Postprint of a Study on Factors Influencing Avoidable Hospitalizations in Elderly Hypertensive Patients in Guangdong Province

Authors: Hao Aihua, Zeng Ziying, Jin Aiqiong, Tang Lingling, Zheng Zique, Ma Jingtai, Zhao Jianguo, Zeng Weilin, Xiao Jianpeng, Nie Hui, Yang Ying, YANG Ying

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Abstract

Background Currently, numerous studies have been conducted on hospitalization costs for hypertensive patients, but few scholars have investigated avoidable hospitalizations among hypertensive patients based on big data. Objective To understand the current status of avoidable hospitalizations among elderly hypertensive patients in Guangdong Province, and to provide references for integrating and optimizing medical and health resources in our province' s compact medical communities. Methods Health information and 2022 hospitalization data for elderly individuals aged 65 and above throughout the province were integrated and obtained through the Guangdong Primary Healthcare Information Management System, Guangdong Provincial Universal Health Information Platform, and inpatient medical record homepage data. Data on per capita GDP, general practitioners, active employees, etc., were sourced from the 2022 Guangdong Health Statistics Yearbook and Guangdong Statistical Yearbook 2022, with yearbook data matched to individual cases at the prefecture-level city unit. Logistic regression analysis was employed to explore influencing factors of avoidable hospitalizations among elderly hypertensive patients. Results The avoidable hospitalization rate for elderly hypertensive patients in Guangdong Province was 8.76%. Elderly female hypertensive patients had a greater likelihood of experiencing avoidable hospitalizations compared to males [OR (95%CI) =1.231 (1.217, 1.246)] . Hypertensive patients aged 65-69, 70-74, 75-79, and 80-84 years had likelihoods of avoidable hospitalizations that were 2.044 times [OR (95%CI) =2.044 (1.981, 2.109)] , 1.640 times [OR (95%CI) =1.640 (1.590, 1.693)] , 1.288 times [OR (95%CI) =1.288 (1.248, 1.329)] , and 1.110 times [OR (95%CI) =1.110 (1.073, 1.147)] that of elderly hypertensive patients aged 90 years, respectively. Hypertensive patients in regions with per capita GDP of 100,000 yuan or more had a likelihood of avoidable hospitalizations that was

1.314 times that of those with per capita GDP below 100,000 yuan [OR (95%CI) =1.314 (1.278, 1.350)] . When the number of general practitioners was $ $4 per 10,000 population, hypertensive patients had a likelihood of avoidable hospitalizations that was 1.039 times that of areas with fewer than 4 per 10,000 population [OR (95%CI) =1.039 (1.105, 1.063)] . When the availability of secondary and tertiary hospitals was $ $0.20 per 10,000 population, the likelihood of avoidable hospitalizations for hypertensive patients decreased by 40.60% [OR (95%CI) =0.594 (0.570, 0.619)] . When the number of visits to secondary and tertiary hospitals was $ $3, hypertensive patients had a likelihood of avoidable hospitalizations that was 1.047 times that of those with fewer than 3 visits per capita to secondary and tertiary hospitals [OR (95%CI) =1.047 (1.021, 1.074)] . When the number of visits to primary healthcare institutions was $ $3 per capita, hypertensive patients had a likelihood of avoidable hospitalizations that was 1.229 times that of those with fewer than 3 visits per capita [OR (95%CI) =1.229 (1.191, 1.268)] . Conclusion Gender, age, and other factors are influencing factors for avoidable hospitalizations among elderly hypertensive patients. Higher per capita GDP levels, more frequent medical visits, and greater numbers of general practitioners increase the likelihood of avoidable hospitalizations. Increased numbers of secondary and tertiary hospitals did not increase the risk of avoidable hospitalizations.

