Analysis of Medical Service Utilization Differences Between Floating and Registered Populations Based on Mobile Signaling Data

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Abstract. Accurately assessing the utilization of medical services in floating and registered populations is crucial for the sustainable use of urban healthcare resources and the social equity. At present, the research on medical resource allocation lacks attention to the utilization of medical services by the floating population, especially long-staying population, which affects the fairness of medical resource allocation. This study constructs an approach for identifying the floating population using mobile signaling data and then investigates their duration of stay, spatial distribution, and clustering patterns. On this basis, the criteria for assessing healthcare-seeking behavior are developed to compare the behaviors of cross-province long-staying floating populations with those of registered residents, offering deeper insights into the medical behaviors of the floating population. This study takes Ningbo City as a case, providing valuable insights into its healthcare development. The findings aim to offer a scientific basis for urban medical reforms and the effective allocation of public healthcare services.

Keywords: medical service, floating population, mobile signaling data, Ningbo

1 Introduction

The medical service system plays a crucial role in ensuring the safety and health of individuals, serving as a vital pillar in the country's social development[1]. Most academic studies on the use of medical services mainly focus on regional differences and inequalities, and few studies pay attention to the differences between the floating population and the registered population in the use of medical services[2]. The floating population not only contributes valuable labor and consumption demand to cities but also increases pressure on urban public service infrastructure[3, 4]. In view of this situation, studying the differences in medical service utilization between the floating population and the registered population can reveal the specific needs of different social groups, thereby promoting a more equitable allocation of medical resources and optimizing social governance.

Most studies on the floating population currently rely on questionnaire surveys or directly utilize national population dynamics monitoring survey data to analyze the spatial distribution,

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service usage patterns, and economic impacts of the floating population in urban areas[5,6]. However, due to the sampling nature of the questionnaire survey, they cannot comprehensively cover the entire population, thus restricting the effectiveness of related planning and policies. The use of mobile signaling data can address this limitation, enabling a more comprehensive study of the differences in medical service utilization between the floating and registered populations.

Mobile signaling data is a natural collector of population distribution and travel trajectory, which has the characteristics of massive, real, blind spot-free, dynamic real-time and continuity[7, 8]. The data records time and space information such as user's residence and travel, as well as attribute information such as user's gender, age, and cell phone tag, which can be used for profile of users to match the demand. In particular, the address code attribute is the first six digits of the user's ID card, which can be precisely located to the district and county level administrative units. The profile analysis based on the address code can clarify the origin of a large range of floating population and provide insight into the daily behavioral characteristics of the floating population[9].

At present, mobile signaling data is mostly used for the identification research of permanent residents and service population[10,11], but there is little research on its application to the identification of floating population in medical services. Therefore, this study takes the central urban area of Ningbo as the research area and constructs a full procedure of floating population identification based on the December 2019 Unicom mobile signaling data. On this basis, the floating population is further screened out for cross-province long-staying floating population according to their origin and stay time, and the judgment criteria for population health care behavior are proposed to reveal the differences in health care behavior between the floating population and the registered population. The research approach of this study is shown in Fig. 1. In addition, based on the above research, this study proposes medical development suggestions, which provides scientific foundation for urban medical reform, public medical resource allocation, and population management.

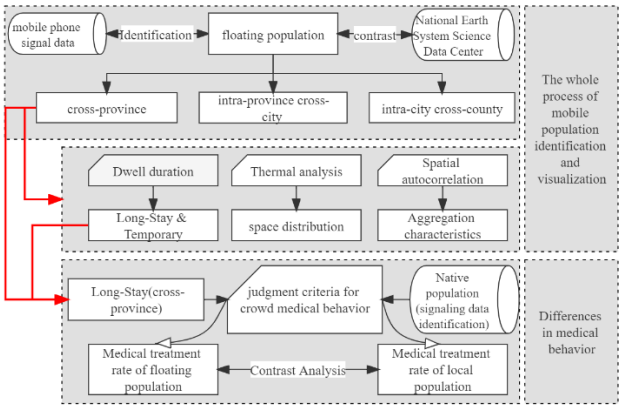

Fig. 1. Research approach of this study.

