to control the interaction between independent variables and reduce the confusion, and taking into account the spatial distribution characteristics of samples, this study respectively selected three short-distance medical regions with different economic levels (Beijing, Liaoning and Hebei) and three high economic level medical regions with different distances from the insured region (Tianjin, Zhejiang and Guangdong) to construct an independent logistic regression model. Since the \( p \) values of the parallel line tests of ordered multivariate logistic regression models without adjustment were all less than 0.01, the models failed the test. This study selected disordered multiple logistic regression models for analysis. According to the adjusted model results: when the distances between cross-regional medical regions and the insured region were basically the same, the patients in the medical region with high economic levels were more likely to form higher total medical expenses (AOR = 2.932), lower actual medical insurance payment level (AOR = 2.603), and the group with high out-of-pocket expenses (AOR = 3.620) (Table 2); When the economic levels of cross-region medical regions were similar, the patients in the short-distance medical region were more likely to form lower actual medical insurance payment level (AOR = 5.976) and the group with high out-of-pocket expenses (AOR = 1.882), while the patients in the middle-distance medical region were less likely to form higher total medical expense (AOR = 0.424) and the group with high out-of-pocket expenses (AOR = 0.545) (Table 3).

Sensitivity analysis

This study first conducted sensitivity analysis by adding the covariable length of stay, which may also affect on the dependent variable. The adjusted model results obtained by using the same method were basically unchanged (Tables 4, 5). Subsequently, the patients with lung cancer, which accounted for the largest proportion (23.5%) of the original sample as a single disease, were selected for sensitivity analysis excluding the interference of disease species. The new sample was used to repeat the above modeling steps of this study, and the adjusted model results were basically consistent with the previous
Fig. 3 Cross-provincial medical distribution of malignant tumor patients from Heilongjiang Province in 2020

Table 1 The top 10 cross-provincial medical regions

| Region     | N   | %  | Ranking of PCGDP in 2020 (from high to low) | Ranking of distance from the insured region (from short to long) |
|------------|-----|----|------------------------------------------|---------------------------------------------------------------|
| Beijing    | 15,776 | 28.7 | 1                                        | 5                                                             |
| Tianjin    | 7,960  | 14.5 | 5                                        | 6                                                             |
| Shandong   | 6,591  | 12.0 | 11                                       | 7                                                             |
| Liaoning   | 5,974  | 10.9 | 15                                       | 3                                                             |
| Shanghai   | 4,606  | 8.4  | 2                                        | 11                                                            |
| Hebei      | 3,053  | 5.6  | 27                                       | 4                                                             |
| Guangdong  | 3,023  | 5.5  | 7                                        | 26                                                            |
| Jiangsu    | 1,474  | 2.7  | 3                                        | 10                                                            |
| Zhejiang   | 1,474  | 2.7  | 6                                        | 12                                                            |
| Jilin      | 1,300  | 2.4  | 24                                       | 1                                                             |
| The others | 3,673  | 6.7  | –                                        | –                                                             |
| Variable                      | N   | %   | Total medical expenses (reference = low) | Actual medical insurance payment level (reference = high) | The group with high out-of-pocket expenses |
|-------------------------------|-----|-----|------------------------------------------|----------------------------------------------------------|--------------------------------------------|
|                               |     |     |                                           |                                                          |                                            |
|                               |     |     | Middle                                   | High                                                     | Middle                                    |
|                               | P   | AOR (95% CI) | P   | AOR (95% CI) | P   | AOR (95% CI) | P   | AOR (95% CI) |
| Age                           |     |     |                                           |                                                          |                                            |
| < 60                          | 9819| 39.6| 0.909                                    | 1.004 (0.940, 1.073)                                    | 0.006                                     | 1.098* (1.028, 1.174)                              | < 0.001                          | 1.157* (1.060, 1.264) |
| ≥ 60 (reference)              | 14,984| 60.4|                                           |                                                          |                                            |                                            |                                    |                           |
| Insurance type                |     |     |                                           |                                                          |                                            |
| Urban and rural residents     | 8281| 33.4| 0.173                                    | 0.954 (0.891, 1.021)                                    | 0.124                                     | 0.947 (0.883, 1.015)                               | < 0.001                          | 6.138* (5.672, 6.643)  |
| Urban workers (reference)     | 16,522| 66.6|                                           |                                                          |                                            |                                            |                                    |                           |
| Economic level                |     |     |                                           |                                                          |                                            |
| High                          | 15,776| 63.6| < 0.001                                  | 1.407* (1.286, 1.539)                                   | < 0.001                                  | 2.932* (2.644, 3.250)                              | < 0.001                          | 1.263* (1.151, 1.385)  |
| Middle                        | 5974| 24.1| < 0.001                                  | 2.603* (2.333, 2.904)                                   | < 0.001                                  | 3.166* (2.803, 3.577)                              | < 0.001                          | 1.688* (1.518, 1.878)  |
| Low (reference)               | 3053| 12.3|                                           |                                                          |                                            |                                            |                                    |                           |