Full Text

Analysis of Factors Influencing Avoidable Hospitalization for Elderly Hypertensive Patients in Guangdong Province

HAO Aihua[1], ZENG Ziying[2], JIN Aiqiong[3], TANG Lingling[4], ZHENG Zique[4], MA Jingtai[1], ZHAO Jianguo[1], ZENG Weilin[1], XIAO Jianpeng[1], NIE Hui[5], YANG Ying[1]*

[1]Guangdong Provincial Center for Disease Control and Prevention & Guangdong Provincial Institute of Public Health, Guangzhou 511430, China
[2]School of Health Management, Guangzhou Medical University, Guangzhou 511436, China
[3]Guangdong Provincial Stomatology Hospital, Guangzhou 510280, China
[4]Guangdong Provincial Center for Disease Control and Prevention, Guangzhou 511430, China
[5]Health Commission of Guangdong Province, Guangzhou 510060, China

Corresponding author: YANG Ying, Chief physician; E-mail: yang99063@126.com

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Abstract

Background: While numerous studies have examined hospitalization costs among hypertensive patients, few have investigated avoidable hospitalization in this population using big data approaches. **Objective:** This study aims to

assess the prevalence of avoidable hospitalization among elderly hypertensive patients in Guangdong Province and provide evidence for optimizing healthcare resource allocation within integrated medical communities. **Methods:** Health information for residents aged 65 and older across Guangdong Province was integrated from the Provincial Primary Healthcare Information Management System, Provincial Universal Health Information Platform, and inpatient medical record data for 2022. Data on per capita GDP, general practitioners, and employed workers were obtained from the 2022 Guangdong Provincial Health Statistics Yearbook and Guangdong Statistical Yearbook 2022, with city-level data matched to individual cases. Logistic regression analysis was used to identify factors influencing avoidable hospitalization among elderly hypertensive patients. **Results:** The avoidable hospitalization rate for elderly hypertensive patients in Guangdong Province was 8.76%. Female elderly hypertensive patients had a higher likelihood of avoidable hospitalization than males [OR (95%CI) = 1.231 (1.217, 1.246)]. Compared with patients aged 90+ years, those aged 65-69, 70-74, 75-79, and 80-84 years were 2.044 times [OR (95%CI) = 2.044 (1.981, 2.109)], 1.640 times [OR (95%CI) = 1.640 (1.590, 1.693)], 1.288 times [OR (95%CI) = 1.288 (1.248, 1.329)], and 1.110 times [OR (95%CI) = 1.110 (1.073, 1.147)] more likely to experience avoidable hospitalization, respectively. Patients in areas with per capita GDP $\geq$ 100,000 yuan were 1.314 times more likely to have avoidable hospitalization than those in areas with lower per capita GDP [OR (95%CI) = 1.314 (1.278, 1.350)]. When the number of general practitioners was $\geq$ 4 per 10,000 population, the likelihood of avoidable hospitalization was 1.039 times higher [OR (95%CI) = 1.039 (1.105, 1.063)]. Having $\geq$ 0.20 secondary and tertiary hospitals per 10,000 population reduced the probability of avoidable hospitalization by 40.60% [OR (95%CI) = 0.594 (0.570, 0.619)]. Patients with $\geq$ 3 visits to secondary/tertiary hospitals had 1.047 times higher likelihood of avoidable hospitalization [OR (95%CI) = 1.047 (1.021, 1.074)], while those with $\geq$ 3 visits to primary healthcare institutions had 1.229 times higher likelihood [OR (95%CI) = 1.229 (1.191, 1.268)]. **Conclusion:** Gender and age are significant factors influencing avoidable hospitalization among elderly hypertensive patients. Higher per capita GDP, more frequent healthcare visits, and greater numbers of general practitioners were associated with increased likelihood of avoidable hospitalization, whereas increased numbers of secondary and tertiary hospitals did not elevate this risk.

