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Original Article

Global Temporal Trends in Prevalence of Hearing Loss in Young Adults Aged 15-39 Years and Projections to 2040

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Abstract

Background: Hearing loss (HL) constitutes a significant hazard to the health and social welfare, yet there is a lack of data on its burden in young adults (YAs) aged 15-39 yr. This study aimed to delineate the global temporal trends and predict the future burden of HL in YAs.

Methods: Using data from the Global Burden of Disease study 2021, we analyzed the prevalent cases and age-standardized prevalence rates (ASPR) of HL in YAs by age, sex, and Socio-demographic Index(SDI). The age-period-cohort (APC) model was used to assess trends, while the Bayesian Age-Period-Cohort (BAPC) model projected future epidemiological trajectories.

Results: Globally, HL prevalent cases in YAs increased from 171.77 million (95% CI: 145.95–200.16) in 1992 to 256.16 million (95% CI: 222.49–293.87) in 2021. The ASPR rose from 7862.80 to 8474.66 per 100,000 over this period, with males consistently showing higher rates than females. APC analysis revealed age-dependent increases in hearing loss risk, adverse period effects in recent years (2012–2021), and a peak relative risk in the 1997–2006 birth cohort. The BAPC model projects 291.37 million (95% CI: 182.25–400.49) prevalent cases by 2040.

Conclusion: The global burden of HL in YAs is rising, particularly since the relative risk of HL has continued to grow during the last 10 years, highlighting the need for further research and intervention.

Keywords: Hearing loss; Young adults; Age-period-cohort analysis; Temporal trends; Global burden of disease

Introduction

Hearing loss (HL) is the most prevalent disability affecting sensory organs, impacting approximately 1.57 billion individuals globally in 2019 (1). This condition substantially diminishes quality of life, hampers communication, and is associated with a range of emotional and cognitive issues,

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including loneliness, depression, and cognitive decline (2–6). With the ongoing aging of the global population, the prevalence of HL is projected to increase significantly. By 2050, it is estimated that 2.45 billion people will experience HL, representing a 56.1% increase compared to current estimates (1). This escalating burden highlights the urgent need for effective public health interventions.

Young adults (YAs) aged 15 to 39 yr are a population easily overlooked, characterized by unique developmental opportunities and challenges (7,8), including educational pressures, work adjustments, and lifestyle choices such as prolonged use of in-ear headphones and exposure to recreational noise (7–13). These factors contribute to the rising incidence of HL among YAs, making it imperative to prioritize early interventions to mitigate this trend (14). Importantly, in 25 years, this age group will shift to the 40–64 age range, associated with a sharp increase in the burden of HL. Therefore, investigating the HL burden among YAs is of critical significance.

To address this critical issue, we utilized data from the Global Burden of Disease (GBD) study 2021 to analyze the epidemiological trends of HL among YAs. Furthermore, we employed an age-period-cohort (APC) model to analyze the temporal progression of HL prevalence and a Bayesian APC (BAPC) model to forecast future epidemiological trajectories. These findings aimed to underpin evidence-driven strategies for preventing and controlling HL among YAs and provide pivotal insights for public health planning endeavors.

Methods

Overview

The GBD project offers a comprehensive evaluation of the epidemiological levels and trends related to communicable diseases, non-communicable diseases, and injuries on a global scale. The research uses GBD 2021 data that systematically evaluates 371 illnesses and injuries and 88 risk factors in 204 countries and regions (15). Further information is available on the IHME web site (https://vizhub.healthdata.org/gbd-results/).

Case definition and data sources

HL is defined in the GBD as the faintest sound detectable by an individual in their ear with better auditory function, calculated as the pure-tone average (PTA) of the audiometric thresholds measured at frequencies of 0.5 kHz, 1 kHz, 2 kHz, and 4 kHz. PTA ≥20 dB was defined as HL.

In our data retrieval process, we employed 'hearing loss' as the key search term under the category of cause, specifically targeting the extraction of data related to HL among individuals aged 15–39. We further calculated the prevalent cases and age-standardized prevalence rates (ASPR), and corresponding 95% confidence intervals (CI) based on the world standard population reported in the GBD 2021. In addition, we classified the world population into 21 regions according to epidemiology and geographical proximity. To further classify the regions, we used the Socio-demographic Index (SDI), a composite metric of development status linked to health outcomes, calculated as the geometric mean of three indices: total fertility rate under age 25, mean education for individuals aged 15 and older, and lag-distributed income (16). An SDI of 0 represents the theoretical minimum development level, while an SDI of 1 represents the theoretical maximum. In the GBD 2021, 204 countries and territories were classified into five SDI-based development levels: low (≤0.4658), low-middle (0.4658–0.6188), middle (0.6188–0.7120), high-middle (0.7120–0.8103), and high (>0.8103) (Appendix 1; https://ghdx.healthdata.org/record/global-burden-disease-study-2021-gbd-2021-socio-demographic-index-sdi-1950%E2%80%932021).