This table contained three adjusted logistic regression models and *** indicated significant at the 0.01 level.
analysis results of the full sample, which indicated once again that the results of this study were relatively stable and reliable (Additional file 1: Tables S1, S2).

Discussion
There are seasonal differences in cross-regional medical treatment

According to the temporal characteristics of cross-regional medical treatment in patients with malignant tumors, there were certain seasonal differences in cross-regional medical treatment. This may be related to seasonal characteristics of population mobility and disease incidence [48, 49].

In terms of the number of patients, one year can be divided into four stages: falling period, rapid growth period, transition period, and peak period. Firstly, due to the custom of returning home during the Spring Festival in China, a large number of people temporarily living in other regions went back to their hometowns during the Spring Festival in January and February [50], which may lead to a large decrease in the number of unplanned cross-regional medical patients. After the Spring Festival, people returned to the regions where they used to live due to work, study, and other reasons, forming the return peak, meanwhile, due to the rapid warming of the southern region since March, rural migrant workers in the north gradually left their homes and began to resume work [51, 52]. This would lead to a rapid increase in the number of cross-regional patients in spring (from Feb to Apr). In summer and autumn (from May to Sept), due to more frequent travels, business trips, and other outings, the probability of emergency treatment, hospitalization, and other unplanned medical behaviors in other regions caused by emergencies would increase [53, 54], which would lead to a slight increase in the total number of cross-regional medical patients. Then, the winter in Heilongjiang Province had started from October with a sudden drop in temperature [39, 55]. Although the number of people going out mentioned above would decrease affected by the weather, the long heating season can also lead to a decline in air quality due to a large number of air pollutant emissions [56], which can increase the risk of cancer incidence [57], meanwhile, the harsh climatic conditions in winter would bring some challenges to the sustainable treatment of cancer [58], in addition to the fact that the backward medical resources in the insured region cannot meet the needs of patients for accurate diagnosis and high-quality medical care. Therefore, the planned cross-regional medical treatment of malignant tumor patients increased significantly, resulting in the total number of patients decreased first and then rose rapidly from October to December, and reached the peak at the end of the year.

As can be seen from Fig. 2, although the number of patients was constantly changing, seasonal factors had little influence on the average medical expense per time and the average medical insurance payment amount per time. The monthly fluctuation trends of the two were basically the same, but the fluctuation range of the former was slightly larger, and it generally increased in winter. This phenomenon showed that the medical insurance payment did not respond well to the changes of medical expenses, especially in winter, when the increase of severe diseases may lead to higher treatment expenses, the medical insurance policies had not been timely adjusted, which was likely to increase in the average out-of-pocket expenses of cross-regional patients with malignant tumors.

The patients in cross-regional medical regions with high economic level are more likely to form the group with high out-of-pocket expenses

This survey found that the number of cross-regional medical patients in regions with high economic level accounted for more than 60% of the total sample, and nearly 60% of the short-distance cross-regional medical treatment occurred in areas with high economic level (Table 1). This is because higher economic levels often mean higher income, more employment opportunities, and better medical conditions, which can attract more floating population (unable to obtain household register) and out-of-town patients [37, 44, 59]. However, for patients with malignant tumors, such regions were more likely to form higher total medical expenses and lower actual medical insurance payment levels, thus increasing the possibility of becoming the group with high out-of-pocket expenses (Table 2). This should be the result of the combined influence of the regional economy, medical insurance policies and population mobility. On the one hand, under the influence of the market economy, the higher the regional economic level, the higher the price of medical service, and the threshold line for medical insurance may be [60]. And hospitals with better medical conditions tend to use more high-end medical devices and innovative drugs that are not covered by health insurance or have lower reimbursement rates [61, 62]. If the reimbursement level specified by the policy remains unchanged, the actual payment level will decrease and
Table 3  The influence of distances from the insured region

