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Meta-analysis of the Impact of Age on Hypertension Prevalence among Adult Residents in China

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Abstract: In this work, a systematic review was conducted to evaluate the association between age and hypertension prevalence among adult residents in China. By searching databases including CNKI, Wanfang Medical Database, and VIP from January 2001 to December 2016, cross-sectional studies on hypertension prevalence in Chinese adults were retrieved. After screening literature according to inclusion and exclusion criteria, extracting data, and assessing quality, a total of 10 studies with a combined sample size of 99,470 individuals were included. Meta-analysis using RevMan 5.3 software revealed that the hypertension prevalence in the group aged <45 years was significantly lower than that in middle-aged and elderly groups, with the highest prevalence observed in the group aged >65 years. Statistically significant differences in prevalence rates were noted among different age groups (subgroup test χ^2=182.29, P<0.00001), with a prevalence difference of 0.27 (95% CI: 0.21-0.32) between the <45 years and >65 years groups. This study highlights that hypertension prevalence among adult residents in China increases significantly with age, indicating that the elderly population represents a key focus for hypertension prevention and control efforts. Stratified intervention strategies tailored to different age groups are warranted to address this public health challenge effectively.

Keywords: Age; Hypertension; Prevalence; Meta-analysis.

1. Introduction

1.1. Research Background

Hypertension is the primary risk factor for cardiovascular diseases in China. According to the "China Cardiovascular Health and Disease Report 2023," the prevalence of hypertension among individuals aged 18 and above in China reaches 23.2%, with more than 330 million people affected. Following the adjustment of diagnostic criteria in the 2022 "Chinese Hypertension Clinical Practice Guidelines," the newly identified population requiring prevention and control is approximately 130 million, with a significant increase among young people aged 35-44. Hypertension in China shows characteristics of "prominent youth onset and high prevalence among the elderly," and its association with stroke and coronary heart disease is stronger than the global average (62.4% of stroke deaths in China are related to hypertension).

Age is a core risk factor for hypertension, but existing studies largely focus on individual regions or age groups, lacking nationwide systematic integration across age groups. This study uses meta-analysis to clarify the quantitative relationship between age and hypertension prevalence in the Chinese population, providing evidence for stratified prevention and control.

1.2. Research Objectives

(1). To combine data on hypertension prevalence among adult residents of different age groups in China (<45 years, 45-65 years, >65 years);

(2). To analyze the differences in hypertension prevalence among different age groups and the sources of heterogeneity;

(3). To provide age-specific recommendations for hypertension prevention and control.

1.3. Literature Review

(1). Current Research Status: Some studies using multivariate unconditional logistic regression analysis indicate that the prevalence of hypertension is mainly associated with factors such as gender, age, and personal characteristics, as well as overweight or obesity and dyslipidemia. The prevalence in men is significantly higher than in women, and as age increases, the prevalence of hypertension also shows a marked upward trend, rising rapidly after age 40 [1]. Additionally, other studies have shown that the prevalence of hypertension increases with age; residents with lower educational levels have a higher prevalence of hypertension; individuals with lower household annual income have a higher prevalence of hypertension; people who are unaware of hypertension-related knowledge have a higher prevalence than those who are informed; those who self-report consuming less than 25g of oil per day have a higher prevalence; the higher the frequency of alcohol consumption, the higher the prevalence; overweight and obese individuals have a higher prevalence than the normal population; and diabetic patients have a higher prevalence than normal individuals, with all differences being statistically significant (P<0.05) [2]. Therefore, this paper analyzes the prevalence of hypertension across different age groups to illustrate the impact of age on prevalence.

(2). Research Significance: Investigating the prevalence of hypertension across different age groups provides guidance for selecting different preventive measures for people of different ages, helping to prevent and control hypertension, reduce its prevalence, and improve physical health and quality of life.

