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Global, Regional, and National Burdens of Otitis Media From 1990 to 2019: A Population Based Study

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Objectives: Otitis media is one of the most important causes of hearing loss at an early age. Effective vaccination with the routine 7-valent pneumococcal conjugate vaccine (PCV-7) was introduced in 2000. It has been gradually replaced by the pneumococcal nontypeable Haemophilus influenzae protein D conjugate vaccine or the higher-valent 13-valent PCV (PCV-13) since 2010. Data on the change in otitis media burden in recent years are sparse at the global, regional, and national levels.

Design: The Global Burden of Disease 2019 study was used to evaluate the prevalence, incidence, mortality, disability-adjusted life year (DALY) rates, and the average annual percentage changes (AAPCs) in otitis media in geographic populations worldwide from 1990 to 2019. These global trends were further analyzed by subgroup (age, sex, and sociodemographic index [SDI]).

Results: Globally, the all-age rate of prevalence (AAPC = –0.7, 95% confidence interval [CI] = –0.7 to –0.8), DALYs (AAPC = –1.0, 95% CI = –1.1 to –1.0), and mortality (AAPC = –6.8, 95% CI = –7.3 to –6.4) from otitis media decreased constantly between 1990 and 2019. The all-age rate of incidence decreased sharply between 2000 and 2009 with an AAPC of –1.2 (95% CI = –1.4 to –0.9) and continued the downward trend between 2010 and 2019 (AAPC = –0.2, 95% CI = –0.3 to –0.1). In 2019, children aged 1 to 4 years old had the highest incidence at 29,127.3 per 100,000 population, while young adults under 30 years old accounted for 91.3% of the incident cases. Individuals living in middle-SDI countries had the largest increase in the incidence of otitis media, with an AAPC of 0.3 (95% CI = 0.3 to 0.3) between 1990 and 2019. The incidence and DALYs from otitis media decreased with increasing SDI. Regionally, the largest increase in incidence was observed in high-income Asia Pacific, Eastern Europe, and Western Sub-Saharan Africa between 1990 and 2019. Nationally, the largest increase in the incidence of otitis media was observed in the Republic of Korea, with an AAPC of 0.8 (95% CI = 0.6 to 1.1) in the same time period.

Conclusions: There have been successful previous endeavors to reduce DALYs and mortality attributed to otitis media on a global scale. The worldwide incidence of otitis media experienced a sharp decline following the introduction of PCV-7 in 2000, and this downward trend persisted in subsequent years with the adoption of PCV-13/pneumococcal nontypeable Haemophilus influenzae protein D conjugate vaccine. Continual epidemiological surveillance of otitis media's global trends, pathogen distribution, and resistance patterns remains imperative.

Key words: Epidemiology, Global Burden of Diseases, Incidence, Otitis media, Pneumococcal conjugate vaccine.

Abbreviations: AAPCs = average annual percentage changes; CIs = confidence intervals; DALY = disability-adjusted life year; GBD = Global Burden of Disease; HAQ = healthcare access and quality; PCV-7 = 7-valent pneumococcal conjugate vaccine; PHiD-CV = pneumococcal nontypeable Haemophilus influenzae protein D conjugate vaccine; SDI = sociodemographic index; UI = uncertainty interval;WHO = World Health Organization's.

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INTRODUCTION

The World Health Organization's World Report on Hearing 2021 warns that by 2050, nearly 2.5 billion people will have some degree of hearing loss worldwide, and at least 700 million of these people will need access to hearing care and other rehabilitation services if no action is taken (WHO 2021). Otitis media is one of the major causes of hearing loss and deafness, especially in children under the age of five and in individuals in developing countries (Vergison et al. 2010; GBD 2019 Hearing Loss Collaborators 2021). The Global Burden of Disease (GBD) Collaboration released hearing loss data in 2019, which included otitis media. However, the long-term trends of incidence and disability-adjusted life years (DALYs) associated with otitis media, particularly in low- and middle-income countries, remain unclear (Monasta et al. 2012; Leach et al. 2020). Trend analysis could uncover insights regarding the impact on policies or interventions, providing specific recommendations for healthcare providers, policymakers, and researchers.