| Variable                        | N   | %    | Total medical expenses (reference = low) | Actual medical insurance payment level (reference = high) | The group with high out-of-pocket expenses |
|---------------------------------|-----|------|-----------------------------------------|----------------------------------------------------------|------------------------------------------|
|                                 |     |      |                                         |                                                          |                                          |
|                                 |     |      | Middle                                  | High                                                      | Low                                      |
|                                 |     |      | P AOR (95% CI)                           | P AOR (95% CI)                                           | P AOR (95% CI)                           |
| Age                             |     |      | < 60                                     | 6761 54.3                                                | < 0.001 1.373* (1.249, 1.510)            | < 0.001 1.413* (1.284, 1.554)            | < 0.001 1.748* (1.577, 1.937)            | < 0.001 1.675* (1.520, 1.845)          | 0.064 0.886 (0.779, 1.007)             |
|                                 |     |      | ≥ 60 (reference)                         | 5696 45.7                                                | < 0.001 1.745* (1.575, 1.932)            | < 0.001 1.378* (1.220, 1.555)            | < 0.001 1.675* (1.520, 1.845)          | 0.064 0.886 (0.779, 1.007)             |
| Insurance type                  |     |      |                                         |                                                          |                                          |                                          |                                          |                                          |
| Urban and rural residents       | 4696| 37.7 | < 0.001 0.948 (0.865, 1.039)             | < 0.001 0.838* (0.764, 0.919)                           | < 0.001 3.698* (3.334, 4.103)            | < 0.001 1.745* (1.575, 1.932)            | < 0.001 1.378* (1.220, 1.555)            |                                          |
| Urban workers (reference)       | 7761| 62.3 |                                         |                                                          |                                          |                                          |                                          |                                          |
| Distance from the insured region|     |      |                                         |                                                          |                                          |                                          |                                          |                                          |
| Short                           | 7960| 63.9 | < 0.001 0.952 (0.853, 1.062)             | < 0.001 0.102 (0.986, 1.231)                            | < 0.001 5.976* (5.275, 6.771)            | < 0.001 3.114* (2.969, 3.698)            | < 0.001 1.882* (1.598, 2.217)            |                                          |
| Middle                          | 1474| 11.8 | < 0.001 0.498* (0.429, 0.578)            | < 0.001 0.424* (0.362, 0.498)                            | 0.116 0.861 (0.714, 1.038)               | 0.022 1.184 (1.024, 1.368)               | < 0.001 0.545* (0.405, 0.734)            |                                          |
| Long (reference)                | 3020| 24.3 |                                         |                                                          |                                          |                                          |                                          |                                          |

This table contained three adjusted logistic regression models and "*" indicated significant at the 0.01 level.
Table 4  Sensitivity analysis of the models in Table 2