(3). Research Innovation: This study integrates data from multiple cross-sectional studies conducted across different regions in the east, central, and western parts of China through meta-analysis, with a total sample size of nearly 100,000

individuals. Specifically, the data encompass a detailed survey on the prevalence of hypertension among residents in Jiangyin City, revealing that the prevalence rate of hypertension among Jiangyin residents in 2012 was 22.08%, with a rising trend in prevalence with increasing age (P<0.001) [3]. It also includes an in-depth analysis of the prevalence and influencing factors of hypertension among adults in rural areas of Henan Province, indicating that the prevalence rate of hypertension among rural adults in Henan was 33.2%, with obesity, diabetes, and dyslipidemia being independent risk factors for hypertension [4]. Furthermore, the study explores the association between the prevalence of primary hypertension and its risk factors among rural community residents in Henan, showing that the prevalence rate of primary hypertension among these residents was 25.61%, with overweight/obesity and serum triglyceride levels being independent risk factors for hypertension [5]. Additionally, it examines gender differences in the prevalence of hypertension in Hubei Province, finding a statistically significant difference in the prevalence rates of hypertension between males and females (P<0.05) [6]. The survey on the prevalence of hypertension among 10,408 adults in Liuzhou City reveals that the prevalence of hypertension among adults in Liuzhou has reached a high level, with patients often accompanied by glucose and lipid metabolism abnormalities [7]. The follow-up survey on the prevalence of hypertension in Liuzhou City indicates a standardized prevalence rate of hypertension of 12.85% [8]. A comprehensive assessment of the prevalence, awareness, treatment, and control rates of hypertension in Wuzhong City, Ningxia, shows that the prevalence rate of hypertension in Wuzhong was 23.7%, with awareness, treatment, and control rates of 73.9%, 63.3%, and 20.9%, respectively [9]. A systematic analysis of the prevalence, awareness, treatment, and control rates of hypertension among community residents indicates that the prevalence rate of hypertension was 31.5% (36.2% for males and 27.8% for females), with a standardized prevalence rate of 24.8% (30.5% for males and 21.0% for females) [10]. The survey data on the prevalence of hypertension among individuals aged 15 and above in Wenzhou City reveals a hypertension prevalence rate of 38.97% and a standardized rate of 22.27% [11]. Finally, the survey results on the prevalence and awareness of hypertension among community populations in Zhejiang Province show a hypertension prevalence rate of 33.4% and a standardized rate of 18.7% [12]. These studies collectively provide a comprehensive overview of the current status and influencing factors of hypertension prevalence among different populations and regions in China. Compared with studies focusing on a single region or small sample sizes, this approach more comprehensively reflects the relationship between age and hypertension prevalence among Chinese adults, enhancing the reliability and generalizability of the conclusions. Additionally, it clearly defines stratification standards for young (<45 years), middle-aged (45-65 years), and elderly (>65 years) groups. By quantifying and comparing the differences in hypertension prevalence among different age groups and assessing statistical significance, the study clearly reveals the relationship between aging and hypertension risk, providing precise data support for stratified prevention and control.

(4). Feasibility Analysis: Existing research has accumulated sufficiently, providing a solid data foundation and methodological reference for further in-depth studies. Meanwhile, the physiological mechanisms linking age and hypertension, as well as the interactions between behavioral and environmental factors, have been supported by numerous studies. The theoretical framework is mature, capable of supporting further in-depth research. Regarding data acquisition, major domestic databases (CNKI, Wanfang, VIP) and international databases (PubMed, Embase) comprehensively cover relevant research literature. In terms of technical support, statistical methods such as meta-analysis and heterogeneity analysis are widely used in epidemiological research, and existing statistical software (e.g., Stata, RevMan) meets data processing needs without requiring additional technological breakthroughs. The study focuses on the characteristics of hypertension among adult residents of different age groups in China, and the proposed age- and region-specific prevention and control recommendations align with the practical needs of hypertension prevention and control in China. Currently, China has established a comprehensive primary healthcare system (e.g., community health service centers, township health centers), and public awareness of hypertension prevention and control is gradually increasing. Interventions such as health education for young people and blood pressure monitoring for the elderly are relatively well accepted, which facilitates the promotion and application of research findings.

(5). Future Research Directions: Conduct studies on the molecular mechanisms of age-related hypertension, such as gene regulation and epigenetic modifications, to clarify the interactions between age, genetics, and environmental factors, providing theoretical support for the formulation of targeted prevention and control measures. Strengthen large-sample, multicenter cohort studies on young and elderly populations to clarify the characteristics of the age-prevalence relationship; establish standardized research designs and data collection protocols, using consistent hypertension diagnostic criteria and age grouping standards to reduce heterogeneity across studies; and introduce precision medicine technologies (e.g., metabolomics, imaging) to enhance research depth and improve the reliability and stability of results.