Statistical analysis

An APC model related internal estimation (IE) approach is employed together with population data from GBD 2021 to analyse the temporal tendency of HL prevalence in YAs by age, period, and birth cohort. To maintain the APC model parameters in an acceptable amount and to achieve a smooth curve of the time-effect curve, we classified age-specific prevalence rates into five age groups (15-19, 20-24, 25-29, 30-34, 35-39). Correspondingly, the whole study period (1992-2021) was split into 6 five-year periods, namely, 1992-1996, 1997-2001, 2002-2006, 2007-2011, 2012-2016, 2017-2021. The main metrics derived from the APC model utilizing the IE algorithm are net drift, local drift, as well as period and cohort risk ratios (RR). Net drift indicates the annual percentage change in the logarithmic value of prevalence, accompanied by a 95% CI, adjusted for nonlinear period and cohort effects. Meanwhile, local drift captures the annual percentage variation in the logarithmic prevalence across different age categories. The period (or cohort) RR is defined as the quotient of age-specific prevalence rates in each period (or cohort) relative to that of the reference period (or cohort).

Furthermore, we used the BAPC model, which makes use of integrated nested Laplace approximations, to forecast the future temporal trends of HL prevalence in YAs globally from 2022 to 2040. The significance of estimable parameters and functions was evaluated using the Wald χ^2 test and all statistical tests were two sided. All analyses and visualizations were conducted using R Software (version 4.3.3). *P*<0.05 was regarded as indicating statistical significance.

Results

Global and SDI regional trends

Globally, the prevalent cases of HL in YAs rose from 171.77 million (95% CI: 145.95–200.16) in 1992 to 256.16 million (95% CI: 222.49–293.87) in 2021, representing an increase of approximately 47.47%. The ASPR increased from 7862.80 (95% CI: 6706.74–9136.70) to 8474.66 (95% CI: 7351.46–9733.30) per 100,000 from 1992 to 2021, with a 7.78% growth. Furthermore, the APC model estimated a global net drift of HL prevalence in YAs at 0.305% (95% CI: 0.28%−0.33%) per year, and the highest net drifts were 0.31% (95% CI: 0.29%−0.34%) in middle SDI region and 0.30% (95% CI: 0.28%−0.32%) in high-middle SDI region (Table 1).

Table 1: Trends of prevalence for hearing loss in young adults aged 15-39 from 1992 to 2021 by sex and SDI quintiles

Variable	1992			2021			1992 - 2021 APC
	prevalent cases in millions (95% CI)	ASPR per 100,000 (95% CI)		prevalent cases in millions (95% CI)	ASPR per 100,000 (95% CI)		Net Drift (%/year, 95% CI)
Global	171.77 (145.95, 200.16)	7862.80 (6706.74, 9136.70)		256.16 (222.49, 293.87)	8474.66 (7351.46, 9733.30)		0.31 (0.28, 0.33)
By sex							
Males	95.16 (80.87, 110.77)	8605.88 (7339.76, 9991.32)		141.32 (123.23, 161.69)	9236.02 (8044.79, 10576.64)		0.29 (0.27, 0.31)
Females	76.62 (64.69, 89.52)	7101.24 (6019.26, 8273.66)		114.83 (99.23, 132.16)	7693.71 (6642.21, 8866.48)		0.33 (0.30, 0.35)
By SDI							
High SDI	20.62 (17.91, 23.70)	5691.33 (4931.63, 6558.19)		22.25 (19.45, 25.29)	5871.60 (5116.06, 6698.80)		0.19 (0.17, 0.21)
High-middle SDI	36.00 (30.89, 41.73)	7778.31 (6675.08, 9020.37)		39.94 (35.13, 45.36)	8291.97 (7259.78, 9458.65)		0.30 (0.28, 0.32)
Middle SDI	62.37 (52.89, 72.78)	8458.97 (7216.28, 9827.32)		87.19 (76.27, 99.37)	9059.11 (7904.46, 10349.10)		0.31 (0.29, 0.34)
Low-middle SDI	38.02 (31.67, 44.72)	8638.33 (7266.93, 10081.56)		71.32 (61.21, 82.37)	9101.48 (7833.50, 10488.26)		0.2 (0.17, 0.27)
Low SDI	14.63 (12.06, 17.41)	8286.41 (6917.28, 9761.31)		35.27 (29.61, 41.57)	8596.54 (7294.69, 10041.16)		0.18 (0.13, 0.22)

Abbreviations: ASPR=age-standardized prevalence rate; SDI=Socio-demographic Index; APC=age-period-cohort; CI=confidence intervals

The prevalent cases and ASPR of HL in YAs increased across both sexes and all SDI regions from 1992 to 2021. Compared to 1992, the low and low-middle SDI regions showed the highest increase in prevalent cases in 2021, increased by 141% (from 14.63 million [95% CI: 12.06−17.41] to 35.27 million [95% CI: 29.61−41.57]) and by 87.59% (from 38.02 million [95% CI: 31.67−44.72] to 71.32 million [95% CI: 61.21−82.37]), respectively (Table 1). Overall, the ASPR in low, low-middle, middle and high-middle SDI regions had continuously above the global average, whereas the high SDI region had the lowest rates. Additionally, the ASPR of HL in YAs exhibited a sex- related disparity, which was significantly higher in males than that in females from 1992 to 2021. Notably, the ASPR of all SDI regions showed a slight decrease from 2020 to 2021, except for the low SDI region (Fig. 1).