| Variable                  | M/N (P25, P75)/% | Total medical expenses (reference = low) | Actual medical insurance payment level (reference = high) | The group with high out-of-pocket expenses |
|---------------------------|------------------|------------------------------------------|----------------------------------------------------------|------------------------------------------|
|                           |                  | Middle | High                         | Middle | High                         | Middle | High                         | Middle | High                         | Middle | High                         |
|                           |                  | P      | AOR (95% CI)                  | P      | AOR (95% CI)                  | P      | AOR (95% CI)                  | P      | AOR (95% CI)                  | P      | AOR (95% CI)                  |
| Length of stay            | 5 (2, 11)        | <0.001 | 1.251* (1.238, 1.263)         | <0.001 | 1.506* (1.490,1.523)          | <0.001 | 0.988* (0.985,0.992)          | <0.001 | 1.006* (1.003, 1.009)        | <0.001 | 1.106* (1.101, 1.110)        |
| Age                       |                  |        |                               |        |                               |        |                               |        |                               |        |                               |
| <60                       | 9819 39.6        | 0.010  | 1.097 (1.022, 1.176)          | <0.001 | 1.412* (1.295,1.540)          | <0.001 | 1.619* (1.508,1.737)          | <0.001 | 1.584* (1.480,1.695)         | <0.001 | 1.244* (1.127, 1.374)        |
| ≥60 (reference)           | 14,984 60.4      |        |                               |        |                               |        |                               |        |                               |        |                               |
| Insurance type            |                  |        |                               |        |                               |        |                               |        |                               |        |                               |
| Urban and rural residents | 8281 33.4        | 0.006  | 0.902* (0.839,0.970)          | <0.001 | 0.801* (0.731,0.877)          | <0.001 | 6.183* (5.713,6692)           | <0.001 | 2.649* (2.446,2.869)         | <0.001 | 1.440* (1.301, 1.593)        |
| Urban workers (reference) | 16,522 66.6      |        |                               |        |                               |        |                               |        |                               |        |                               |
| Economic level            |                  |        |                               |        |                               |        |                               |        |                               |        |                               |
| High                      | 15,776 63.6      | <0.001 | 2.608* (2.357,2.887)          | <0.001 | 15.509* (13.274, 18.120)      | <0.001 | 2.551* (2.286,2.847)          | <0.001 | 1.279* (1.166, 1.404)        | <0.001 | 8.375* (6.576,10.667)        |
| Middle                    | 5974 24.1         | 0.070  | 0.905 (0.813,1.008)           | <0.001 | 2.129* (2.087,2.510)          | <0.001 | 3.109* (2.752,3513)           | <0.001 | 1.713* (1.540,1.905)         | <0.001 | 5.159* (3.994,6662)          |
| Low (reference)           | 3053 12.3         |        |                               |        |                               |        |                               |        |                               |        |                               |

This table contained the results of three models after adding the length of stay variable and *"indicated significant at the 0.01 level
Table 5  Sensitivity analysis of the models in Table 3

| Variable                  | M/N (P25, P75)/% | Total medical expenses (reference = low) | Actual medical insurance payment level (reference = high) | The group with high out-of-pocket expenses |
|---------------------------|------------------|----------------------------------------|-------------------------------------------------|---------------------------------|
|                           |                  | Middle                                      | High                                               | Low                             | Middle                                      |
|                           |                  | P  AOR (95% CI)                            | P  AOR (95% CI)                                   | P  AOR (95% CI)                 | P  AOR (95% CI)                             |
| Length of stay            | 5                | <0.001 1.247* (1.228, 1.268)              | <0.001 1.593* (1.564, 1.622)                      | <0.001 0.997* (0.992, 1.002)   | <0.001 1.113* (1.106, 1.119)               |
| Age                      | 6761 54.3        | <0.001 1.596* (1.445, 1.764)              | <0.001 2.278* (2.002, 2.592)                      | 0.274 1.742 (1.572, 1.931)     | <0.001 1.684* (1.528, 1.856)               | 0.017 0.913 (0.791, 1.055)               |
|                          | ≥ 60 (reference) | 5696 45.7                                  |                                                   |                                |                                            |                                            |
| Insurance type            | Urban and rural residents 4696 37.7 | 0.003 0.866* (0.787, 0.953)              | <0.001 0.627* (0.554, 0.709)                      | <0.001 3.707* (3.341, 4.113)   | <0.001 1.735* (1.567, 1.922)               | <0.001 1.392* (1.214, 1.595)               |
|                          | Urban workers      7761 62.3             |                                                   |                                                   |                                |                                            |                                            |
| Distance from the insured region | Short 7960 63.9 | 0.066 1.027 (0.916, 1.152)                | <0.001 1.517* (1.305, 1.763)                      | <0.001 5.971* (5.270, 6.766)   | <0.001 3.346* (2.997, 3.735)               | <0.003 2.574* (2.132, 3.108)               |
|                          | Middle            1474 11.8             | <0.001 0.603* (0.515, 0.705)                | <0.001 0.554* (0.441, 0.697)                      | 0.016 0.857 (0.710, 1.033)     | 0.010 1.210 (1.047, 1.400)                 | <0.001 0.576* (0.403, 0.824)               |
|                          | Long (reference)  3023 24.3           |                                                   |                                                   |                                |                                            |                                            |

This table contained the results of three models after adding the length of stay variable and * indicated significant at the 0.01 level.
the out-of-pocket expenses of patients will rise significantly. On the other hand, compared with low-income areas, high-income areas can attract more young labor force and increase the proportion of non-elderly people in unplanned cross-regional medical patients [63]. When they suffer from malignant tumors, they tend to choose more advanced treatments for longer survival times, which makes them likely to have longer treatment cycles, less probability of palliative care, and higher medical expenses than the elderly [64, 65], in addition, the medicare treatment of the elderly in China is generally higher. All of these can make non-elderly people more likely to become patients with high out-of-pocket expenses, and also increase the probability of patients with high out-of-pocket expenses in regions with high economic levels (Table 2).

