Trends in Disease Burden of Hearing Loss Among Middle-Aged and Elderly Adults in China, 1990-2021: Postprint

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Abstract

Background Hearing loss is a common health issue among middle-aged and elderly individuals, affecting quality of life and social participation, and is associated with the risk of cognitive decline. In recent years, population aging in China has intensified, with an increasing proportion of middle-aged and elderly individuals; however, the trends in the disease burden of hearing loss in this population from 1990 to 2021 remain unclear.

Objective To analyze the trends in the disease burden of hearing loss among middle-aged and elderly people in China from 1990 to 2021, and to provide evidence for formulating effective public health strategies and medical resource allocation.

Methods Based on data regarding the disease burden of hearing loss among individuals aged $ $55 years in China extracted from the Global Burden of Disease Study 2021 (GBD 2021) database, including case numbers, disability-adjusted life years (DALYs), prevalence, DALY rates, and their standardized rates. Joinpoint regression analysis was employed to investigate the trends and inflection points in the disease burden of hearing loss among individuals aged $ $55 years in China, and an age-period-cohort model was utilized to estimate the age, period, and cohort effects on the prevalence of hearing loss in China.

Results From 1990 to 2021, the number of cases, prevalence, DALYs, and DALY rate of hearing loss among individuals aged $ $55 years in China all increased, with cases rising from 100.997 million to 286.859 million, prevalence increasing from 70,372.2/100,000 to 75,697.3/100,000, DALYs increasing from 2.814 million person-years to 8.712 million person-years, and DALY rate increasing from 1,961.0/100,000 person-years to 2,298.9/100,000 person-years. Joinpoint regression analysis revealed that from 1990 to 2021, the prevalence, DALY rate,

age-standardized prevalence, and age-standardized DALY rate of hearing loss among individuals aged $ $55 years in China all exhibited increasing trends, with average annual percent changes (AAPC) of 0.24%, 0.53%, 0.19%, and 0.28%, respectively (all P<0.05). The disease burden was slightly higher in males than in females. The age-standardized prevalence rate (ASPR) of hearing loss in males increased most rapidly during 2000-2009, with an APC of 0.31% (P<0.05); the age-standardized DALY rate (ASDR) increased most rapidly during 2001-2004, with an APC of 1.68% (P<0.05). For females, both the ASPR and ASDR of hearing loss increased most rapidly during 2015-2019 (APC of 0.47% and 0.91%, respectively, P<0.05); however, they showed a decreasing trend during 2019-2021 (APC of -0.07% and -0.23%, respectively, P<0.05). The age effect demonstrated that the prevalence of hearing loss among individuals aged $ $55 years initially increased and then remained stable with age, with relative risk (RR) ranging from 0.74 to 1.08 across age groups; the period effect indicated that prevalence increased monotonically over time, with RR ranging from 0.96 to 1.05 across periods; the cohort effect showed that prevalence gradually decreased with successive birth cohorts, with RR ranging from 0.96 to 1.06 across birth cohorts. No significant gender differences were observed in these effects.

Conclusion From 1990 to 2021, the burden of hearing loss among middle-aged and elderly individuals in China has gradually increased, with notable gender differences.

Full Text

Analysis on the Trend of Disease Burden of Hearing Loss in Middle-aged and Elderly People in China from 1990 to 2021

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Abstract

Background: Hearing loss is a prevalent health issue among middle-aged and older adults, adversely affecting quality of life and social interaction, and is associated with an increased risk of cognitive decline. With China' s deepening population aging and growing proportion of middle-aged and older adults,

trends in the disease burden of hearing loss within this demographic from 1990 to 2021 remain unclear.

Objective: To analyze trends in the disease burden of hearing loss among middle-aged and older adults ($ $55 years) in China from 1990 to 2021, providing evidence for formulating effective public health strategies and healthcare resource allocation.