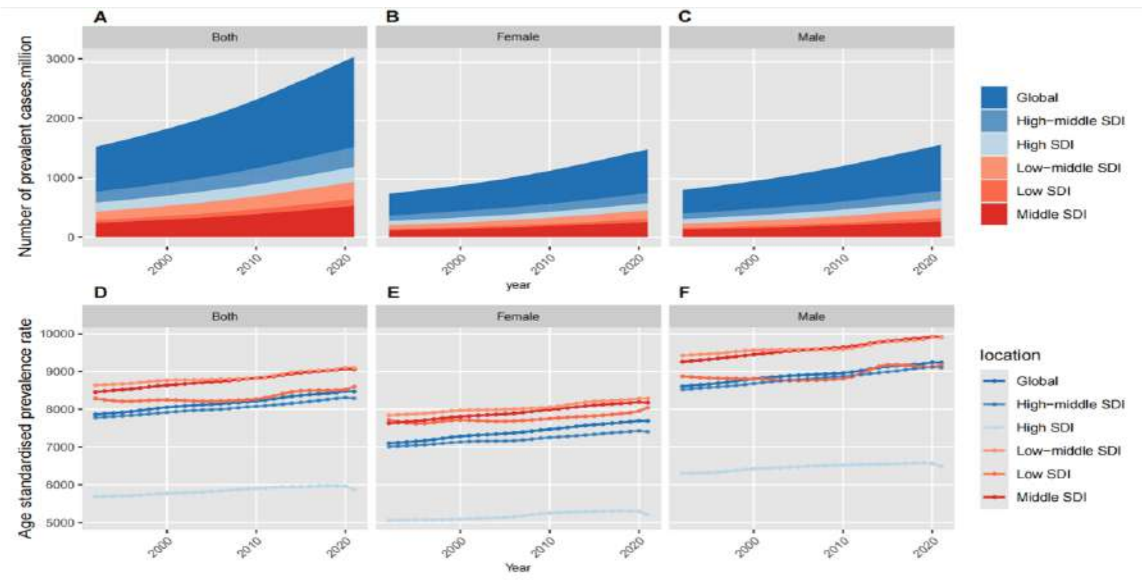

Fig. 1: The prevalent cases (A for both, B for females, C for males) and age-standardized prevalence rate (D for both, E for females, F for males) of hearing loss in global and the five SDI regions among young adults from 1992 to 2021

National trends

In 2021, the countries and territories where the ASPR of HL in YAs was higher than the global average were mainly located in Africa, Asia and Oceania. Furthermore, Madagascar had the highest ASPR (11013.60, 95% CI: 9500.37−12710.65) per 100,000, followed by Malawi, Kenya, Djibouti, and India. On the other hand, Finland had the lowest ASPR (4268.73, 95% CI: 3636.34−4992.70) per 100,000, followed by Canada, the United States of America, Greenland, and Sweden (Fig. 2A and Appendix 2 Table S1).

The net drift calculated by the APC model showed that, out of the 204 countries and regions, merely 18 exhibited a declining pattern in HL prevalence. Among the countries demonstrating a downward trend in prevalence, Cameroon leads the way in this trend of decreasing prevalence, with a net drift of -0.18% (95% CI: -0.05%−-0.31%) per year. Among countries with the fastest-growing prevalence of HL, the United Kingdom leads the charge, registering an annual net drift of 1.02% (95% CI: 0.94%−1.10%) per year, followed by Equatorial Guinea, Ethiopia, China and Mozambique (Fig. 2B and Appendix 2 Table S1).