Prevention and treatment for otitis media have changed greatly in recent decades. Vaccination with the pneumococcal conjugate vaccine (PCV) has been introduced as an effective measure to prevent otitis media caused by *Streptococcus pneumoniae* (Sigurdsson et al. 2018). The PCV-7, which is highly associated with otitis media, has been available since 2000. As of August 2008, it had received authorization in around 90 out of 193 World Health Organization member countries

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(Hu et al. 2022). Subsequently, it gradually gave way to the pneumococcal nontypeable Haemophilus influenzae protein D conjugate vaccine (PHiD-CV) or the higher-valent 13-valent PCV (PCV-13) from 2010 (Izurieta et al. 2022). Previous studies have shown that both PHiD-CV and PCV-13 offer advantages over PCV-7 (Izurieta et al. 2022). On the other hand, the treatment of otitis media mainly relies on the use of antibiotics, and the abuse of antibiotics can easily lead to antibiotic resistance (Li et al. 2023). On the basis of previous research on the impact of international, regional, and national clinical treatment guidelines, particularly antibiotic prescribing rates, it appears that compliance with published guidelines in most countries is poor (Smith 2013; Marchisio et al. 2014). It is reasonable and urgent to verify the changing trend in the incidence of otitis media before and after the introduction of this vaccine and the corresponding DALYs in recent years.

In this study, we hypothesized that there was a decrease in otitis media incidence from 1990 to 2019. We aimed to examine the global trends in otitis media incidence, DALYs, prevalence, and mortality in the past 3 decades; to stratify the global trends by age, sex, and sociodemographic index (SDI); and to report these trends at the regional and national levels for 204 countries and territories from 1990 to 2019.

MATERIALS AND METHODS

Data Source

In this analysis of the GBD Study 2019, we obtained repeated cross-sectional data from the Global Health Data Exchange, which includes the global burden of 369 diseases and injuries, including otitis media, in 21 GBD regions and 204 countries and territories from 1990 to 2019. The GBD 2019 used a range of data sources including vital registration systems, surveys, censuses, healthcare records, disease surveillance systems, and scientific literature to estimate disease burden. To summarize, the GBD 2019 study utilized standardized methodologies to process data and estimate various variables of interest based on age, sex, location, and year. Three key standardized methodologies were utilized: the integrated model of cause of death (CODEm), spatiotemporal Gaussian process regression, and DisMod-MR. CODEm serves as a highly structured tool for analyzing cause of death data. It uses an ensemble of diverse modeling approaches for rates or cause fractions, accommodating varied covariate options. CODEm's efficacy is validated through predictive validity testing that extends beyond the original sample. DisMod-MR, on the other hand, operates as a Bayesian meta-regression tool. It evaluates all available data related to disease incidence, prevalence, remission, and mortality. This methodology ensures consistency among epidemiological parameters. Spatiotemporal Gaussian process regression constitutes a collection of regression techniques that harness the collective power of different locations and temporal periods to evaluate single metrics of interest. These metrics encompass elements such as risk factor exposures or mortality rates (GBD 2019 Diseases and Injuries Collaborators 2020). Details of the methodology used in GBD 2019 have been explained in previous studies and are presented in Supplemental data 1 in Supplemental Digital Content, http://links.lww.com/EANDH/B253 (GBD 2019 Diseases and Injuries Collaborators 2020).

We extracted rates per 100,000 population of incidence, prevalence, mortality, and DALYs of otitis media, then calculated their average annual percentage changes (AAPCs) at the global, regional, and national levels between 1990 and 2019 by SDI. Prevalence refers to the proportion of individuals in a population who have otitis media at a particular point in time. Incidence refers to the number of new cases of otitis media that occur within a defined population during a specific period. Mortality refers to the number of deaths due to otitis media that occur within a population during a given time period. DALYs are a metric used to quantify the overall burden of otitis media. It combines years of healthy life lost due to premature death (Years of life lost) and years lived with disability (Years lived with disability) into a single measure. The SDI is a composite indicator that reflects the social and economic development of a country or region. It takes into account factors such as income, education, and fertility rates to provide a summary measure of sociodemographic development. The SDI is often used in health research to examine the relationship between development indicators and health outcomes. The healthcare access and quality (HAQ) index is a measure that evaluates the accessibility and quality of healthcare services within a country or region. It takes into account various indicators such as availability of healthcare facilities, healthcare workforce, and the effectiveness of healthcare interventions. The HAQ Index helps assess the overall performance of a healthcare system and its impact on population health outcomes.

The GBD Study adheres to the guidelines for accurate and transparent health estimates reporting. The Institute for Health Metrics and Evaluation, the institute responsible for administering the GBD Study, uses only de-identified and aggregated data.

Case Definition

Otitis media was defined as an infection of the middle ear in the GBD 2019 study, which included acute otitis media, chronic otitis media, and hearing loss due to chronic otitis media in the GBD nonfatal outcome modeling. Estimates of hearing loss due to chronic otitis media is included in the hearing loss report provided separately. The ICD 10 codes are H65-H75.83, and the ICD 9 codes are 381-384.9.