Methods: Data on the disease burden of hearing loss for individuals aged $ $55 years in China were extracted from the Global Burden of Disease Study 2021 (GBD 2021). This included prevalence counts, Disability-Adjusted Life Years (DALYs), prevalence rates, DALY rates, and their age-standardized rates. Joinpoint regression analysis was employed to identify temporal trends and inflection points in the disease burden. The age-period-cohort model was utilized to estimate the age, period, and cohort effects on hearing loss prevalence rates.

Results: From 1990 to 2021, the number of prevalent cases, prevalence rate, number of DALYs, and DALY rate for hearing loss among individuals $ $55 years in China all increased. Prevalent cases rose from 100.99 million to 286.85 million, while the prevalence rate increased from 70,372.2 per 100,000 to 75,697.3 per 100,000. DALYs increased from 2.81 million person-years to 8.71 million person-years, and the DALY rate increased from 1,961.0 per 100,000 person-years to 2,298.9 per 100,000 person-years. Joinpoint regression indicated a consistent upward trend during 1990–2021 for crude prevalence rate, crude DALY rate, age-standardized prevalence rate (ASPR), and age-standardized DALY rate (ASDR). The average annual percentage changes (AAPC) were 0.24%, 0.53%, 0.19%, and 0.28%, respectively (all $P<0.05$). The disease burden was slightly higher in males than in females. The male ASPR increased most rapidly during 2000–2009 (APC=0.31%, $P<0.05$), while the male ASDR increased most rapidly during 2001–2004 (APC=1.68%, $P<0.05$). The female ASPR and ASDR both increased most rapidly during 2015–2019 (APC=0.47% and 0.91%, respectively; $P<0.05$) but showed declining trends during 2019–2021 (APC=-0.07% and -0.23%, respectively; $P<0.05$). The age-period-cohort model revealed that the age effect manifested as an initial increase followed by stabilization in prevalence rates with advancing age among those $ $55 years (RR ranged 0.74 to 1.08 across age groups). The period effect showed a monotonic increase in prevalence rates over time (RR ranged 0.96 to 1.05 across periods). The cohort effect indicated a gradual decrease in prevalence with more recent birth cohorts (RR ranged 0.96 to 1.06 across cohorts). Gender differences in these effects were not pronounced.

Conclusion: The burden of hearing loss among middle-aged and older adults in China steadily increased from 1990 to 2021, with discernible gender disparities in trends.

Key words: Hearing loss; Disease burden; DALY; Prevalence rate; Age-period-cohort model

Introduction

Hearing loss, also known as hearing impairment, refers to functional abnormalities in the sound transmission, perception, or comprehensive analysis components of the auditory system, resulting in varying degrees of hearing decline. As the most widely distributed sensory organ disorder worldwide, hearing loss affected 407 million people in China in 2019, with an age-standardized prevalence rate as high as 21.11%—a growth rate exceeding the global average [1]. The global health loss burden attributable to hearing loss is estimated at 43.4 million disability years [2], making it the third leading cause of years lived with disability after low back pain and migraine [3]. Middle-aged and elderly populations constitute the primary affected group, with 62.1% of hearing loss patients being over 50 years old [4]. Due to degenerative changes in the auditory system during natural aging and cumulative effects of long-term noise exposure, the risk of hearing loss among middle-aged and older adults increases significantly. Previous studies have reported a prevalence as high as 37% among individuals aged $ $65 years [5].

The impact of hearing loss on middle-aged and older adults is extensive, not only reducing quality of life but also increasing social medical burden [6]. However, the public currently underestimates the impact of hearing impairment on quality of life and health in older adults [7]. In daily life, older adults with hearing loss experience limited verbal communication abilities, reduced social participation, and are prone to social isolation [8]. Additionally, hearing loss is closely associated with anxiety and depression [9-10], represents an important risk factor for cognitive decline [11-12], affects balance ability, and increases fall risk among middle-aged and older adults [13-14].