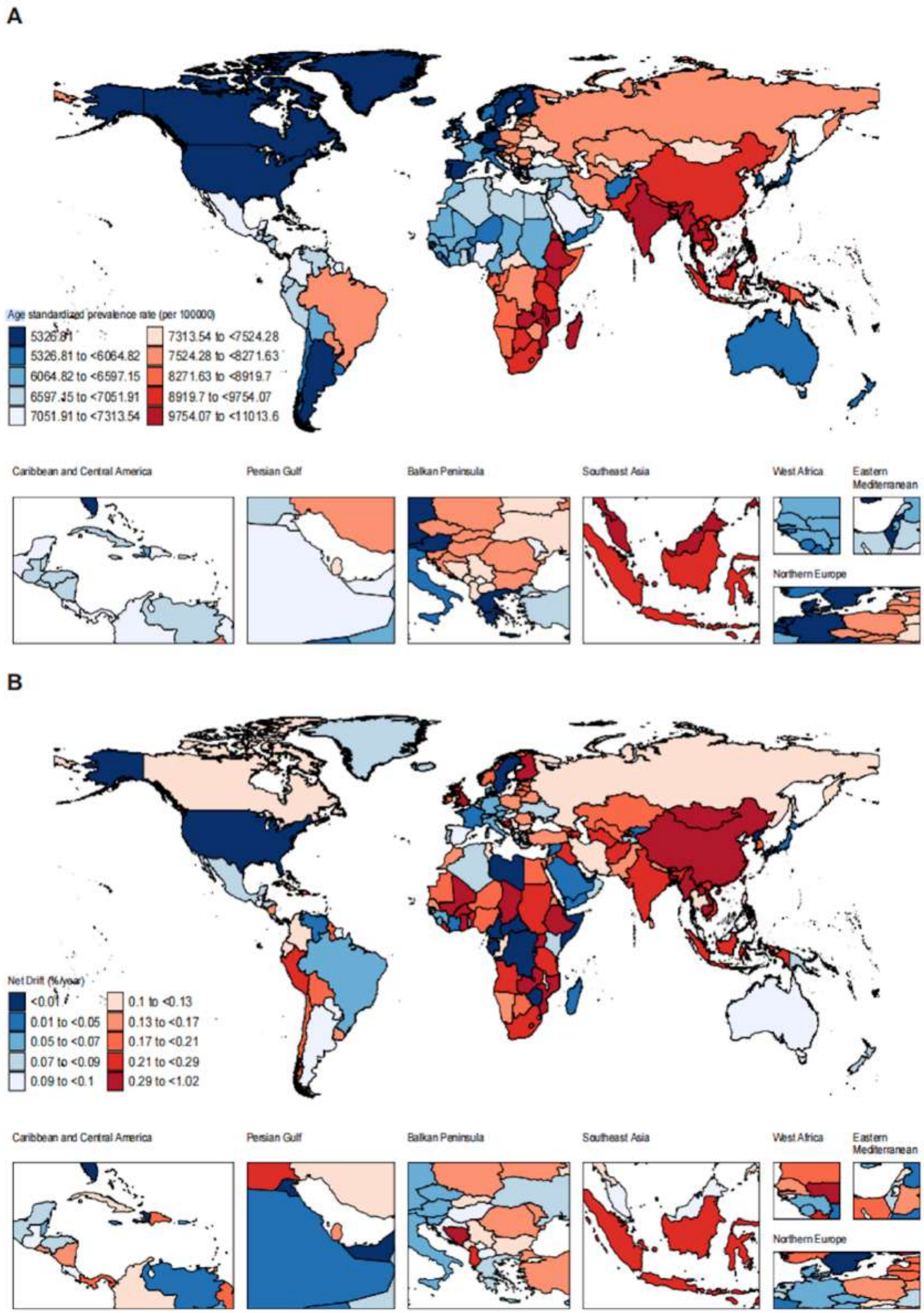

Fig. 2: Map of age-standardized prevalence rate in 2021 (A) and net drift of prevalence from 1992 to 2021 (B) for hearing loss in young adults in 204 countries and territories

Temporal trends across different age groups

Globally, the annual change of HL prevalence in YAs exhibited an age-dependent decline, progressively decreasing from 0.45% (95% CI: 0.40%−0.50%) in the 15-19 age group to 0.16% (95% CI: 0.13%−0.19%) in the 35-39 age group. In high-middle, middle, low-middle and low SDI regions, trends in the annual change of prevalence from 15-19 to 35-39 age groups were similar to global trends. However, in low-middle and low SDI regions, there was a slow declining trend in the annual change of prevalence from 15-19 to 20-24 age groups. The highest annual change of prevalence was observed in 15-19 yr group in high-middle and middle regions, reaching 0.56% (95% CI: 0.50%−0.63%) and 0.55% (95% CI: 0.49%−0.61%), respectively. In high SDI region, the annual change of prevalence kept flat from 15-19 to 30-34 age groups, and decreased from 30-34 to 35-39 age groups (Fig. 3A and Appendix 2 Table S2) .

Globally, the percentage of HL prevalent cases increased with the growth of age groups. The HL prevalent cases showed a slight increase in the older young populations, and this increasing trend was more evident in high-middle and middle SDI region. Additionally, a greater proportion of the prevalence was attributed to the older age groups (older than 30 yr) within the YAs cohort (Fig. 3B and Appendix 2 Table S2).