Statistical Analysis

To characterize the burden of otitis media by age, sex, year, and location, descriptive analyses were conducted. The rates and their 95% uncertainty intervals (UIs) were directly obtained from the Institute for Health Metrics and Evaluation website. The AAPCs were calculated to assess the epidemiologic trends in otitis media using linear regression analyses, and all rates were reported per 100,000 population. The trends in rates were reflected in AAPC values and their 95% confidence intervals (CIs). The rate had an increasing trend when the AAPC and the lower boundary of the 95% CI were positive; conversely, the rate had a decreasing trend when the AAPC and the upper boundary of the 95% CI were negative. The joinpoint program is designed to analyze trends and identify significant changes, known as "joinpoints," in a time series data set. The program utilizes the Joinpoint Regression Model, which fits a series of line segments to the data and determines the optimal number of joinpoints. Joinpoint analysis is commonly used in epidemiology, public health, and other fields to examine trends in various health outcomes, including disease incidence, mortality rates, and healthcare utilization. It allows

researchers to identify points in time where the trend significantly changes, providing insights into the underlying factors driving the observed patterns. The Joinpoint program uses a permutation-based method to test for statistical significance of joinpoints and calculates annual percent change estimates for each segment. These annual percent change estimates quantify the average annual rate of change within each segment, allowing for a detailed analysis of trends over time. The Joinpoint program provides several features and options for data analysis, including choosing the maximum number of joinpoints, selecting the most appropriate statistical model, adjusting for covariates, and generating graphical outputs such as joinpoint plots and trend graphs. Furthermore, the patterns of the associations between the incidence and DALYs with SDI and the HAQ index in 2019 in different countries were examined by using Spearman's correlation. All statistical analyses were performed using GraphPad Prism (version 8.0), Rstudio software (version 1.4.1106), and the Joinpoint Regression Program (version 4.9.0.0).

RESULTS

Global Trends

Globally, the all-age rate of incidence decreased between 1990 and 1999 (AAPC = −0.7 [95% CI = −0.7 to −0.8]), decreased sharply between 2000 and 2009 (AAPC = −1.2 [−1.4 to −0.9]), and continued to decrease between 2010 and 2019 (AAPC = −0.2 [−0.3 to −0.1]) (Table 1). Overall, the all-age rate of incidence decreased from 1990 to 2019 with an AAPC of −0.8 (95% CI = −0.9 to −0.7) (Table 1). The all-age rate of prevalence, mortality, and DALYs decreased from 1990 to 2019 and every decade in between. The joinpoint regression analysis identified a substantial change in the all-age rate of incidence of otitis media in 2000, 2005, 2014, and 2017 (Fig. 1).

Global Trends by Sex and Age Group

The age-standardized incidence of otitis media increased in both males and females from 1990 to 2019, with an AAPC of 0.1 (95% CI = 0.01 to 0.1; from 4861 per 100,000 population [95% UI = 3223.6 to 7187.1] in 1990 to 5214.9 per 100,000 population [3476.7 to 7624.2]) in males and an AAPC of 0.1 (95% CI = 0.02 to 0.1; from 5171.6 per 100,000 population [95% UI = 3461.8 to 7504] to 5384.4 per 100,000 population [3558.2 to 7804.6]) in females (Supplemental data 2 in Supplemental Digital Content, http://links.lww.com/EANDH/B254). There were decreases in the age-standardized prevalence, mortality, and DALYs in both males and females from 1990 to 2019 (Supplemental data 3 to 4 in Supplemental Digital Content, http://links.lww.com/EANDH/B255).

In addition, the age-specific incidence of otitis media increased in neonates and those aged 10 to 29 years of age from 1990 to 2019. Adults aged ≥40 years had a decrease in age-specific incidence in the same period. The highest age-specific incidence of otitis media in 2019 was observed in those aged 1 to 4 years old (29,127.3 per 100,000 population [95% UI = 14,947.2 to 50,127.2]). All age subgroups had decreasing age-specific DALYs from otitis media between 1990 and 2019. Early neonates had the highest age-specific DALYs in 2019 (606.9 per 100,000 population [17.1 to 2510.4]) (Supplemental data 2 in Supplemental Digital Content, http://links.lww.com/EANDH/B254).

Global Trends by SDI

The largest increase in age-standardized incidence of otitis media by SDI quintile was observed in the middle-SDI quintile (from 4200.7 per 100,000 population [95% UI = 2773.3 to 6163.1] in 1990 to 4605.3 per 100,000 population [3031.1 to 6791.83] in 2019; AAPC = 0.3 [95% CI = 0.3 to 0.3]). The next largest increase was found in the high-middle SDI quintile (from 3916.6 per 100,000 population [2727.1 to 5565.1] in 1990 to 4032.6 per 100,000 population [2753.4 to 5780.3] in 2019; AAPC = 0.1 [0.1 to 0.1]). The high, low-middle, and low SDI quintiles had decreasing trends in the age-standardized incidence of otitis media from 1990 to 2019. In addition, countries in all SDI quintiles had a reduction in the age-standardized DALYs from otitis media during the same period (Supplemental data 2 in Supplemental Digital Content, http://links.lww.com/EANDH/B254).