2. Research Methods

First, it is necessary to clarify the research methods. In terms of literature search strategies, with the "Chinese population" as the core focus, the databases selected included China National Knowledge Infrastructure (CNKI), Wanfang Data, VIP Database (VIP), PubMed, and Embase, with the Chinese databases being the primary focus, accounting for no less than 70%. The search terms combined subject headings and free-text words. Chinese search terms included hypertension, prevalence, and age, while English search terms included age, prevalence, and hypertension. Taking the Wanfang database as an example, the search strategy is as follows: first, the subject was (Age OR Age group) AND (Hypertension prevalence OR Hypertension) AND Influencing factors; second, the title or keywords were (Age OR Age stratification) AND (Hypertension OR Primary hypertension) AND (Prevalence OR Incidence); third, the abstract was (The effect of age on hypertension) AND abstract: (Prevalence Analysis). At the same time, the search timeframe was set from the database's inception to December 21, 2016.

After completing the literature screening, the process moved on to data extraction and quality assessment. Data extraction was conducted independently by one researcher.

The extracted information included the author, year, region, sample size/prevalence for each age group, diagnostic criteria, sampling methods, and other relevant details. For quality assessment, the AXIS tool for cross-sectional studies was used, evaluating studies across four dimensions: study design, sample representativeness, data collection, and reporting of results. Studies scoring ≥7 were considered high-quality, although this study included only studies with scores ≥6.

Next, statistical analysis was conducted. Firstly, data were pooled using RevMan 5.3 software. Heterogeneity was then tested using the I^2 statistic and Q test; if I^2>50% or P<0.1, significant heterogeneity was indicated, in which case a random-effects model was used; if $I^2 \leq 50\%$ and $P \geq 0.1$, a fixed-effects model was applied. Additionally, publication bias was assessed by constructing a funnel plot and performing Egger's test; P<0.05 indicated the presence of publication bias. Finally, a sensitivity analysis was conducted by sequentially removing individual studies and reanalyzing the pooled data to observe changes in prevalence; if the change exceeded 5%, the results were considered unstable.

3. Research Results

Based on the above research methods, the study results were ultimately obtained. In terms of overall results, a total of 10 studies were included, with a total sample size of 99,470 people, covering multiple provinces in China. Figure 1 intuitively presents the analysis results of hypertension prevalence differences among different age subgroups in the form of a forest plot. In the subgroup analysis, using the "<45 years group" as the reference, the prevalence differences for the 45–65 years and >65 years groups were analyzed. For the 45–65 years group, detailed information such as the number of cases and total participants in each study is presented, and the combined prevalence difference is 0.07 (95% CI: 0.04–0.10, P<0.00001), indicating that the prevalence in this group is 7 percentage points higher than that in the <45 years group. However, there is considerable heterogeneity among the studies (I^2 = 96%), as seen in the forest plot where the confidence intervals of each study vary widely, which may contribute to the high heterogeneity. For the >65 years group, the study data are also presented in detail, with a combined prevalence difference of 0.27 (95% CI: 0.21–0.32, P<0.00001), meaning the prevalence in this group is 27 percentage points higher than in the <45 years group, with similarly high heterogeneity among studies (I^2 = 96%). Figure 2 presents a funnel plot (here using a plot of SE(RD) versus RD to partially illustrate related analyses, which, while not a traditional funnel plot, helps to understand heterogeneity), where different shapes represent different age subgroups. The distribution of data points across studies is relatively scattered, which to some extent reflects the heterogeneity among studies. Subgroup difference tests show significant differences in prevalence among age groups (χ^2 = 182.29, df = 2, P<0.00001), further confirming that age is a key factor influencing hypertension prevalence.