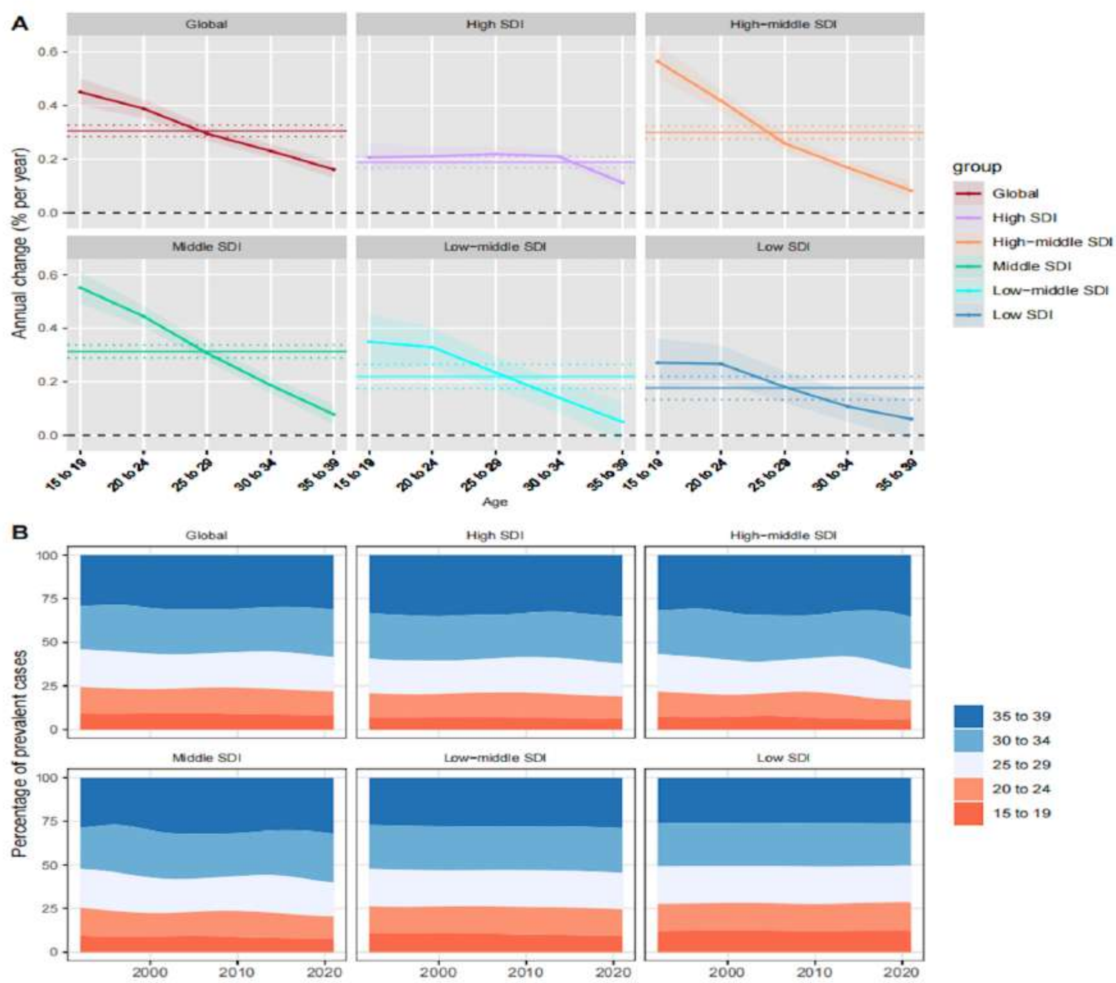

Fig. 3: Local drift and age distribution of prevalence from 1992 to 2021 for hearing loss in young adults across SDI quintiles. (A) Local drift of prevalence in five age groups. (B) Temporal changes in age distribution

Age, period and birth cohort effects on HL prevalence in YAs

Across all SDI regions, the age effect showed a similar pattern, with the lowest risk being observed in YAs aged 15-19 yr, followed by a subsequent increase in risk as individuals advance in age (Fig. 4A and Appendix 2 Table S3).