Regional Trends

Regionally, an increase in the age-standardized incidence of otitis media was observed in the following: Eastern Europe (from 4962.8 per 100,000 population [95% UI = 3558.9 to 6859.3] in 1990 to 4971.7 per 100,000 population [3555.6 to 6843.9] in 2019; AAPC = 0.01 [95% CI = 0.01 to 0.01]); high-income Asia Pacific (from 3860.4 per 100,000 population [2692.9 to 5299.2] in 1990 to 4095.3 per 100,000 population [2789.5 to 5676.1] in 2019; AAPC = 0.2 [0.2 to 0.3]); and Western Sub-Saharan Africa (from 6789.9 per 100,000 population [4393.6 to 10,272.1] in 1990 to 6907.4 per 100,000 population [4360.2 to 10,580.2] in 2019; AAPC = 0.01 [0.01 to 0.01]) between 1990 and 2019. Notably, high-income North America had the largest decrease in the age-standardized incidence of otitis media (from 4850.7 per 100,000 population [3157.4 to 6969.9] in 1990 to 4312.4 per 100,000 population [3327.9 to 5536.5] in 2019; AAPC = −0.7 [−0.9 to −0.6]). Furthermore, almost all the regions had a reduction in the age-standardized DALYs from otitis media during the same period. The Southeast

TABLE 1. Global AAPCs in all-age rate of incidence, prevalence, mortality, and DALYs for otitis media from 1990 to 2019

	Incidence		Prevalence		Mortality		DALYs	
Years	AAPC (95% CI)	*p*	AAPC (95% CI)	*p*	AAPC (95% CI)	*p*	AAPC (95% CI)	*p*
1990–1999	−0.7 (−0.7 to −0.8)	<0.001	−0.6 (−0.7 to −0.5)	<0.001	−7.8 (−8.6 to −7.0)	<0.001	−1.2 (−1.3 to −1.1)	<0.001
2000–2009	−1.2 (−1.4 to −0.9)	<0.001	−0.8 (−0.9 to −0.8)	<0.001	−7.3 (−8.0 to −6.7)	<0.001	−1.0 (−1.0 to −0.9)	<0.001
2010–2019	−0.2 (−0.3 to −0.1)	0.01	−0.7 (−0.7 to −0.6)	<0.001	−3.6 (−3.9 to −3.3)	<0.001	−0.8 (−0.8 to −0.8)	<0.001
1990–2019	−0.8 (−0.9 to −0.7)	<0.001	−0.7 (−0.7 to −0.8)	<0.001	−6.8 (−7.3 to −6.4)	<0.001	−1.0 (−1.1 to −1.0)	<0.001

AAPC, average annual percentage change; CI, confidence interval; DALYs, disability-adjusted life years.