2 Identification of different types of population

Before conducting differential analysis, it is necessary to first identify different types of populations. This study screened users living in the central urban area of Ningbo using Unicom signaling data and identified their type by analyzing the "first six ID card numbers" attribute in the mobile signaling data. If the "first six ID card numbers" match the administrative division code of Ningbo's central urban area, the user is classified as a registered population. Otherwise, the user is classified as a floating population, thus determining the registered population and floating population in the central urban area of Ningbo who use the mobile phone number of Unicom [12, 13]. On this basis, we further calculated the total floating population and the total registered residence in the central urban area of Ningbo according to the sample expansion method provided by Unicom.

Traditional research on medical service demand primarily focuses on the registered population, but the healthcare needs of the floating population cannot be overlooked. According to the calculation of mobile signaling data, the floating population in the central urban area of Ningbo in December 2019 was 5.012 million. To reveal the special needs and difficulties of the floating population in medical services and improve their medical security level, this study will subdivide these floating populations from the perspectives of source and duration of stay.

2.1 Identification of floating populations from different origins

Analyzing the origin of the floating population is helpful to screen out the groups with different medical insurance policies and facilitate the follow-up analysis of their medical service utilization. Based on the "address code" attributes, the floating population is classified into three categories: Intra-city cross-county, Intra-province cross-city, and Cross-province. The results of the division of the floating population by origin are shown in Table 1. As can be seen from Table 1, the cross-province floating population in Ningbo City is the largest.

Table 1. Statistical table of floating population sources.

Types	Intra-city cross-county	Intra-province cross-city	Cross-province
population(104person)	36.7231	78.7357	385.6997
Proportion (%)	7.328	15.711	76.962

2.2 Identification of floating population with different stay times

Due to the demand for nearby medical treatment, the radiation range of medical resources is mainly concentrated on the long-staying population locally. This study defines individuals who stay in the same location for more than a certain number of days within a month as long-staying floating population. We calculated the number of days that users stayed at the same location for three types: Intra-city cross-county, Intra-province cross-city, and Cross-province, as shown in the figure. The data in the figure shows that the segmentation thresholds for the floating population between counties, cities, and provinces are 17 days, 18 days, and 18 days, respectively. Ultimately, this study identified temporary and long-staying floating population under different types.

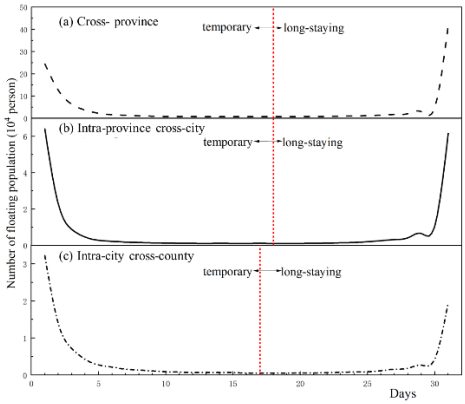

Fig. 2. Accumulated residence days of floating population.

3 Analysis of floating population

Studying the spatial distribution characteristics of the floating population is essential for achieving the rational allocation of medical services[14].This study analyzes the spatial distribution and clustering characteristics of the floating population from the perspectives of different time periods and places of origin, aiming to provide insights for optimizing the allocation of healthcare services and improving service accessibility.

3.1 Spatial distribution characteristics of floating population

This study examines the distribution of two types of floating populations—long-staying and temporary—at 2h intervals, analyzing their distribution patterns and potential evolution over time. Given the large number of time periods and space limitations, this paper focuses on the distribution of long-term and temporary floating populations during three key time slots representing the most stable working and living hours: 01:00-03:00, 9:00-11:00, and 15:00-17:00. These time periods are shown in Figure 3.