The middle-distance medical regions may be the best choice for patients with planned cross-regional medical treatment

More than 70% of the medical regions with a high economic level in this survey were close to the insured regions (Table 1). This indicated that the principle of proximity existed in cross-regional medical treatment. Especially for patients with planned cross-regional medical treatment, while pursuing high-quality medical services, most of them tend to choose short-distance cross-regional medical regions due to the consideration of medical urgency and transportation, accommodation and other non-medical economic burdens [6]. However, the results of this study showed that the possibility of becoming patients with high out-of-pocket expenses was less in the middle-distance medical regions (Table 3). This can also be explained in terms of medical insurance policies and population mobility. On the one hand, to control a large number of unreasonable referrals and relieve the payment pressure of local medical insurance funds, the reimbursement ratios of planned cross-regional medical treatment are often reduced by local governments [66]. This approach may be radical and to some extent undermines the rights of patients who are normally referred. On the other hand, as winter weather conditions in South China are more suitable for living or recuperating, a large number of “migratory birds” elderly have appeared in northeast China in recent years, and they are concentrated in Guangdong, Hainan and its surrounding areas, resulting in a significant increase in long-distance cross-regional medical treatment [67, 68]. In response, Heilongjiang Province has introduced a policy of exemption from authorization to ensure the normal reimbursement of the “migratory birds” elderly for medical treatment (http://ybj.hlj.gov.cn/ljyb/1849.jhtml). However, this study found that the average length of stay for such long-distance medical treatment was longer, increasing the risk of high medical costs (Table 5), which may be related to the higher expenditures on drugs and medical devices [68], as well as a lack of remote collaborative supervision resulting in excessive diagnosis and treatment.

Limitations

In this study, some limitations are present. Although the sample size of this study is large, there are fewer covariables in this study due to less basic information of patients available in the database, which may affect the credibility of the model results. In addition, this is a cross-sectional study and it is difficult to establish a causal relationship between variables. Future research may use panel data with more variables and do further analysis on patients with specific diseases.

Conclusion

Cross-regional medical patients with malignant tumors in low-income areas are concentrated in the regions with higher economic level and closer to their insured regions, the number of them will be affected by seasonal factors. At the same time, their total medical expenses, actual medical insurance payment levels and out-of-pocket expenses are all affected by the economic levels and distances of medical regions. And the middle-distance medical regions may be the best choice for patients with planned cross-regional medical treatment. The relevant policymakers should pay attention to the above phenomena, fully consider patient mobility and regional differences, and reasonably improve the fairness, responsiveness and sustainability of medical insurance for cross-regional medical patients with serious diseases so as to further reduce their out-of-pocket expense burden. At the same time, more attention should be paid to the supervision of cross-regional medical treatment and the development of telemedicine.

Abbreviations

NHS: National Health Service; EU: European Union; EHIC: European Health Insurance Card; EC: European Community; GBD: Global Burden of Disease; DALY: Disability-adjusted life year; PCGDP: Per capita gross domestic product; PCDI: Per capita disposable income; NBS: National Bureau of Statistics.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12962-022-00368-x.

Additional file 1: Table S1. The second sensitivity analysis of the models in Table 2. Table S2. The second sensitivity analysis of the models in Table 3.

Acknowledgements

Not applicable.
Author contributions
ZK took overall responsibility for the study design. BZ, HW, GT were responsible for data analysis and manuscript writing. TZ, HZ applied and obtained the research data. QS, JL, JX helped with data interpretation and manuscript writing. JL, QW made the charts and participated in the manuscript revision. All authors critically reviewed and revised the manuscript. All authors read and approved the final manuscript.

Funding
This study was funded by the National Natural Science Foundation of China (19AZD013). The funding body had no influence on study design, data collection, data analysis, data interpretation or writing the manuscript.

Availability of data and materials
The datasets generated and analyzed during the current study are not publicly available because the datasets are currently used for another project, but are available from the corresponding author on reasonable request.