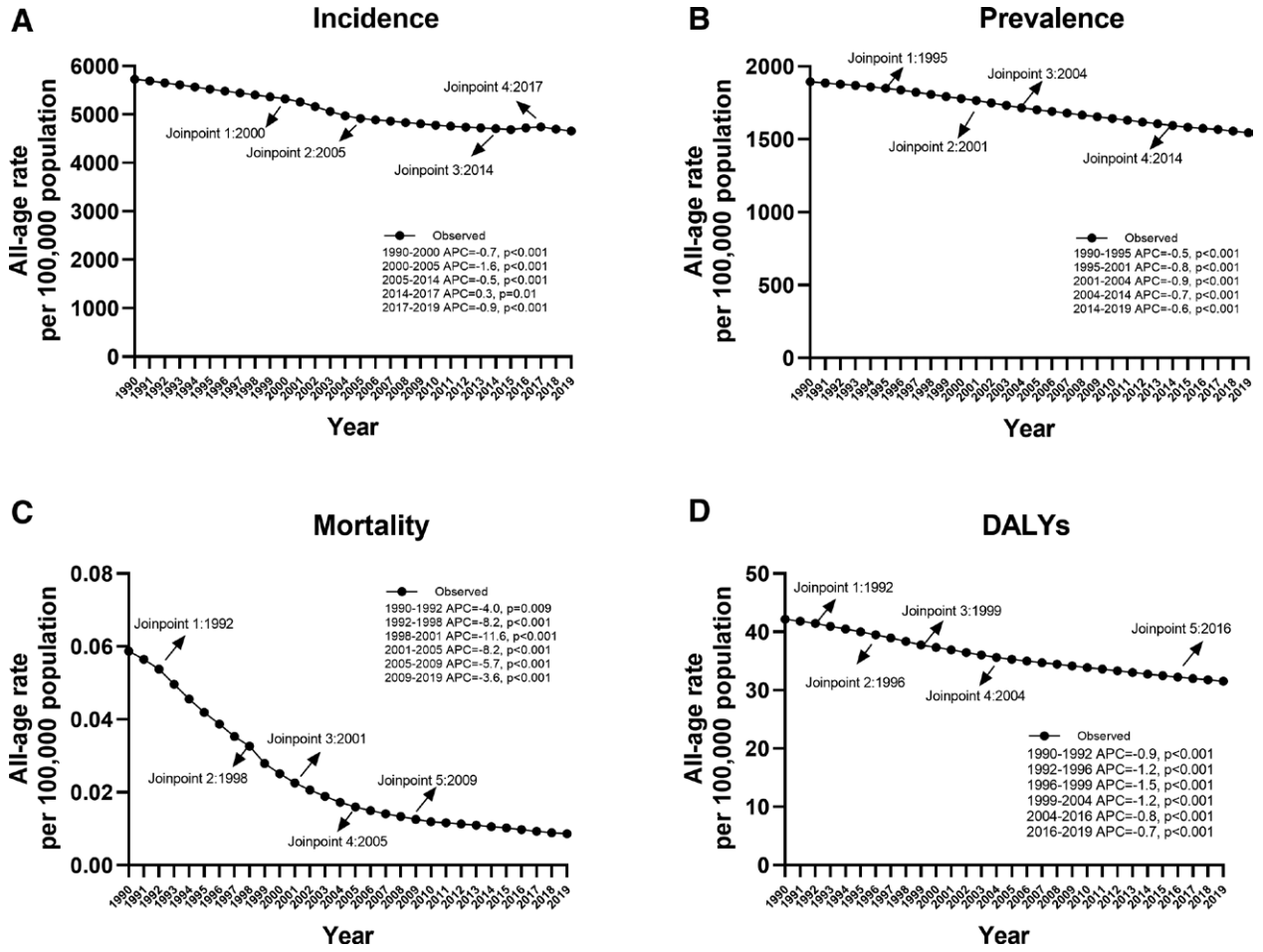

Fig. 1. Joinpoint regression analysis of global otitis media for all-age rate of incidence (A), prevalence (B), mortality (C), and DALYs (D) from 1990 to 2019. APC indicates average annual percentage change; DALYs, disability-adjusted life year.

Asia Region and South Asia experienced the greatest decreases, despite having the highest age-standardized DALY burden in 2019 (Supplemental data 2 in Supplemental Digital Content, http://links.lww.com/EANDH/B254).

National Trends

At the national level, the largest increase in the age-standardized incidence of otitis media from 1990 to 2019 was in the Republic of Korea (from 3021.8 per 100,000 population [95% UI = 2202 to 4009] to 3741.5 per 100,000 population [2526.1 to 5146.6]; AAPC = 0.8 [95% CI = 0.6 to 1.1]), followed by Germany (AAPC = 0.3), Thailand (AAPC = 0.2), and Saudi Arabia (AAPC = 0.2). Between 1990 and 2019, the largest increase in the age-standardized DALYs from otitis media was observed in Zimbabwe (AAPC = 0.6), Nauru (AAPC = 0.4), and the Northern Mariana Islands (AAPC = 0.4). Notably, in 2019, the country with the highest age-standardized incidence of otitis media was Nepal (9860.3 per 100,000 population [95% UI = 6114.4, 14,883.8]), while the country with the highest age-standardized DALYs from otitis media was Somalia (87.9 per 100,000 population [48.1 to 167.9]) (Fig. 2 and Supplemental data 5 in Supplemental Digital Content, http://links.lww.com/EANDH/B256).

National Burden of Otitis Media by SDI and HAQ Index

Figure 3 shows the association between the national-level age-standardized incidence and DALYs from otitis media and the SDI and HAQ index in 2019 among 204 countries and territories. The age-standardized incidence and DALYs of otitis media decreased with the increasing SDI and HAQ index.

DISCUSSION

To our knowledge, this is the first study to describe the most up-to-date estimates of the incidence, prevalence, mortality, and DALYs for otitis media from 1990 to 2019 at the global, regional, and national levels. Over the past 3 decades, the incidence, prevalence, mortality, and DALYs for otitis media have shown a downward trend, which is a benefit of the improvement in prevention and treatment. Children and young adults accounted for more than 90% of the incident cases of otitis media in 2019. The burden of incidence and DALYs from otitis media decreased with increasing SDI and HAQ index among 204 countries and territories.