It can be seen from Figure 3 that the distribution of the floating population in Ningbo has an obvious multi-center structure, showing a three-center structure of the center of the ring road - northern Beilun - eastern Fenghua in different time periods, and the floating population is mainly distributed within the ring road, with small-scale population gatherings in Beilun and Fenghua districts. The high density floating population (>50,000) is distributed in only a few areas, and is concentrated in the center of the ring road. The medium density (3000~50000) distribution area is highly identifiable, with the central location of the ring line as the core, symmetrical distribution and piecewise distribution, while there is also a small amount of distribution in the population gathering centers of Beilun and Fenghua districts. The 9:00-11:00 and 15:00-17:00 time periods show a more obvious central circle structure compared to the 1:00-3:00 time period, when the core area of the city has a higher recognition. According to the above phenomenon, on the one hand, it shows that the Ring Road area, being part of the nucleus in the "one core, two wings, two belts and three bays" of Ningbo City, plays the main function of the city due to its transportation location and economic advantages, and attracts a large number of floating population to live and work here. On the other hand, it shows that Beilun District, as a part of the industrial zone of the eastern coastal town, is connected to Shanghai to the north and to

Sanmen Bay to the south, and its location and port trade create more job opportunities. The attractiveness of Fenghua District to the floating population may be due to its location advantage as a member of the "South Wing", its excellent tourism and ecological resources, and its large development potential.

3.2 Spatial aggregation characteristics of the floating population

The agglomeration characteristics of floating population is the basis for developing a fair medical service system and optimizing the spatial pattern of urban health service[15]. Therefore, in order to further explore the agglomeration characteristics of long-staying and temporary floating population, this study further conducts local spatial autocorrelation analysis on the spatial patterns of the two types of floating population. The results are shown in Figure 4.

From Figure 4, compared with temporary floating population, long-staying floating population has obvious characteristics of Low-Low agglomeration, mainly distributed near the central urban ring road. It may be due to the High-High agglomeration areas that encourage floating population to gather inside the ring road, forming high-value agglomeration areas with dense floating population, while low value sparse areas diffuse the attractiveness of high-value agglomeration areas, becoming a low value circular floating population depression. Temporary floating population aggregation is mainly dominated by High-High clustering area (HH) and Low-Low clustering area (LL), which are mainly distributed within the central city ring line, and the characteristics of population aggregation are roughly the same at different time periods. This reflects that the temporary floating population tends to be more active within the central city ring road with limited time.

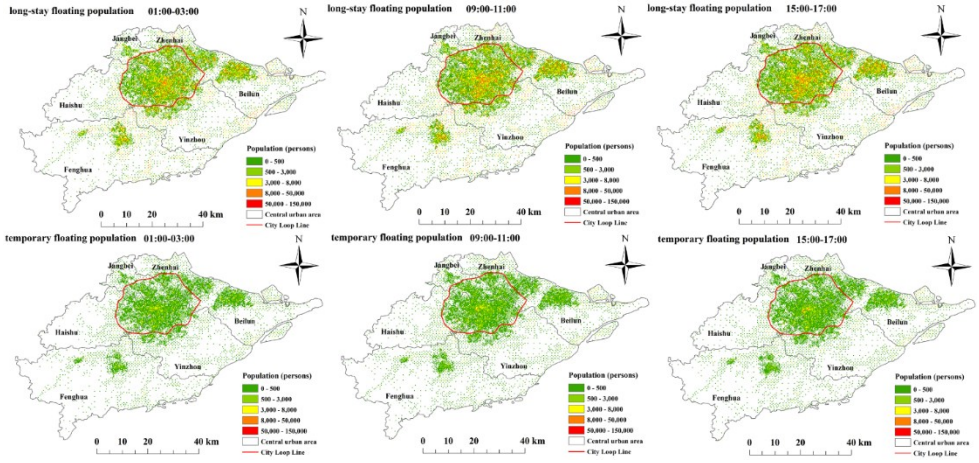

Fig. 3. Distribution of long-staying and temporary floating population in all period