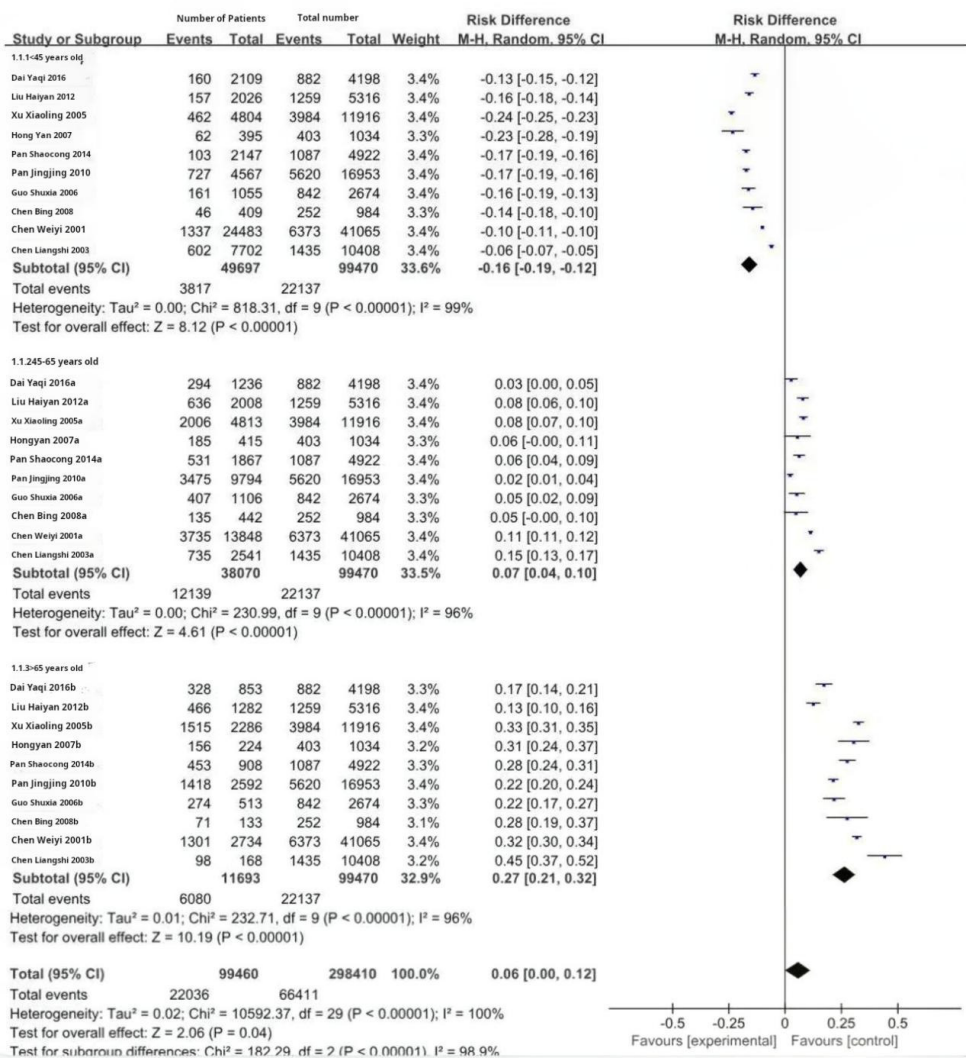


Figure 1. Meta-analysis forest plot of the effect of age on hypertension prevalence among adult residents in China

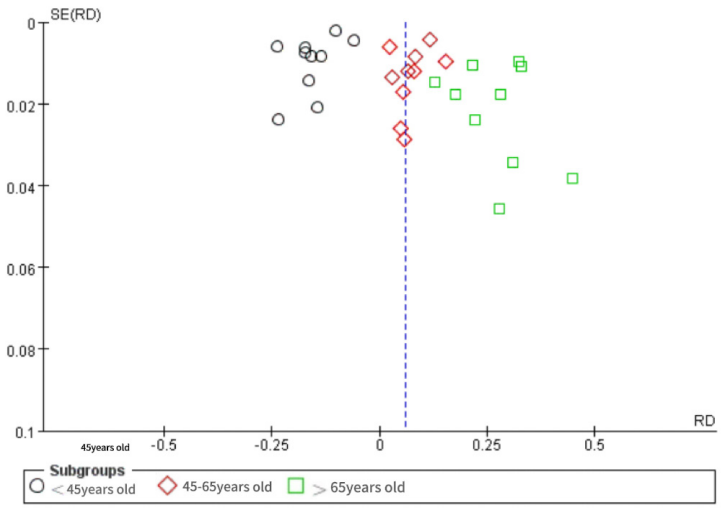


Figure 2. Funnel Plot of Meta-Analysis on the Impact of Age on Hypertension Prevalence Among Chinese Adult