Over the past 2 decades, considerable medical progress has been made in the treatment and prevention of otitis media. Key interventions include conjugate vaccines against *S. pneumoniae*. The sharp decline in the incidence of otitis media occurred in

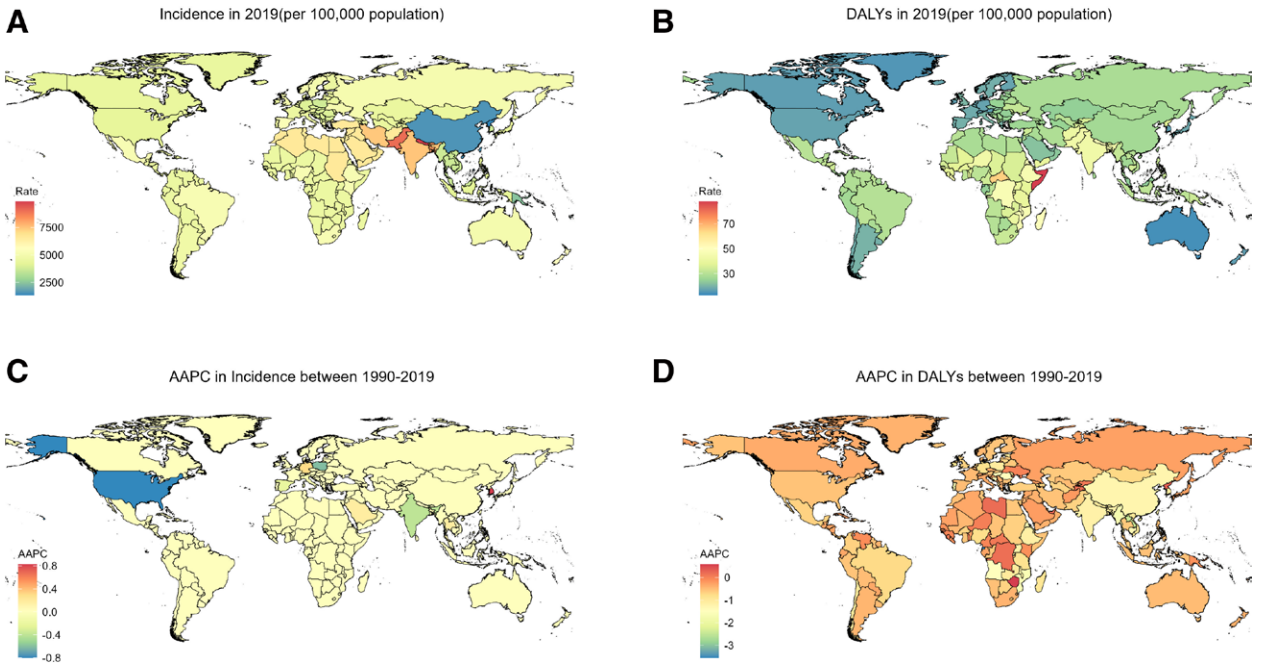

Fig. 2. Global map of 2019 age-standardized incidence (A) and DALYs (B) of otitis media and average annual percentage changes in incidence (C) and DALYs (D) from 1990 to 2019. AAPC indicates average annual percentage change; DALYs, disability-adjusted life years.

2000, approximately coinciding with the introduction of PCV-7 in the same year. However, it was not until a few years later that it became a routine of the national childhood immunization program. Indeed, we should also acknowledge that apart from vaccination, changes in environmental factors and socioeconomic disparities can also impact the variations in the burden of otitis media. Between the years 2010 and 2019, following the introduction of PHiD-CV and PCV-13, we observed a consistent reduction in the burden of otitis media aligning with previous research findings (Izurieta et al. 2022; Wannarong et al. 2023). Nevertheless, this study identified an upward trend in the global incidence of otitis media from 2014 to 2017. Because the widespread use of PCV/PHiD-CV, the pneumococcal population has changed because of an increase in nonvaccine serotypes in the nasopharynx both in asymptomatic carriers and in patients with otitis media, a process termed "serotype replacement" (Casey et al. 2010). The increased antibiotic resistance of pneumococci observed in the population after PCV-13/PHiD-CV may reflect serotype replacement and may have contributed to the increased incidence of otitis media during 2014 to 2017 (Halgrimson et al. 2014; Dagan et al. 2016). These changes require that new vaccines provide broader serotype protection. It's important to explore a multifaceted approach that combines serotype coverage expansion with innovative immunological strategies to effectively manage and reduce otitis media incidence over the long-term.

Neonates, children under five, and young adults suffered the most from incident otitis media, indicating the need for a more effective early detection tool for clinicians and pediatricians. Factors that could increase the otitis media incidence include the lack of breastfeeding, increasing environmental air pollutants and risk of upper respiratory tract infection, and exposure to second-hand tobacco smoke (Vergison et al. 2010; Victora et al. 2016; Ma et al. 2021; World Health Organization 2021). For neonates and children under five, improving the breastfeeding rate in children to enhance immunity is the most cost-effective way to prevent children's diseases (The United Nations Children's Fund 2021). To prevent the occurrence of otitis media, we can continue to actively improve environmental factors, promote breastfeeding, develop vaccines against otitis media pathogens, and explore nonantibiotic agents for the treatment of otitis media.