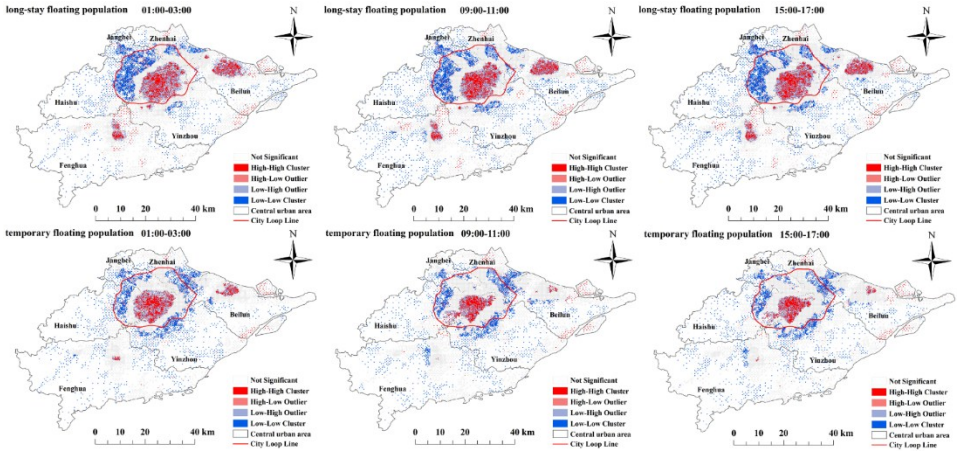

Fig. 4. LISA cluster of long-staying and temporary floating population in all period.

4 Analysis on the difference of medical service utilization among "Floating- Registered" population

4.1 Criteria for determining the utilization of medical services for specific populations

Both the long-staying floating population and the registered population are key consumers of medical service resources. Exploring the basic characteristics and differences in their utilization of medical services can contribute to improving the equity of healthcare services. Seeking medical treatment is a typical travel behavior, and it is mostly focused on factors influencing medical treatment and choices of medical treatment behavior [16-18].This study takes medical behavior as an example to explore the differences between the floating population and the registered population. Since the medical insurance policies of Ningbo City are different for the population inside and outside the province, and the cross-province floating population occupies an absolute advantage in the total floating population (Section 2.1), this study focuses on the cross-province long-staying population and compares it with the registered population.

The criteria for judging the medical behavior of the population are as follows: ① Determine the study population and calculate the total daily visit time of users in this population to the hospital; ② Exclude medical staff, i.e. screen out patients who visit the hospital daily (stay for 0.5~5 hours) and inpatients (stay>13 hours); ③ Count the number of daily visits to hospitals and expand the sample to obtain the medical situation of this population.

Based on the above criteria, the number of long-staying floating population and registered population seeking medical care was calculated. To compare the differences in medical treatment behaviors between the two groups, this study evaluates the medical treatment behavior of the cross-province long-staying floating population based on the medical treatment frequency of the registered population, as shown in the following formula:

$$R = \frac{P_{F\_H}/P_F}{P_{R\_H}/P_R} \times 100\% \quad (1)$$

In the formula, R represents the ratio of the cross-province long-staying population to registered population for medical treatment, P_F and P_R represent the number of the cross-

province long-staying floating population and registered population respectively, P_{F_H} and P_{R_H}represent the number of medical visits of long-staying floating population and registered population respectively.

4.2 Difference in medical service utilization among "Floating and Registered" population

Tertiary hospitals typically cover a large service area and treat a high volume of patients. Considering factors such as hospital influence and transportation accessibility, this study selected Ningbo First Hospital, Second Hospital, and the Maternal and Child Health Hospital as a case to identify the number of long-staying floating and registered population who visit their hospitals daily. Using the formula mentioned above, the proportion of long-staying floating population visiting these three hospitals relative to the registered population was calculated, as shown in Figure 5.