Declarations
Ethics approval and consent to participate
Ethics approval for the study protocol was obtained from the Ethics Committee of Harbin Medical University. All data used in this article have been approved and the data used in this study are anonymous.

Consent for publication
Not applicable.

Competing interests
The authors declare no conflict of interest.

Author details
1 School of Health Management, Harbin Medical University, Harbin 150081, China. 2 Department of Nuclear Medicine, The Fourth Affiliated Hospital of Harbin Medical University, Harbin 150001, China. 3 School of Public Health, Harbin Medical University, Harbin 150081, China.

Received: 2 March 2022   Accepted: 5 July 2022

Published online: 21 July 2022

References
1. Ghanbari MK, Behzadifar M, Doshmangir L, et al. Mapping research trends of universal health coverage from 1990 to 2019: bibliometric analysis. JMR Public Health Surveill. 2021;7(1):99–110.
2. Gorsky M, Sirrs C. Universal health coverage as a global public health goal: the work of the International Labour Organisation, c.1925–2018. Historia Ciencias Saude-Manguinhos. 2020;271:71–93.
3. Vilcu I, Mathauer I. State budget transfers to health insurance funds for universal health coverage: institutional design patterns and challenges of covering those outside the formal sector in Eastern European high-income countries. Int J Equity Health. 2016;15(7):1–19.
4. Sugahara T. Analysis of regional variation in the scope of eligibility of basic medical insurance in Heilongjiang Province. Chin Health Econ. 2012;27:1–19.
5. Macha J, Harris B, Gashong B, et al. Factors influencing the burden of health care financing and the distribution of health care benefits in Ghana, Tanzania and South Africa. Health Policy Plan. 2012;271:46–54.
6. Zheng Y, Kang Z, Liang X, et al. Analysis on the current situation and target problem of direct settlement of cross-provincial medical treatment of basic medical insurance in Heilongjiang Province. Chin Health Econ. 2021;40(2):35–7.
7. Santana IR, Aragon MJ, Rice N, et al. Trends in and drivers of healthcare expenditure in the English NHS: a retrospective analysis. Health Econ Rev. 2020;10(1):1–11.
8. De Wispeelaere F, Berki G. The role and limits of the European health insurance card: (too) great expectations? J Eur Soc Policy. 2021;31(4):424–31.
9. Wendt C. Social health insurance in Europe: basic concepts and new principles. J Health Politics Policy Law. 2019;44(4):665–77.
10. Yip W, Fu H, Chen AT, et al. 10 years of health-care reform in China: progress and gaps in universal health coverage. Lancet. 2019;394(10204):1192–204.
11. Techniker Kranken-kasse. TK Europe survey 2009: German patients en route to Europe. Corporate Development Department (UE) and the Scientific Institute for Benefit and Efficiency in Healthcare (WINEG). 2009.
12. Liu L. The origin of dilemma, policy analysis and system cracking of floating population seeking cross-provincial medical treatment. J Sichuan Univ Sci Eng (Soc Sci Ed). 2020;35(5):31–47.
13. Zhao S, Wang X, Ma Z. Study on fractal characteristics of migration-population flow-evidence from Egypt. ISPRS Int J Geo-Inf. 2021;10(2):45.
14. Tong W, Lo K. Back to the countryside: rural development and the spatial patterns of population migration in Zhejiang, China. Agriculture. 2021;11(8):788.
15. Qi W, Yi J. Spatial pattern and driving factors of migrants on the Qinghai-Tibet Plateau insights from short-distance and long-distance population migrants. J Geogr Sci. 2021;31(2S):215–30.
16. Amin C, Sukamdi S, Rijanta R. Exploring migration hold factors in climate change hazard-prone area using grounded theory study: evidence from Coastal Semarang, Indonesia. Sustainability. 2021;13(8):4335.
17. Duan C. Research on floating population in China. Beijing: China Popula- tion Press; 2012. p. 18.
18. Xi T. Research review of border migration. J Shijiazhuang Univ. 2018;20(4):125–30.
19. Baeten R. Cross-border patient mobility in the European Union: in search of benefits from the new legal framework. J Health Serv Res Policy. 2014;19(4):195–7.
20. Ormond M, Lunt N. Transnational medical travel: patient mobility, shifting health system entitlements and attachments. J Ethn Migr Stud. 2020;46(20S):4179–92.
21. He Y, Feng L, Hou Z. Experience and reference to China’s trans-provin- cial healthcare from European cross-border healthcare management. Chin J Health Policy. 2018;11(1):13–20.
22. Golyoker O. EU coordination of social security from the point of view of EU integration theory. Eur J Soc Secur. 2020;22(2S):110–37.
23. Azzopardi-Muscat N, Baeten R, Clemens T, et al. The role of the 2011 patients’ rights in cross-border health care directive in shaping seven national health systems: looking beyond patient mobility. Health Policy. 2018;122(3):279–83.
24. Xie L, Hu H. Evolution and trend of the cross-pooling healthcare policy of basic medical insurance in China: based on content analysis of policy document. Chin J Health Policy. 2021;14(06):45–50.
25. den Exter A, Santuari A, Sokol T. One year after the EU patient mobility directive: a three-country analysis. Eur Law Rev. 2015;40(2):279–93.
26. Li L, Zhang Z, Wang C. Enlightenment of health care security system in German to China. Chin Hosp Manag. 2016;36(1):94–6.
27. Finozelli C. Cross-border healthcare in the EU: welfare burden or market opportunity? Evidence from the Spanish experience. JCMS. 2015;59(3):608–24.
28. Larrucea X, Moffie M, Asaf S, et al. Towards a GDPR compliant way to secure European cross-border healthcare industry 4.0. Comp Stand Interfaces. 2020;69:103408.
29. Nien S. Interregional patient mobility in the Italian NHS: a case of badly-managed decentralization. Int J Health Policy Manag. 2015;4(12):857–9.
30. Verra SE, Kroeze R, Ruggeri K. Facilitating safe and successful cross-border healthcare in the European Union. Health Policy. 2016;120(6):718–27.
31. Bray F, Ferlay J, Soerjomataram I, et al. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2018;68(6):394–424.
32. Katzev VA, Kaaks R, Kuehn T. Lifestyle and cancer risk. Cancer J. 2015;21(2S):104–10.
33. Min HS, Yang HK, Park K. Supporting low-income cancer patients: recommendations for the public financial aid program in the Republic of Korea. Cancer Res Treat. 2018;50(4):1074–83.
35. Lueckmann SL, Kowalski C, Schumann N. Financial toxicity of cancer current understanding and status of international and German research on objective financial burden and subjective financial distress. Onkologe. 2021;12(7):593–600.