Accurately understanding trends in the disease burden of hearing loss in China is crucial for developing prevention and control strategies. The age-period-cohort model, based on epidemiological principles, can effectively separate age, period, and birth cohort effects, overcoming limitations of traditional analytical methods that cannot distinguish influences of different factors, thereby providing deeper insights for disease trend research. However, current research on hearing loss burden trends in China rarely employs this model for in-depth analysis, focusing mostly on descriptive statistics of the entire population and lacking exploration of interactions among factors specific to middle-aged and older adults. This study, based on the GBD 2021 database, utilizes the age-period-cohort model to dissect trends in hearing loss disease burden among middle-aged and older adults in China, aiming to clarify the influence of various factors and provide scientific evidence for formulating hearing health interventions.

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1. Methods

1.1 Data Sources All data for this study were extracted from the Global Burden of Disease Study 2021 (GBD 2021) database [15], released by the Insti-

tute for Health Metrics and Evaluation at the University of Washington. This database employs standardized disease statistical indicators and burden assessment methods to systematically evaluate the disease burden caused by 389 diseases and injuries and 87 risk factors across 204 countries and regions worldwide, providing important evidence for global health policy formulation. This study selected data on age-related and other hearing loss in mainland China (excluding Taiwan Province) from GBD 2021 for analysis.

1.2 Disease Definition and Indicator Extraction In GBD 2021, hearing loss is defined as: in a quiet environment, using the better-hearing ear as the standard, the average pure-tone hearing threshold at four specific frequencies (0.5, 1.0, 2.0, and 4.0 kHz) represents the minimum volume an individual can perceive. If the average pure-tone hearing threshold is $ $20 dB, it is defined as hearing loss, with severity graded from mild to profound.

Since hearing loss primarily occurs in older populations, this study selected hearing loss data for individuals aged $ $55 years in China from the GBD database (1990–2021). The disease burden was quantified using prevalence counts/rates, DALY counts/rates, and their age-standardized rates across different years, genders, and age groups. Prevalence counts provide a direct measure of the overall scope of hearing loss impact. Prevalence rates, linked to specific populations, accurately reflect the relative burden and facilitate multidimensional comparisons for prevention strategies. DALYs comprehensively capture premature mortality and disability losses, reflecting the overall impact of hearing loss on health and quality of life. The DALY rate eliminates demographic factors for objective disease burden assessment. Age-standardized rates remove the influence of age structure differences, enabling precise comparison of prevalence and DALY levels across different populations and years.

Individuals aged $ $55 years were grouped into nine age groups at 5-year intervals. To avoid temporal overlap between adjacent birth cohorts, analysis was conducted at specific time points: 1994, 1999, ···, 2021. Birth cohorts were calculated by subtracting age from the corresponding year.

1.3 Statistical Methods Data were organized using Excel 2019. Prevalence counts/rates, DALY counts/rates, age-standardized prevalence rate (ASPR), and age-standardized DALY rate (ASDR) were used to describe the hearing loss disease burden across different years, genders, and ages. Joinpoint Regression Program 4.9.1.0 was employed for Joinpoint regression analysis to explore local variation characteristics in hearing loss trends. This model identifies inflection points (joinpoints) in disease development, segments overall trends accordingly, and calculates annual percent change (APC), estimated annual percent change (EAPC), and average annual percent change (AAPC). APC refers to the percentage change in trend during a specific period. In Joinpoint models, each period has an APC indicating growth or decline rate. EAPC measures the APC estimated by the statistical model for a given period. AAPC represents the average

percentage change in trend throughout the entire study period, calculated as a weighted average of all APCs to comprehensively reflect overall trends.