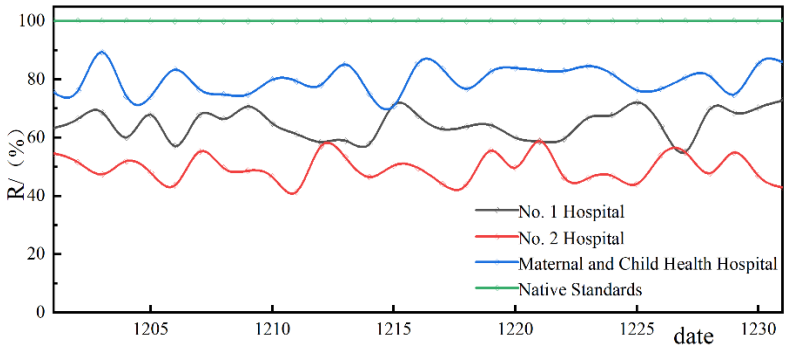

Fig. 5. The proportion of long-staying floating population relative to registered population.

As can be seen from Figure 7, although the cross-province long-staying floating population has differences in the proportion of medical treatment relative to the domiciled population due to different hospitals, each basically remains at a stable level, and none of them reaches the standard of medical treatment for the domiciled population. The above phenomenon indicates that the floating population is disadvantaged in the utilization of public health service resources compared to the domiciled population, and the results are similar to those of scholars such as Yujie Gan and Yumeng Tang [16, 19]. This phenomenon is also observed in cities like Shanghai, primarily due to the complex procedures involved in transferring medical insurance and referrals for cross-provincial migrants. This results in lower levels of medical security compared to registered population, leading to healthcare concerns and differences in medical behaviors.

4.3 Ningbo Medical Development Suggestions

In fact, for people from non-Yangtze River Delta regions who travel and work in Ningbo, outpatient expenses account for the bulk of medical expenses. Fortunately, the current policy of improving the settlement of outpatient expenses across provinces and other places is being rolled out across the country in full swing. Many experts and scholars have also provided valuable suggestions for further improving the construction of China's medical security system. For example, Zheng Xianping and others have summarized the characteristics and existing problems of the current inter-provincial outpatient billing in different places, and proposed

optimization countermeasures [20]. In the future, Ningbo City can actively promote "outside-province co-management" and medical insurance interoperability to meet the demands of inter-provincial floating population for medical treatment, dispel their concerns about medical treatment, provide convenient and fast settlement services for people cross-provincial seeking medical treatment in different places.

5 Conclusion

This study aims to compare healthcare utilization between the floating and registered populations, highlighting disparities that may impact the equitable distribution of urban medical resources. Using Ningbo city district as the study area, mobile signaling data was applied to accurately identify a wide range of floating populations and examine their length of stay, spatial distribution, and aggregation characteristics. Criteria were subsequently proposed to assess the healthcare behavior of these populations, and healthcare utilization between the long-staying cross provincial floating and registered populations was quantitatively compared, revealing that the healthcare utilization rate of the floating population in Ningbo is significantly lower than that of the registered population. Recognizing the differences in medical care behavior between the urban floating population and the registered resident population, future research will focus on strategies and policies to bridge these disparities and address the healthcare needs of both groups, which is crucial for advancing urban population management, medical reform, public healthcare resource allocation, and infrastructure development. Despite this, our study still has some limitations. The mobile signaling data comes from only one company, which may not fully capture changes in healthcare utilization. However, the data expansion and ratio analysis minimize this impact. Future studies will address this by using longer-term, more granular data for a more accurate and comprehensive understanding of healthcare utilization patterns.

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References

[1] Yu Yan, Yan Qiqi, Yan Cheng, et al. Evaluation of Medical Resource Equity in Ningbo Based on Mobile Signaling Data. Geospatial Information. 2024, 22(07): 1-4+11.

[2] Yang Xin. Differences in Utilization of Basic Public Health Services Between Registered and Floating Populations and Their Influencing Factors. Chinese Journal of Public Health. 2018, 34(6): 781-785..

[3] Wang De, Gu Jin. The Use of Public Facilities by Floating Population in Shanghai—Case Study of Hongjin Community. URBAN PLANNING FORUM. 2010, 04: 76-82.

[4] Yu, Y., Meng, W., Fan, J., Ma, W., Xia, Y., Development of Public Health Emergency Response Strategies Based on Economic Space Field Theory and ESDA. Geomatics and Information Science of Wuhan University. 2021, 46, 159-166+220.