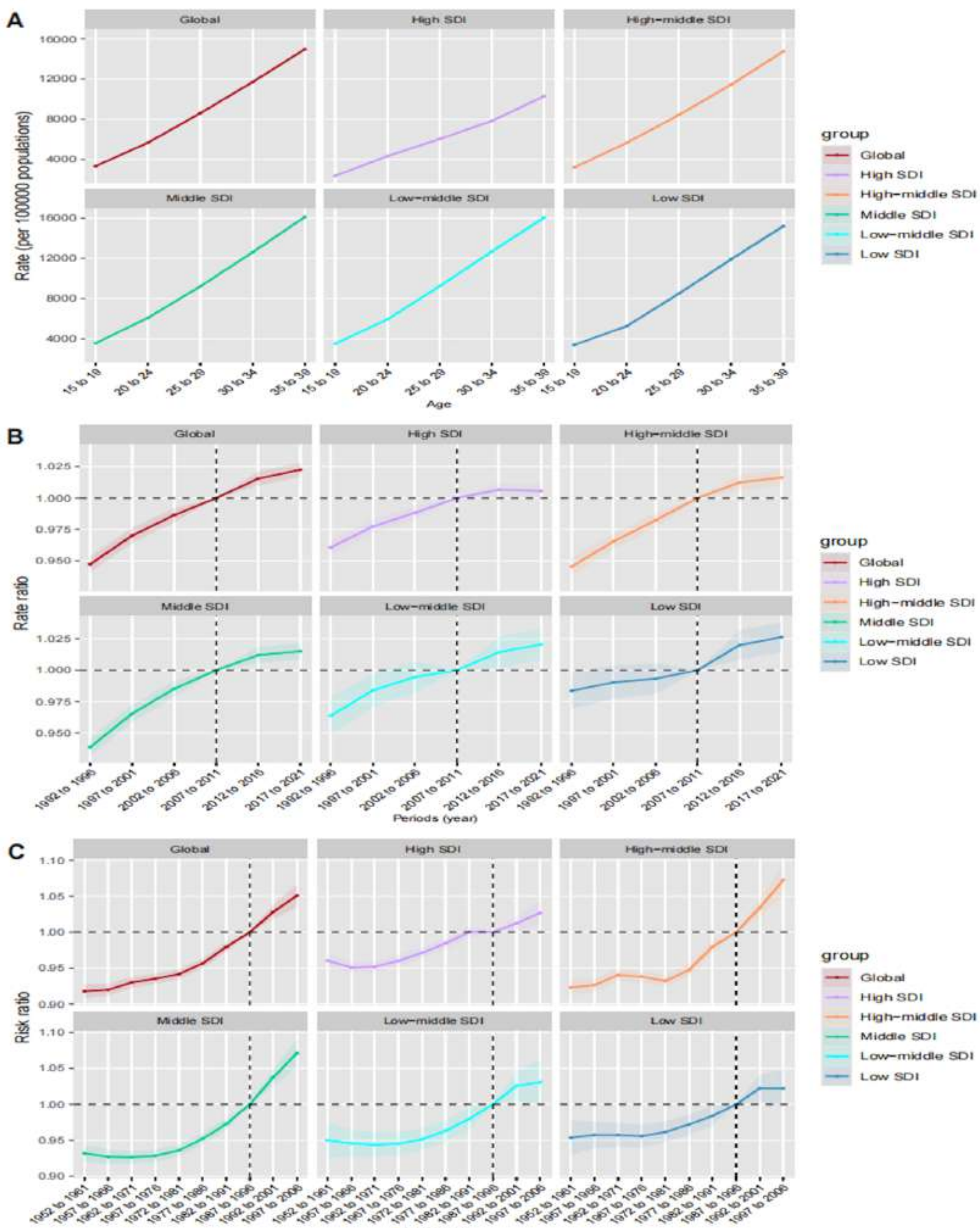

Fig. 4: The age, period and birth cohort effects on hearing loss prevalence in young adults. (A) Rates by SDI groups (15-39). (B) Period-stratified prevalence by SDI groups (1992-2021). (C) Birth cohort-stratified prevalence by SDI groups (1952-2006)

Overall, the period effect displayed a similar pattern and a persistent upward trend in the ASPR in all SDI regions. During the entire study period, all SDI regions predominantly experienced unfavorable period risks in the 2012-2016 and the 2017-2021, whereas generally exhibited favorable period risks in other periods before the 2007-2011. Globally, compared with individuals in the reference 2007-2011, the relative period risks for individuals in the 2012-2016, 2017-2021 were 1.015 (95% CI: 1.010−1.021) and 1.023 (95% CI: 1.017−1.028) , respectively (Fig. 4B and Appendix 2 Table S4).

Birth cohort analyses worldwide show significant increases in the risk ratios for HL in YAs. Risk ratios increased more slowly in the cohort born before 1972 to 1981 cohort (the flattening-out period) than in the cohort born thereafter (the acceleration period). Compared with those born in the reference 1987-1996 cohort, individuals born in 1992-2001 (RR=1.003, 95% CI: 1.018−1.039) and 1997-2006 (RR=1.051, 95% CI: 1.035−1.067) cohorts had a higher relative risk of HL prevalence, especially in high-middle and middle SDI regions. Furthermore, the 1997-2006 cohort showed the highest relative risks, which were 1.073 (95% CI: 1.052–1.094) in high-middle SDI regions and 1.071 (95% CI: 1.052–1.090) in middle SDI regions (Fig. 4C and Appendix 2 Table S5).