36. Bygrave A, Whittaker K, Paul C, et al. Australian experiences of out-of-pocket costs and financial burden following a cancer diagnosis: a systematic review. Int J Environ Res Public Health. 2021;18(5):2422.

37. Brekke KR, Levaggi R, Siciliani L, et al. Patient mobility and health care quality when regions and patients differ in income. J Health Econ. 2016;50:372–87.

38. Durham J, Blondell SJ. A realist synthesis of cross-border patient movement from low and middle income countries to similar or higher income countries. Glob Health. 2017;13:1–14.

39. Zhang L, Li Y, Zhang F, et al. Changes of winter extreme precipitation in Heilongjiang province and the diagnostic analysis of its circulation features. Atmos Res. 2020;245:105094.

40. Sun H, Zhang M, Wang W, et al. Malignant tumor epidemiology in registration areas of Heilongjiang province in 2017. J Pract Oncol. 2021;36(03):222–7.

41. Brenna E, Spandonaro F. Regional incentives and patient cross-border mobility: evidence from the Italian experience. Int J Health Policy Manag. 2015;4(6):363–72.

42. Li H, Xie X, Yin J, et al. Comparison between low-dose chemotherapy and surgery for the treatment of extremity-associated solitary bone lesions in children with Langerhans cell histiocytosis in South China: a case–control study. J Bone Oncol. 2018;12:1–6.

43. Holle M, Wolff T, Herant M. Trends in the concentration and distribution of health care expenditures in the US, 2001–2018. JAMA Netw Open. 2021;4(9):e212571.

44. Fang W, An P, Liu S. Evolution characteristics and regional roles’ influencing factors of interprovincial population mobility network in China. Complexity. 2021. https://doi.org/10.1155/2021/6679580.