Keywords: Hypertension; Aged; Avoidable hospitalization; Root cause analysis; Guangdong province

Introduction

Hypertension is the most common chronic disease and has been identified by the World Health Organization as a leading cause of death from cardiovascular and cerebrovascular diseases [1]. The prevalence of hypertension among Chinese adults aged 60 and older is 58.3% [2], and hospitalization costs for elderly hy-

pertensive patients have risen from 11,500 yuan in 2017 to 14,100 yuan in 2020 [4], consuming substantial medical and social resources. Hypertension is widely recognized as a condition amenable to avoidable hospitalization, with avoidable hospitalization costs in China reaching 29.789 billion yuan in 2020, primarily among those over 60 years old [3]. Timely and effective primary healthcare can prevent complications from chronic diseases including hypertension, reduce the risk of acute episodes, and prevent hospitalizations [5].

While numerous studies have examined hospitalization costs among hypertensive patients, few have utilized big data to investigate avoidable hospitalization rates in this population. To understand the current situation of avoidable hospitalization among elderly hypertensive patients in Guangdong Province and provide evidence for integrated medical communities to optimize healthcare resource allocation, this study was conducted.

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1. Materials and Methods

1.1 Data Sources Data were collected through the Guangdong Province Primary Healthcare Information Management System, Guangdong Province Universal Health Information Platform, and inpatient medical record homepage data. Oracle database was used to import the collected data. Using the Guangdong Provincial Public Security population database as the foundation, other datasets were linked through ID number matching for population tagging. ID numbers were used to precisely match and integrate different datasets, generating province-wide health information and 2022 hospitalization records for residents aged 65 and older. The dataset included name, sex, ID number, home address, phone number, and hospitalization records for conditions such as coronary heart disease, stroke, hypertension, diabetes, chronic kidney disease, chronic obstructive pulmonary disease (COPD), cancer, immunodeficiency diseases, disability, dialysis, and chemotherapy/radiotherapy.

Data on per capita GDP, general practitioners, and employed workers were obtained from the 2022 Guangdong Provincial Health Statistics Yearbook [6] and Guangdong Statistical Yearbook 2022 [7], with city-level data matched to individual cases.

1.2 Study Content The study examined the avoidable hospitalization rate among hypertensive patients aged 65 and older in 2022. Comparisons were made across different sexes, regions, age groups, city-level per capita GDP, hospital geographic accessibility, city-level general practitioner availability, city-level secondary/tertiary hospital density, and per capita visit frequency to secondary/tertiary hospitals.

1.3 Indicator Definitions Due to the absence of admission indications in the aggregated inpatient medical record data, the OECD definition of avoidable

hospitalization could not be applied. Based on data availability and reference to domestic and international literature [5,8], this study defined avoidable hospitalization for hypertension as hospitalizations in hypertensive patients without complications of coronary heart disease or stroke and without any comorbidities such as diabetes, chronic kidney disease, COPD, or cancer. Following the statistical method for resident hospitalization rates in the China Health Statistics Yearbook [9], the avoidable hospitalization rate for hypertension was calculated as the ratio of avoidable hospitalizations to the surveyed population.

1.4 Data Processing Based on the study objectives, only patients aged 65-94 years were retained. Samples with unknown death status and mismatched home and hospital locations were excluded. Patients with a discharge diagnosis of hypertension (ICD-10 codes I10-I15) were selected, yielding 715,909 cases with a median age of 73 (IQR: 10) years, including 314,412 males (43.92%). Among them, 217,810 cases (30.42%) were aged 65-69 years, and 618,055 cases (86.33%) resided in the Pearl River Delta region. There were 543,044 avoidable hypertension hospitalizations, yielding an avoidable hospitalization rate of 8.76%, which accounted for 75.85% of all hypertension-related hospitalizations.