The age-period-cohort model was constructed using the intrinsic estimator method, which constrains the sum of coefficients for age, period, and cohort groups to zero, thereby excluding confounding effects among the three factors. The model' s primary parameters are relative risk (RR) values for age, period, and cohort, which describe hearing loss risk levels in China. The average risk across age, period, and birth cohorts was set as the reference. RR>1 indicates increased risk, while RR<1 indicates decreased risk, with higher values representing greater risk. Stata 14.0 was used to construct the age-period-cohort model, and the "ggplot" package in R 4.2.3 was used for visualization. A two-sided significance level of α=0.05 was applied.

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2. Results

2.1 Trends in Disease Burden of Hearing Loss Among Individuals Aged $ $55 Years in China From 1990 to 2021, the number of prevalent cases, prevalence rate, DALY count, and DALY rate for hearing loss among individuals aged $ $55 years in China all increased. Prevalent cases rose from 100.997 million to 286.859 million, and the prevalence rate increased from 70,372.2 per 100,000 to 75,697.3 per 100,000. DALYs increased from 2.814 million person-years to 8.712 million person-years, and the DALY rate increased from 1,961.0 per 100,000 person-years to 2,298.9 per 100,000 person-years. The EAPC for prevalence rate and DALY rate were 0.24% and 0.53%, respectively. Among males, prevalent cases increased from 50.173 million to 140.934 million, while among females they increased from 50.824 million to 145.924 million. The EAPC for prevalence rate was 0.25% in males and 0.23% in females; for DALY rate, 0.57% in males and 0.48% in females. Both prevalence and DALY counts increased significantly across all age groups.

When residents aged $ $55 years were grouped into nine age groups at 5-year intervals, the 55–59 age group showed an increase in prevalent cases from 24.668 million to 65.797 million and DALYs from 522,000 person-years to 1.445 million person-years. The 80–84 age group showed an increase in prevalent cases from 4.555 million to 17.624 million and DALYs from 204,000 person-years to 804,000 person-years. The DALY rate EAPC for the $ $90 age group showed negative growth (-0.01% to -0.06%). See Table 1 .

2.2 Joinpoint Analysis of Disease Burden of Hearing Loss Among Individuals Aged $ $55 Years in China Joinpoint regression analysis revealed that the DALY rate for hearing loss among individuals aged $ $55 years increased most significantly during 2014–2018 (APC=1.77%, P<0.05). The prevalence rate also increased notably during this period (APC=0.93%, P<0.05). The ASPR showed an upward trend during 2015–2019 (APC=0.48%, P<0.05),

and the ASDR increased during 2014–2019 (APC=0.78%, P<0.05). After 2019, the growth rate of all indicators slowed or showed slight declines. Overall, from 1990 to 2021, the prevalence rate, DALY rate, ASPR, and ASDR among individuals aged $ $55 years in China all showed upward trends, with AAPCs of 0.24%, 0.53%, 0.19%, and 0.28%, respectively (P<0.05). See Figure 1 [Figure 1: see original paper].

From 1990 to 2021, prevalence rates, DALY rates, ASPR, and ASDR for hearing loss among males and females showed fluctuating upward trends. Specifically, the male ASPR increased most rapidly during 2000–2009 (APC=0.31%, P<0.05), while the male ASDR increased most rapidly during 2001–2004 (APC=1.68%, P<0.05). The female ASPR and ASDR both increased most rapidly during 2015–2019 (APC=0.47% and 0.91%, respectively; P<0.05) but showed declining trends during 2019–2021 (APC=-0.07% and -0.23%, respectively; P<0.05). See Figure 1.

2.3 Age-Period-Cohort Model Analysis of Hearing Loss Prevalence Among Individuals Aged $ $55 Years in China The age-period-cohort model analysis revealed the age, period, and cohort effects on hearing loss prevalence among individuals aged $ $55 years in China. The age effect showed that prevalence increased with age, following a pattern of initial rise followed by stabilization. The RR for the 55–59 age group was 0.74, while for the $ $95 age group it was 1.07. The period effect showed a monotonic increase in prevalence over time, with RR ranging from 0.96 in 1990–1994 to 1.05 in 2020–2021. The cohort effect indicated that earlier-born cohorts (e.g., 1895–1899, RR=1.06) had higher risk, while later-born cohorts (e.g., 1965–1969, RR=0.96) had relatively lower risk. Additionally, age, period, and cohort effects were similar between males and females, with no pronounced gender differences. Overall, the age effect was most significant, while period and cohort effects also showed clear trends. See Figure 2 [Figure 2: see original paper].