45. Durham J, Blondell SJ. Research protocol: a realist synthesis of cross-border patient mobility from low-income and middle-income countries. BMJ Open. 2014;4(1):e006514.

46. Chen J, Qian Z, Yang L, et al. The risk factors for Chinese medical economic burden of aging: a cross-sectional study based on Guangdong Province. Biomed Res Int. 2021. https://doi.org/10.1155/2021/6680441.

47. Li Y, Zhao Y, Yi D, et al. Differences exist across insurance schemes in China post-consolidation. PLoS ONE. 2017;12(11):e0187100.

48. Buckee CO, Tatem AJ, Metcalf CJE. Seasonal population movements and the surveillance and control of infectious diseases. Trends Parasitol. 2017;33(3):10–20.

49. Nurullah A, Kuhle S, Maguire B, et al. Seasonality in incidence and trends of pediatric cancer diagnoses: a population based study from Maritimes, Canada. Pediatr Blood Cancer. 2017;64(1):560.

50. Hu M. Visualizing the largest annual human migration during the spring festival travel season in China. Environ Plan Econ Space. 2019;51(8):1618–21.

51. Li J, Ye Q, Deng X, et al. Spatial-temporal analysis on spring festival travel rush in china based on multisource big data. Sustainability. 2016;8(11):1184.

52. Shi Y, Cheng H, Ren T, et al. Impact of returning population migration after the Chinese spring festival on the COVID-19 epidemic. Chin Sci Bull. 2020;65(22):2314–20.

53. Guo Y, Zhang J, Zhang H. Rank-size distribution and spatio-temporal dynamics of tourist flows to China’s cities. Tour Econ. 2016;22(3):451–65.

54. Rossello J, Saenz-de-Miera O. Road accidents and tourism: the case of the Balearic Islands (Spain). Accid Anal Prev. 2011;43(3):675–83.

55. Li H, Wang H, Jiang D. Influence of October Eurasian snow on winter temperature over Northeast China. Adv Atmos Sci. 2017;34(1):116–26.

56. Wang S, Li Y, Hague M. Evidence on the impact of winter heating policy on air pollution and its dynamic changes in North China. Sustainability. 2019;11(10):2728.

57. Xing DF, Xu CD, Liao XY, et al. Spatial association between outdoor air pollution and lung cancer incidence in China. BMC Public Health. 2019;19(1):1–11.

58. Nogueira LM, Yabroff KR, Bernstein A. Climate change and cancer. CA Cancer J Clin. 2020;70(4):239–44.

59. Cebula RJ, Clark JR. The effects of economic freedom, regulatory quality and taxation on the level of per capita real income: a preliminary analysis for OECD nations and non-G8 OECD nations. Appl Econ. 2014;46(31):3836–48.

60. Weng K, Xia F, Lin W, et al. Performance comparison of public hospitals between 2014 and 2018 in different regions of Guangdong Province, China, following 2017 medical service price reforms. Front Public Health. 2021;9:701201.

61. Liu Y, Lyu W. Applying data envelopment analysis to evaluate financial leasing performance of medical device industry in China. Revista de Cerotecé: Si Interventce Social. 2018;63:304–14.

62. Fang W, Xu X, Zhu Y, et al. Impact of the national health insurance coverage policy on the utilisation and accessibility of innovative anti-cancer medicines in China: an interrupted time-series study. Front Public Health. 2021;9:714127.

63. Shi Q. Compositions of the labour force: is Beijing different from London? Habitat Int. 2019;84:33–42.

64. Sio TT, Chang K, Jayakrishnan R, et al. Patient age is related to decision-making, treatment selection, and perceived quality of life in breast cancer survivors. World J Surg Oncol. 2014;12:1–8.

65. Trogdon, JG, Baggett CD, Gogate A, et al. Medical costs associated with metastatic breast cancer in younger, middle, and older women. Breast Cancer Res Treat. 2020;181(3):653–65.

66. Wu J. Will “lower referral reimbursement rates” keep patients in the community? Dongguan Daily; 2014-07-24(A02).

67. Kou L, Xu H, Hannam K. Understanding seasonal mobilities, health and wellbeing to Sanya, China. Soc Sci Med. 2017;177:87–99.

68. Guo J, Li J. Research on medical security of “migratory bird” long-distance endowment in Sanya City. Rural Econ Sci. 2020;31(05):291–2.

Publisher’s Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.