Global disease burden prediction for HL in YAs till 2040

The BAPC model predicted a gradual increase in the overall prevalent cases and ASPR of HL in YAs aged 15-39 worldwide from 2022 to 2040 (Fig. 5 and Appendix 2 Table S6). Globally, the prevalent cases are projected to rise from 262.79 million (95% CI: 256.07–269.52) in 2022 to 291.37 million (95% CI: 182.25–400.49) in 2040, representing an increase of approximately 10.87% (Fig. 5A). Meanwhile, the ASPR is projected from 8495.14 (95% CI: 8277.55–8712.73) to 8861.53 (95% CI: 5532.82–12190.23), with a 4.31% growth (Fig. 5B). Furthermore, the prevalent cases are projected to rise in females and males, culminating at 129.26 million (95% CI: 80.69–177.84) and 162.11 million (95% CI: 101.56–222.66), respectively(Fig. 5C, 5E). The ASPR are projected to rise in females and males, culminating at 7941.63 (95% CI: 5091.67–10791.60) and 9421.50 (95% CI: 6060.60–12782.40)(Fig. 5D, 5F).

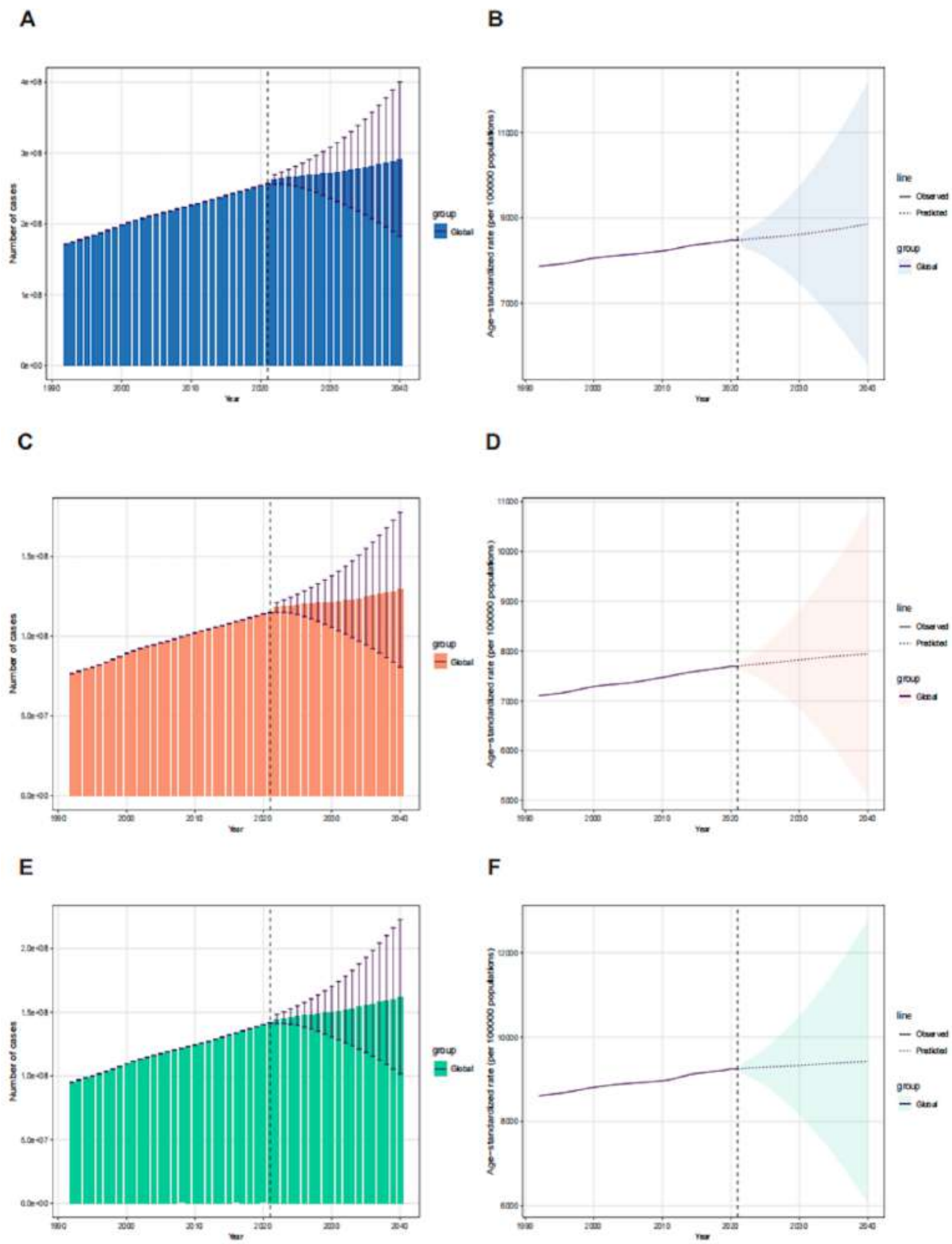

Fig. 5: Global prediction of prevalent cases and age-standardized prevalence rate(ASPR) of hearing loss in young adults up to 2040. Global future trends in case numbers (A) and ASPR (B). Female future trends in case numbers (C) and ASPR (D). Male future trends in case numbers (E) and ASPR (F)

Discussion

To the best of our knowledge, this study is the first to provide a comprehensive and up-to-date evaluation of the temporal trends of HL prevalence among YAs aged 15-39 yr across 204 countries globally. The findings indicate a consistent annual increase in both prevalent cases and ASPR in all SDI regions over the past three decades. The continually rising global burden of HL in

YAs underscores the urgent need for preventive and control measures in this demographic.