For indicators such as geographic accessibility of primary healthcare institutions (square kilometers), density of secondary/tertiary hospitals (per 10,000 population), and per capita GDP, grouping was determined based on 2-4 categories from the study data. General practitioner availability (per 10,000 population) was dichotomized into <4 and $ $4 based on the ideal value specified in the National Health Commission' s 2022 evaluation notice for primary healthcare development indicators. Visit frequency was dichotomized into <3 and $ $3 visits based on the 2022 Guangdong Health Statistics Yearbook showing 2.99 outpatient/emergency visits per capita at primary healthcare institutions.

This study was approved by the Medical Research Ethics Review Committee of the Guangdong Provincial Center for Disease Control and Prevention.

1.5 Statistical Methods Data cleaning and analysis were performed using R version 4.3.0. Categorical data were presented as relative frequencies, with inter-group comparisons using ^{2} tests. Pairwise comparisons among multiple groups used Bonferroni correction. Cochran-Armitage trend test was applied for ordered categorical data. Multivariate logistic regression analysis was used to identify factors influencing avoidable hospitalization. Statistical significance was set at $P<0.05$.

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2. Results

2.1 Comparison of Avoidable Hospitalization Rates by Patient Characteristics Significant differences in avoidable hospitalization rates were observed across sex, region, age groups, city-level per capita GDP, hospital ge-

ographic accessibility, city-level general practitioner availability, city-level secondary/tertiary hospital density, and per capita visits to secondary/tertiary hospitals (P<0.05). No significant differences were found in geographic accessibility of primary healthcare institutions or per capita visits to these institutions (P>0.05). Detailed results are presented in .

2.2 Logistic Regression Analysis of Factors Influencing Avoidable Hospitalization Multivariate logistic regression analysis was conducted with avoidable hospitalization (yes=1, no=0) as the dependent variable and statistically significant variables from univariate analysis as independent variables. Correlation analysis was performed to test for multicollinearity, and variables with correlation coefficients $ $0.7 were excluded. The final model included sex, age, per capita GDP, number of general practitioners, number of secondary/tertiary hospitals, and visit frequency to these hospitals. Although per capita visits to primary healthcare institutions were not statistically significant in univariate analysis, they were included in the multivariate model due to their clinical relevance.

The results showed that female elderly hypertensive patients had higher odds of avoidable hospitalization than males [OR (95%CI) = 1.231 (1.217, 1.246)]. Compared with patients aged $ $90 years, those aged 65-69, 70-74, 75-79, and 80-84 years had 2.044 times [OR (95%CI) = 2.044 (1.981, 2.109)], 1.640 times [OR (95%CI) = 1.640 (1.590, 1.693)], 1.288 times [OR (95%CI) = 1.288 (1.248, 1.329)], and 1.110 times [OR (95%CI) = 1.110 (1.073, 1.147)] higher odds of avoidable hospitalization, respectively. Patients in areas with per capita GDP $ $100,000 yuan had 1.314 times higher odds [OR (95%CI) = 1.314 (1.278, 1.350)] than those in areas with lower per capita GDP. When general practitioner density was $ $4 per 10,000 population, the odds of avoidable hospitalization were 1.039 times higher [OR (95%CI) = 1.039 (1.105, 1.063)]. Having $ $0.20 secondary/tertiary hospitals per 10,000 population reduced the probability of avoidable hospitalization by 40.60% [OR (95%CI) = 0.594 (0.570, 0.619)]. Patients with $ $3 visits to secondary/tertiary hospitals had 1.047 times higher odds [OR (95%CI) = 1.047 (1.021, 1.074)], while those with $ $3 visits to primary healthcare institutions had 1.229 times higher odds [OR (95%CI) = 1.229 (1.191, 1.268)]. Results are detailed in .

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3. Discussion

3.1 Avoidable Hospitalization Avoidable hospitalizations refer to conditions that could have been prevented through timely and effective primary healthcare and disease management [10-12]. This study represents the first analysis of avoidable hospitalization among elderly hypertensive patients in Guangdong using 2022 inpatient medical record data and big data from the provincial primary healthcare information management system. It demonstrates a mean-

ingful attempt at data mining and analysis using health records and hospitalization data at the provincial level.