The incidence of otitis media is also highly related to the local economy, healthcare access and quality, and the regional environment. The incidence of otitis media is high in South Asia, North Africa, and the Middle East, which is explained in part by the low socioeconomic status and poor healthcare services in these regions (Zakaria et al. 2020). Although the public health interventions in North Africa and the Middle East have improved, they are still at lower levels than those in other regions (Nagi et al. 2022). Nationally, the Republic of Korea had the largest increase in incidence of the disease. Because the introduction of PVC7 in 2003 and PCV-10 and PCV-13 in 2010, the incidence of otitis media in children in the Republic of Korea has decreased (Lee et al. 2020). However, analysis of the age-standardized incidence data after normalization with global population data showed an increasing trend from 1990 to 2019, which is probably due to the change in microbial profiles in the Republic of Korea; specifically, the increase in coagulase-negative *Staphylococcus* and bacterial resistance to ciprofloxacin (Kim et al. 2017). The observation of increased reported incidence in South Korea could also be influenced by the country's robust healthcare system and improved surveillance mechanisms. The enhanced detection and reporting of cases, particularly those that might have been previously overlooked, could contribute to the perceived increase in incidence. Further research is warranted to comprehensively assess the factors contributing to the observed changes in otitis media

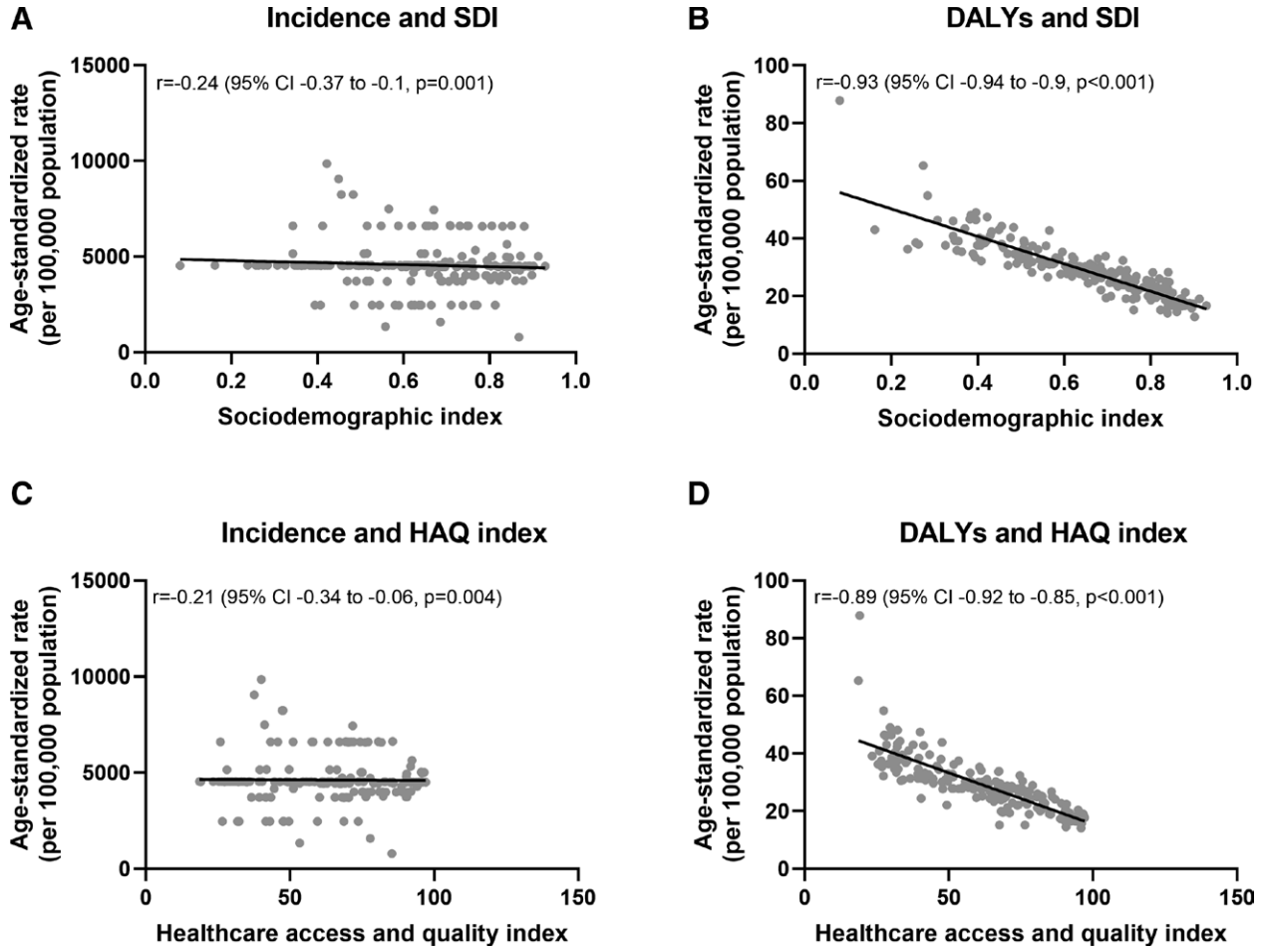

Fig. 3. Age-standardized incidence and disability-adjusted life years of otitis media in 2019 in 204 countries and territories by sociodemographic and HAQ Index. (A) Incidence and SDI; (B) DALYs and SDI; (C) Incidence and HAQ index; (D) DALYs and HAQ index. The circles represent countries that had available sociodemographic, healthcare, and quality index data. CI indicates confidence interval; DALY, disability-adjusted life year; HAQ, healthcare access and quality; SDI, sociodemographic index.

incidence, including both acute and chronic cases, within the context of South Korea's healthcare system, diagnostic practices, and other relevant determinants. In accordance with previous evidence suggesting that the incidence of otitis media varies between developed and developing countries, our results further specified regions and nations with a higher burden of otitis media and related healthcare resources (Ovnat Tamir et al. 2017). For countries and regions with lower economic levels, enhancing access to healthcare services is of paramount importance. This could encompass increasing the number of medical facilities, particularly in rural or underserved areas. Specific recommendations for targeted interventions and rehabilitation choices may vary depending on the resources, infrastructure, cultural context, and socioeconomic factors unique to each region or country. Therefore, conducting a comprehensive assessment of the local healthcare system and fostering collaboration among policymakers, healthcare professionals, and relevant stakeholders are critical in formulating and implementing effective strategies.