[5] Chen Jie, Wang Wei. Economic incentives and settlement intentions of rural migrants: Evidence from China. URBAN STUDIES. 2019, 41(3): 372-389.

[6] Wen, P., Zhou, S.H. Spatial-Temporal Characteristics and Planning Implications of Daily Activities of Migrant Population in Guangzhou. 2018 China Urban Planning Annual Conference, Hangzhou, Zhejiang, China.
[7] Zhong Shuqi, Deng Rufeng, Deng Hongping, Cai Ming. Recognition of traffic mode of mobile phone data based on the combination of point of interest data navigation data. ACTA SCIENTIARUM NATURALIUM UNIVERSITATIS SUMYATSENI. 2020, 59(03): 87-96.
[8] Lauren Alexander, Shang Jiang, Murga Mikel, Marta C. Gonzalez. Origin–destination trips by purpose and time of day inferred from mobile phone data. SCIENCE. 2015, 58: 240-250.
[9] Aguilera Vincent, Sylvain Allio, BeNezech Vincent, Combes Francois, Milion Chloe. Using cell phone data to measure quality of service and passenger flows of Paris transit system. TRANSPORTATION RESEARCH PART C: EMERGING TECHNOLOGIES. 2014, 43: 198-211.
[10] Li Xinyue, Chen Fulin. Regional Connections and Demographic Characteristics of Small-Medium Cities Based on Cellular Signaling Data. Urban Transport. 2020, 18(04): 47-54+70.
[11] Hai Xiaodong, Liu Yunshu, Zhao Pengjun, Zhang Hui. Using Mobile Phone Data to Estimate the Temporal-Spatial Distribution and Socioeconomic Attributes of Population in Megacities: A Case Study of Beijing. Acta Scientiarum Naturalium Universitatis Pekinensis. 2020, 56(03): 518-530.
[12] Wang De, Ren Xiyuan. Distribution and Composition of Actual Population in Urban Space from Daily Human Mobility View. URBAN PLANNING FORUM. 2019, 02: 36-43.
[13] Shi Cheng, Chen Chen, Niu Xinyi. Planning Megacities for the Actual Service Population: A Case of Hangzhou. URBAN PLANNING FORUM. 2018, 04: 41-48.
[14] Ma Zhifei, Yin Shanggang, Zhang Yu, Li Zaijun, Wu Qiyan. Spatial distribution, flowing rules, and forming mechanism of inter-cities floating population in China. Geographical Research. 2019, 38(04): 926-936.
[15] Sheng Yinan, Yang Xuyu. Spatial Patterns and Mechanisms of the Floating Population Agglomeration among Top Three City Clusters in China. Population & Economics. 2021, 06: 88-107.
[16] Gan Yujie, Zhang Longlong. Medical Insurance Coverage and Its Impact on the Medical Choice Behavior of Migrant Population in China. POPULATION AND DEVELOPMENT. 2021, 27(04): 24-36.
[17] Zhang Jian, Cai Jinlong, Huang Yuanying, He Zhongchen, Tang Guizhong. China's Floating Population's Healthcare Utilization Choices and Influencing Factors. CHINESE GENERAL PRACTICE. 2021, 24(16): 2008-2014.
[18] Zheng Yanhui, Hao Xiaoning. Research on Medical Orientation and Influence Factors of Elderly Floating Population. Chinese Health Economics. 2021, 40(08): 56-59.
[19] Tang Yumeng, Li Qian, He Tianjing, Zhang Qingjun. Research Progress and Revelation of Medical Behavior of Floating Population in China. CHINESE JOURNAL OF SOCIAL MEDICINE. 2016, 33(05): 435-438.
[20] Zheng Xianping, Wu Chaonan, Tong Xiao, Liu Ya. Thoughts on the Improvement of Remote Settlement Policy on Medical Insurance Outpatient Fee from the Perspective of Globalization. Chinese Health Economics. 2021, 40(10): 35-38.