The results show an avoidable hospitalization rate of 8.76% for elderly hypertensive patients in Guangdong Province. The rate among those aged 65-74 years was 8.17% (327,947/4,014,513), substantially higher than Canada' s 3.6‰ hospitalization rate for uncomplicated hypertension in the same age group [5]. Austria reported a 7% avoidable hospitalization rate for chronic diseases in 2013 [13], while the US Medicare population had an average avoidable hospitalization rate of 7.16% in 2011 [14]. This study' s focus on hypertension alone yielded a rate exceeding 8%, suggesting that including other chronic conditions would result in an even higher rate. Domestic research indicates that the combined avoidable hospitalization rate for hypertension, COPD, and congestive heart failure in China is 13.01% [8], with approximately one in nine hospitalizations being avoidable and nearly 9 yuan of every 100 yuan in hospital expenses being unnecessary [15]. These findings underscore the need for urgent attention to avoidable hospitalization for hypertension in Guangdong, as inappropriate hospitalizations generate substantial medical costs and waste healthcare resources.

3.2 Influence of Sex and Age on Avoidable Hospitalization Female elderly hypertensive patients showed significantly higher rates of avoidable hospitalization than males, though the underlying reasons require further investigation. Patients aged 65-69 years had the highest likelihood of avoidable hospitalization, indicating the need for careful evaluation of hospitalization necessity in this age group. Research has shown that home-based telehealth interventions can achieve outcomes comparable to traditional inpatient care for certain conditions [16]. For elderly patients with avoidable conditions, wearable devices could be recommended to collect physiological indicators, transmit data, generate alerts, and provide feedback to patients and healthcare providers [17]. This approach promotes active self-management while healthcare provider involvement increases patient confidence and improves self-management behaviors, thereby improving outcomes and reducing medical costs, particularly hospitalization expenses [18]. Medical insurance and commercial insurance funds should adapt by covering or reimbursing wearable devices for chronic disease patients, shifting from a treatment-focused to a prevention-focused investment in health. This represents a fundamental change toward a health-centered approach that can achieve better health outcomes at lower costs. Additionally, experts should develop localized avoidable hospitalization indicators appropriate for China' s context, standardize hospital admission criteria, and strengthen implementation through performance assessments to prevent resource waste.

3.3 Influence of Visit Frequency and General Practitioner Numbers A positive correlation exists between outpatient and inpatient service utilization [19], a finding confirmed by this study. Both secondary/tertiary hospitals and primary healthcare institutions showed increased odds of avoidable hospitalization with $ $3 visits compared with <3 visits. Chen et al. [19] reported that

while urban-rural resident basic medical insurance increased hospitalization utilization among middle-aged and elderly individuals, it also created incentives for overutilization. Furthermore, increasing inpatient admissions remains a primary revenue source for primary healthcare institutions, and insurance policies with higher reimbursement rates for inpatient than outpatient services create incentives for excessive hospitalization [20].

General practitioner workforce development has received considerable attention, with numbers continuing to grow. However, this study found that areas with $ $4 general practitioners per 10,000 population had 1.039 times higher odds of avoidable hospitalization than areas with fewer practitioners. This contrasts with international research showing a significant negative correlation between general practitioner density and avoidable hospitalization, with each standard deviation increase in general practitioners per 1,000 residents associated with an 8.7% reduction in avoidable hospitalizations [11]. This discrepancy likely reflects that China' s general practitioner workforce is dominated by physicians who transitioned through rapid retraining programs. While their designation changed, their disease-centered mindset and institution' s revenue model based on treating illness and receiving insurance payments remained unchanged. Under this paradigm, more general practitioners lead to more patient visits and higher odds of avoidable hospitalization.