Although the DALYs from otitis media have continued to decrease since 1990, the use of antibiotics should be cautiously considered because the treatments for otitis media mainly rely on the use of antibiotics (Li et al. 2023). In recent years, the United Nations and the WHO have realized the threat posed by antibiotic resistance to human health (Gröndal 2018). Various countries and regions have developed guidelines to limit the use of antibiotics and to explore new treatment methods, such as immediate or delayed use of antibiotics, and unilateral or bilateral ear antibiotics based on the severity of the otitis media as well as the age of the patient (Hayashi et al. 2020). The updated NICE guidelines for the management of otitis media also recommend that anesthetics and ear drops for pain should be considered in the initial management of acute otitis media, with the aim of reducing the use of antibiotics (Meredith 2022).

This study has implications for future research. Some studies have shown that the measures taken in response to coronavirus disease of 2019, including an emphasis on personal hygiene and social distancing, may have had a positive impact on the occurrence of otitis media (Choi et al. 2022). However, necessary vaccinations may be delayed because of social distancing, which may increase the risk of vaccine-preventable otitis media. Our study serves as a pre-coronavirus disease of 2019 comparison. Conversely, antibiotic-resistant *Streptococcus pneumoniae* is a global problem, and this study highlights the importance of addressing the burden of otitis media through multiple strategies,

including national vaccination programs, antibiotic control programs, and ongoing antimicrobial resistance surveillance.

This study has several limitations. First, we only considered the relationship between calendar year and rate; other associated factors affecting epidemiologic trends were not considered. Second, our study was limited by differences in the quality of the GBD data as well as the missing data, especially from low- and middle-income countries. In countries with lower levels of health care, the lack of diagnostic facilities may have introduced bias into our results by underestimating the burden of otitis media. In regions where the data were limited, more research is needed to better understand the burden of otitis media and associated vaccine coverage. Third, it's important to acknowledge that specific information about PCV/PHiD-CV vaccination coverage on a country level was not available within the GBD study database, which reduced our ability to thoroughly examine the influence of PCV/PHiD-CV vaccination coverage on the burden of otitis media across different countries. Last, in the modeling strategy for otitis media in the GBD study, estimates for specific types of otitis media were not provided separately. Considering the significance of assessing the burden of acute and chronic otitis media in formulating public health strategies, we suggest that the GBD collaboration should consider separately estimating data for different specific types of otitis media in the future.

Over the past 3 decades, there has been success in previous efforts to reduce the burden of otitis media worldwide. The global incidence of otitis media declined sharply after the introduction of PCV-7 in 2000, and this decrease continued in subsequent years with the replacement of PVC13/PHiD-CV. Interventions such as childhood screening and early hearing health education are highly recommended to ameliorate this burden. Ongoing epidemiologic surveillance of the global patterns of otitis media, pathogen distribution, and resistance is warranted.

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All data will be made available on request to the corresponding author. Proposals will be reviewed and approved by the sponsor, investigator, and collaborators on the basis of scientific merit. After approval of a proposal, data will be shared through a secure online platform after the signing of a data access agreement.

The authors have no conflicts of interest to disclose.

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