We found that the ASPR of HL was significantly higher in boys than in girls. This disparity may result from the interplay between biological susceptibility and social behavioral factors. Lin et al. demonstrated through metabolomics analysis that mitochondrial antioxidant enzyme activities in cochlear hair cells are lower in males, and the microvessel density of the cochlear stria vascularis is reduced compared to females, thereby increasing vulnerability to oxidative stress injury (17). Additionally, males exhibited more severe high-frequency HL (3-6 kHz), indicating gender-specific differences in the physiological sensitivity of cochlear structures, such as the basilar membrane, to high-frequency sound waves (18). Social behavior also plays a critical role; tinnitus in adolescent males is significantly associated with high-risk behaviors like alcohol consumption and drug use (19). Furthermore, the burden of years lived with disability due to occupational HL is greater among middle-aged and older men in China, suggesting that early-life noise exposure (e.g., construction/manufacturing environments or prolonged high-intensity headphone use) may contribute to accelerated hearing decline (20). This continuous exposure, in combination with lifestyle habits such as smoking and alcohol consumption, as well as the presence of multiple chronic diseases, substantially elevates their susceptibility to HL.

At the national level, the countries and territories where the ASPR of HL in YAs was higher than the global average were mainly located in Africa, Asia and Oceania, which are mostly less developed countries. Young workers in developing countries maybe more likely to engage in jobs that involve occupational exposure to noise and sleep deprivation (21,22). Furthermore, less developed countries often face challenges such as inadequate coverage of health services, inadequate occupational protection measures, lack of public health awareness and lack of early HL screening implementation (23). The United Kingdom, Equatorial Guinea, Ethiopia, China and Mozambique are experiencing the swiftest growth in HL prevalence, which should arouse these countries' attention, and relevant precautionary measures should be formulated to slow down the increasing trend of the prevalence of HL. Notably, the ASPR of most regions and countries showed a slight decrease from 2020 to 2021, related to the fact that during the coronavirus disease 2019 (COVID-19) pandemic, YAs reduced their social activities that involved exposure to noise, sleep deprivation and excessive alcohol consumption, and so on.

The peak relative risk of HL in the birth cohort from 1997 to 2006 (RR=1.073) underscores the distinct impact of emerging environmental exposures on younger generations. Notably, studies have documented an increase in recreational noise exposure among adolescents in the United States, despite less than 10% of adolescents utilizing hearing aids—a "silent crisis" coinciding with the proliferation of smartphone audio technology as the 1997–2006 cohort entered adolescence (the 2010s), potentially leading to a substantially earlier onset of noise-induced HL (24). Consequently, the elevated risk within this cohort represents not merely a biomedical issue but also a public health challenge that has yet to be adequately addressed through regulatory measures during the socialization of technology. Urgent action is required to disrupt this adverse cycle through technical advancements and policy interventions, including limitations on sound pressure output and monitoring of usage duration. Furthermore, it is important to ensure greater emphasis on the targeted implementation of primary prevention strategies and the improvement of responsive healthcare systems for YAs. Routine school-centered health examinations, along with the instruction of teachers, and social workers on recognizing hearing impairments, can contribute to the early discovery of otological disorders (25).

Several limitations need to be taken into account when analyzing these findings. First, while the GBD modeling framework employs rigorous statistical methods to address data gaps, estimates for low- and middle-income countries rely more heavily on modeling assumptions than clinical verification, potentially introducing measurement bias in APC effect estimations. Second, diagnostic capacity variations across healthcare systems—particularly in resource-limited settings—may lead to under ascertainment of mild-to-moderate HL cases, though this bias is partially mitigated by GBD's systematic case definitions. Third, the ecological nature of national-level data precludes subnational analyses of regional disparities, which could mask important intra-country heterogeneity in hearing health services.

Conclusion

From 1992 to 2021, the prevalence of HL in YAs aged 15−39 yr has been increasing globally, with substantial variations across SDI regions, age groups, and genders. Notably, younger age groups and individuals born after 1987 exhibit a higher risk, likely due to prolonged exposure to modifiable factors such as environmental noise and unhealthy lifestyle behaviors. Projections extending to 2040 indicate that the number of cases will continue to rise, underscoring the critical need for targeted interventions to reduce preventable HL. Collectively, these findings highlight the necessity of region-specific policies aimed at enhancing health education and ensuring equitable access to preventive care to effectively address this escalating public health challenge.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data availability

All supplementary data not published here will be sent to the respected readers for reasonable application. Please contact the corresponding author.

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