Avoidable hospitalization conditions share characteristics of high prevalence, substantial economic burden, and strong intervention potential. Timely outpatient services, health management, and public health interventions can reduce hospitalization demand and promote the effective operation of China' s tiered healthcare system. On May 23, 2024, the National Health Commission introduced policies to promote the "Sanming healthcare reform experience" from Fujian Province, aiming to advance integrated medical community construction. Through "surplus retention" policies within medical communities, institutions at all levels will be incentivized to control avoidable hospitalizations and truly achieve cost savings. General practitioners play a pivotal role in hypertension prevention, control, and cost containment. Guangdong must continue investing in general practitioner workforce development, empowering them to become a new productive force delivering integrated public health, basic medical care, and health management services. As "health gatekeepers and insurance cost controllers," general practitioners can help patients develop self-management skills to achieve optimal health status, reduce avoidable hospitalization rates, and enhance their professional value and sense of achievement.

3.4 Per Capita GDP as a Factor Influencing Avoidable Hospitalization
This study used per capita GDP as a measure of income level [21]. Contrary to studies reporting that residents in low-income areas have higher hospitalization rates due to lack of timely healthcare access [22,23], this study found that higher per capita GDP was associated with increased odds of avoidable hospitalization, consistent with Chen' s research [24]. Zhao [25] reported that per capita GDP

was positively correlated with avoidable hospitalization for diabetes, with each 10% increase in per capita GDP associated with approximately 7.70 additional avoidable hospitalizations per 100,000 population. Higher-income populations have higher hospitalization rates [26], reflecting greater health awareness and demand for healthcare services. Future efforts should strengthen relationships between family doctors and residents, particularly focusing on health status of low-income populations and providing timely preventive care to reduce avoidable hospitalizations. For high-income populations, high-quality outpatient services and health education should be provided to prevent unnecessary utilization of inpatient resources.

3.5 Influence of Secondary and Tertiary Hospital Numbers Having $ $0.20 secondary and tertiary hospitals per 10,000 population reduced the probability of avoidable hospitalization by 40.60% compared with areas having <0.20 hospitals per 10,000 population. In 2017, Guangdong Province issued implementation plans for deepening basic medical insurance payment reform and became the first province nationwide to implement diagnosis-intervention packet (DIP) payment reform in 2018. That same year, Guangdong launched high-level hospital construction initiatives, with provincial fiscal investment of 21.5 billion yuan supporting 70 high-level hospitals and cross-regional collaboration projects, achieving full coverage across all 21 prefecture-level cities. DIP payment weights differ between secondary/tertiary hospitals and primary healthcare institutions, with policies favoring innovative technologies in key disciplines at high-level hospitals. Under these policy incentives, despite increased numbers of large hospitals in Guangdong, the likelihood of avoidable hospitalization for hypertension decreased.

Limitations Due to data availability limitations, disease classification was based solely on ICD-10 codes, which may contain some diagnostic inaccuracies. Additionally, basic demographic information such as education level and insurance type was not available during data integration. Using integrated data on hypertension-related avoidable hospitalization as the dependent variable while matching city-level data on general practitioner density and per capita GDP from statistical yearbooks may have reduced precision. Despite these limitations, this study reveals the current status of avoidable hospitalization among elderly hypertensive patients in Guangdong using big data, providing insights for medical insurance reform and highlighting the urgency of establishing a provincial avoidable hospitalization disease list and cost-containment strategies within integrated medical communities.

Conclusion The avoidable hospitalization rate for elderly hypertensive patients in Guangdong Province is 8.76%, with the single-disease rate exceeding the combined avoidable hospitalization rates for all chronic diseases in countries like the US and Austria. The substantial waste of medical resources caused by inappropriate hospitalizations warrants serious attention. Gender, age, per capita

GDP, healthcare visit frequency, and general practitioner availability are key influencing factors. Increased numbers of secondary and tertiary hospitals did not elevate avoidable hospitalization risk. These findings provide important evidence for healthcare resource optimization and policy development in integrated medical communities.

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Conflict of Interest: The authors declare no conflicts of interest.

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