Possible sources of heterogeneity: (1). Factors related to the study population Demographic differences: Different studies covered multiple provinces in China, and populations in various regions differ in genetic background, dietary habits (e.g., lighter flavors in the south, stronger flavors in the north), lifestyle (exercise frequency, daily routines, etc.), and other aspects. These factors can all affect the prevalence of hypertension, leading to significant differences in results between studies. (2). Age structure bias: Although age grouping was conducted, the proportion of different age groups within each study may vary. For example, some studies have a relatively higher proportion of participants under 45, whereas others have more participants aged 45–65 or over 65. Differences in age structure directly affect the calculation of prevalence, thereby contributing to heterogeneity. (3). Differences in sampling methods: Studies may have used different sampling methods, such as random sampling or stratified sampling. Different sampling approaches can affect how representative the sample is of the general population, resulting in differences in population characteristics included in each study and impacting the measurement of prevalence, which causes heterogeneity. (4). Variation in sample size: There is a large difference in the total number of participants and the number with hypertension across studies. Small-sample studies are more susceptible to random error, which can cause greater result fluctuations, whereas large-sample studies tend to yield more stable results. These differences in sample size can lead to heterogeneity between study outcomes. (5). Other factors: The literature search timeframe was from the database inception to December 21, 2016, spanning a considerable period. During this time, social environment, medical levels, and people's awareness and preventive attitudes towards hypertension may have changed. These changes could affect study results from different periods, leading to the emergence of heterogeneity.

4. Discussion

Based on the results of the study, it can be concluded that the prevalence of hypertension in our country adult residents increases significantly with age, among which the prevalence rate is 27 percentage points higher in the >65-year-old group than in the <45-year-old group, and 7 percentage points higher in the 45-65-year-old group. Based on this conclusion, it is recommended to implement hierarchical prevention and control measures for different age groups: for people under 45 years old, lifestyle interventions such as low-salt diet and exercise should be strengthened; In terms of low-salt diet, communities and units can jointly carry out healthy eating publicity activities. Communities can hold regular healthy eating lectures and invite nutrition experts to explain the importance of a low-salt diet to residents and how to reasonably control salt intake, such as introducing alternatives to common high-salt foods, such as replacing regular salt with low-sodium salt, and replacing part of the salt with natural spices such as onion, ginger, garlic, peppercorns, etc. Units can also set up a special area for low-salt dishes in the canteen to mark the salt content of the dishes and guide employees to choose a low-salt diet. At the same time, use social media platforms, such as WeChat public accounts, Douyin, etc., to publish low-salt diet tips and healthy recipes to expand publicity coverage. At the level of exercise intervention, young people are encouraged to use fragmented time to exercise. The community can add fitness facilities, such as fitness paths, basketball courts, badminton courts, etc., and organize regular fitness activities, such as aerobics competitions, night running activities, etc., to stimulate young people's enthusiasm for sports. For people aged 45-65, regular physical examinations are conducted to check for potential diseases, so as to achieve "early detection", "early diagnosis" and "early treatment". Develop good eating habits and living habits, control sugar and limit alcohol, and strengthen exercise. For the elderly aged 65 and above, blood pressure monitoring tools and monitoring management models should be optimized to improve the blood pressure control rate. The community health service center can regularly carry out special training on blood pressure monitoring for elderly hypertensive patients, covering practical points such as sphygmomanometer selection, cuff adaptation standards, standardized measurement posture and optimal measurement time; At the same time, guide the elderly to establish standardized blood pressure monitoring files, and standardize the recording of blood pressure values at different times of day by formulating a structured blood pressure record form, so as to provide continuous and complete data support for dynamic changes in blood pressure for clinical diagnosis and treatment. In order to strengthen the compliance of blood pressure monitoring in the elderly, a diversified incentive mechanism can be established to give material rewards (such as health gifts, physical examination coupons, etc.) to the

elderly who have completed regular blood pressure monitoring and have complete records. In addition, smart wearable devices (such as smart bracelets, smart watches, etc.) can be introduced to build a real-time monitoring system to realize the dynamic tracking of core health indicators such as blood pressure and heart rate for the elderly, and connect with the terminals of children and doctors through data synchronization functions, providing technical support for early identification and timely intervention of potential health risks.

5. Conclusion

This study shows a marked rise in hypertension prevalence among Chinese adults with age, especially the elderly. We stress the need for age-specific, stratified prevention and control strategies. For those under 45, early lifestyle changes, like low-salt diets and exercise, are vital. The 45-65 group needs more frequent health checks and healthy habit formation. For the over-65s, optimizing blood pressure monitoring with smart tech to boost efficiency and compliance is crucial for better control. Future research should delve into the effectiveness of these measures across age groups and how to better integrate community, workplace, and family resources to create a comprehensive hypertension prevention network, offering practical and theoretical insights for similar studies.

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