Discussion

As China' s population aging accelerates, hearing health issues among middle-aged and older adults have attracted increasing attention. Based on GBD 2021 data, this study dissected the status of hearing loss among individuals aged $ $55 years in China from 1990 to 2021. The results demonstrate a significantly increasing disease burden, with substantial rises in prevalent cases, prevalence rate, DALY count, and DALY rate. The EAPC values for prevalence rate and DALY rate reached 0.24% and 0.53%, respectively, affecting all age groups—a trend consistent with global patterns [4]. Joinpoint analysis indicated that the disease burden was slightly higher in males than in females. Age-period-cohort analysis revealed that hearing loss risk increased with age initially then plateaued, increased monotonically over time, and decreased with more recent birth cohorts, with no pronounced gender differences in these effects. The changing burden

of hearing loss among individuals aged $ $55 years in China is influenced by multiple factors, necessitating deeper exploration of underlying mechanisms to inform targeted prevention and control strategies.

Currently, population aging is the key factor driving the increasing disease burden of hearing loss in China. The proportion of older adults continues to rise, and as older adults are a high-risk group for hearing loss, their growing share in the population structure inevitably leads to increased overall prevalence, indicating a persistently heavy disease burden [4]. Previous studies have shown that global prevalent cases and DALYs for hearing loss increased from 750 million and 22.01 million person-years in 1990 to 1.46 billion and 40.24 million person-years in 2019, while ASPR and ASDR showed declining trends [16]. These findings suggest that increases in case numbers and DALYs were primarily driven by population aging, and that actual hearing loss prevalence and DALY rates would show declining trends after adjusting for age structure. In contrast, this study found slow growth in ASPR and ASDR in China, further indicating that China' s population aging is more severe than the global average. Additionally, the proportion of hearing loss burden attributable to occupational noise has declined over the past 30 years [9], whereas the impact of aging on hearing loss has become increasingly prominent. Due to aging, the burden of hearing loss has increased over time, and future demand for hearing healthcare services will be even greater.

The disease burden of hearing loss among middle-aged and older adults in China shows gender disparities, with males bearing a slightly heavier burden than females—consistent with previous findings [17]. Joinpoint analysis revealed that male prevalence rates, DALY rates, ASPR, and ASDR were slightly higher than female rates. Hearing loss in middle-aged and older adults is a cumulative process, and gender differences may be attributed to: (1) Males are more likely to work in high-noise occupations (e.g., manufacturing, construction), increasing hearing loss risk [17]. A cross-sectional survey of 2,280 Chinese workers exposed to industrial noise showed significantly higher hearing loss prevalence in males (34.4%) than females (13.8%) [18]. (2) Males have higher rates of smoking and alcohol consumption, factors closely related to hearing loss development [19-20]. (3) Females typically pay more attention to health management and have higher medical compliance, potentially leading to earlier detection and intervention for hearing problems. Therefore, future hearing health prevention and control efforts in China should focus on gender differences, strengthening occupational protection and health guidance for males to improve hearing health among middle-aged and older adults.

The age effect shows that hearing loss risk among middle-aged and older adults in China increases with age—a clear and significant trend. For example, the risk in individuals aged $ $95 years is 1.45 times that of the 55–59 age group. This trend reflects complex physiological and pathological mechanisms. Physiologically, aging causes degenerative changes in the auditory system, such as reduced inner hair cells, atrophy of auditory nerve fibers, and ossicular chain

sclerosis, leading to decreased hearing sensitivity [21]. Concurrently, chronic diseases like hypertension and diabetes, whose incidence increases with age, further damage the auditory system by affecting inner ear blood circulation and metabolism, synergistically elevating hearing loss risk [5]. Environmental noise exposure and medication use in older adults may also exacerbate hearing damage superimposed on age-related changes. Notably, risk reaches a "plateau" at ages 70–74, meaning risk stabilizes after age 75. This suggests that below age 75, risk remains relatively unstable and potentially rising, and interventions during this window may be more likely to disrupt disease progression and positively impact hearing health.

The period effect reveals a concerning trend: hearing loss risk among middle-aged and older adults in China shows a monotonic increase over time. For instance, risk in 2020–2021 increased by 9.38% compared with 1990–1994—a significant upward trajectory. Multiple factors contribute to this: (1) Accelerated industrialization and urbanization have intensified environmental noise pollution from traffic, industry, and construction. Long-term exposure can cause irreversible damage to auditory organs, increasing hearing loss risk. Studies show that exposure to road traffic noise exceeding 70 dB significantly elevates risk of auditory system damage [22]. (2) The fast pace of modern life has popularized prolonged high-volume headphone use, subjecting the inner ear to sustained high-intensity sound stimulation that can lead to hearing decline. Increased social and recreational activities among middle-aged and older adults also add to auditory system burden. (3) In the past, hearing detection equipment lacked precision, making early or mild hearing loss difficult to diagnose accurately. Today, technologies such as pure-tone audiometry and smartphone-based mobile hearing tests [23] can detect subtle hearing changes precisely, enabling diagnosis of more early-stage patients and partially inflating prevalence statistics. Additionally, the impact of population aging cannot be ignored. Therefore, future prevention and control efforts must adopt multifaceted approaches: strengthening environmental noise control, promoting healthy lifestyles, optimizing hearing diagnostic technologies, and improving elderly hearing healthcare service systems.

The cohort effect indicates that hearing loss risk among middle-aged and older adults in China gradually decreases with more recent birth cohorts. The 1965–1969 birth cohort had 10.42% lower risk than the 1895–1899 cohort. Earlier-born cohorts had higher hearing loss risk due to historical environmental and medical constraints, including inadequate occupational protection exposing workers to high-intensity noise, poor public health conditions making children susceptible to infectious diseases like mumps and meningitis that cause ear complications, and scarce medical resources with lagging detection technology and limited treatment options that hindered early intervention and allowed conditions to worsen. Later-born cohorts have lower risk thanks to improved health awareness and widespread early intervention. With social development, hearing health knowledge has spread widely, and newborn hearing screening has become routine, enabling timely detection and intervention that reduce severity of hearing loss

in adulthood [24]. Medical advances have also provided treatment options like hearing aids and cochlear implants for middle-aged and older adults, effectively improving clinical outcomes.

In summary, based on GBD 2021 data, this study dissected the status of hearing loss among individuals aged $ $55 years in China, finding a significantly increasing disease burden with gender disparities and pronounced age, period, and cohort effects. As China' s aging accelerates, hearing loss among middle-aged and older adults has become prominent, indicating significant future public health and healthcare implications. On one hand, widespread hearing screening and targeted education should be implemented for middle-aged and older adults, especially high-risk groups such as the oldest old, with expanded chronic disease management [25]. On the other hand, community-based assessment and intervention service models should be established, with attention to mental health of older adults with hearing loss, to build a continuous three-tier prevention and control system integrating prevention, screening, treatment, and rehabilitation, thereby comprehensively improving hearing health among middle-aged and older adults.

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Author Contributions: ZHANG Yongqing conceived the study, designed the protocol, collected and organized data, and wrote the manuscript; LI Na, GAO Yili, and QIN Jiawen revised the manuscript and were responsible for quality control and review; YU Haiping verified data and edited tables and figures; SHI Hui participated in conceptualization and design, revised the final version, and takes responsibility for the full manuscript.

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