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Autism Spectrum Disorders in China: An Analysis of Temporal Trends in Prevalence, Incidence, and DALYs (1990–2021) Based on GBD 2021 Data

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ABSTRACT

Objective To examine the temporal trends in the prevalence, incidence, and disability-adjusted life years (DALYs) of autism spectrum disorder (ASD) in China from 1990 to 2021 and to project the future burden to 2036.

Methods Data were sourced from the Global Burden of Disease (GBD) 2021 provided by the Institute for Health Metrics and Evaluation (IHME). Join-point regression was applied to estimate the annual percentage change (APC) of prevalence, incidence, and DALYs. Age–period–cohort analysis was used to assess the effects of age, period, and cohort. Decomposition analysis quantified the contributions of population growth, demographic aging, and epidemiological changes. An AutoRegressive Integrated Moving Average (ARIMA) model was employed for projections to 2036.

Results Between 1990 and 2021, the average annual percentage change (AAPC) was 0.22% (95% uncertainty interval [UI]: 0.20%–0.24%) for prevalence, –0.07% (95% UI: –0.14%–0.28%) for incidence, and 0.23% (95% UI: 0.21%–0.25%) for DALYs. ASD prevalence and DALYs peaked in children aged 0–5 years and declined after age 60. Rising prevalence and DALYs were mainly attributable to population growth (89.7% and 95.2%) and epidemiological changes (32.6% and 36.2%), while aging offset growth (–22.4% and –16.0%). Projections indicated stable age-standardized incidence for both sexes but divergent prevalence trends, with rates increasing among males and decreasing among females.

Conclusions The ASD burden in China is rising, largely driven by demographic and epidemiological dynamics, with young children and males being the most affected groups. Prioritizing early detection and gender-sensitive interventions are recommended.

Key words: Autism spectrum disorder; Disease burden; China

INTRODUCTION

Autism spectrum disorder (ASD) is a chronic, neurodevelopmental condition characterized by deficits in social communication and interaction, along with restrictive, repetitive, and stereotyped patterns of behavior and interests[1,3]. This disorder manifests early in life and persists throughout an individual's lifespan[2]. Globally, ASD imposes a substantial health burden.

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The Global Burden of Disease (GBD) 2021, provided by the Institute for Health Metrics and Evaluation (IHME), estimated 61.8 million prevalent cases, with prevalence and DALYs increasing by nearly 50% between 1990 and 2021[4]. ASD ranked ninth among neurological conditions contributing to DALYs and was a leading cause of disease burden in children and adolescents[4]. In China, ASD accounted for around 12% of global cases in 2021, with national estimates also showing a considerable burden among children and adolescents[5].

While existing studies have reported the epidemiology and health burden of ASD[6,7], they had several limitations. First, the majority of previous studies focused on the global level of epidemiology and disease burden on ASD[7]. However, existing evidence has suggested that the disease burden of ASD in China differs from global patterns and has shown a rapid increase in recent years[8]. Despite this, insufficient attention has been given to the epidemiological characteristics and disease burden of individuals with ASD in China. Second, existing studies in China have mainly concentrated on the prevalence and DALYs of ASD in children and adolescents[6], resulting in a lack of comprehensive epidemiological estimates encompassing the overall population prevalence, DALYs, and the temporal trends in health loss associated with ASD. Last, current research lacked longitudinal analyses examining trends in ASD across age, period, and cohort dimensions, as well as predictive analyses on the future incidence, prevalence, and disease burden of ASD based on the GBD 2021 data.

Our present study used the GBD 2021 data to comprehensively analyze the current epidemiology and disease burden of ASD, focusing on trends in prevalence, incidence, and DALYs in China from 1990 to 2021. Moreover, we assessed the influence of age, period, and cohort, and projected the future burden of ASD over the next 15 years, aiming to inform early intervention strategies, health system planning, and policy responses to address the growing impact of ASD in China and other countries with similar conditions.

METHODS

Data sources

We retrieved data for China from the Global Health Data Exchange (GHDx) (http://ghdx. healthdata.org/gbdresults-tool). This evaluation encompassed the counts and age-standardized rates (ASR) of prevalence, incidence, and DALYs from 1990 to 2021.

Join-point regression model

To evaluate the temporal trend in incidence, prevalence, and DALYs of ASD from 1990 to 2021, we performed a Join-point regression model[9] to understand the temporal trend in disease burden. This model employs segmented regression on a log-linear regression model, represented as $ln(y) = \beta \times x + \text{constant}$, to identify inflection points in the trend. We utilized the grid search method (GSM) to calculate all possible join points, selecting the one with the smallest mean squared error (MSE) as the optimal inflection point. Building on this, the optimal number of join points was determined using the Monte Carlo permutation test, allowing for a maximum of 5 join points and a minimum of 0. The final model calculated the annual percentage change (APC), average annual percentage change (AAPC), and the corresponding 95% confidence intervals (CI) for the world and each SDI region to quantify trend changes from 1990 to 2021.

The calculation formula for APC is: $APC=(e\beta-1) \times 100\%$, where β is the regression coefficient from the log-linear model $ln\ (y) = \beta \times x + \text{constant}$. AAPC reflects the overall trend change by weighting each segment's APC according to the time span. This analytical method not only enhances the precision in identifying temporal trends but also improves the robustness of the model. The analysis was performed using the Joinpoint Regression Program (version 5.3.0).

Age-period-cohort model

The age-period-cohort model was employed to examine the impacts of age, period, and cohort on health outcomes. The log-linear regression model and the intrinsic estimator (IE) method, integrated into the age-period-cohort model, were utilized to obtain the net effects across the three dimensions[10]. The age-period-cohort model was constructed using the Age Period Cohort Analysis Tool (https://analysistools.cancer.gov/apc/). For the model's operation, age was grouped into 20 consecutive 5-year intervals (0 – 4 to 95 – 99 years). The data series were divided into consecutive 5-year intervals from 1992 to 2021. Data from 1990 to 1991 were excluded due to not constituting a 5-year interval. The mean levels of age, period, and cohort were chosen as the reference groups. The relative risk (RR) values for each age, period, and cohort

indicate the independent risks relative to the reference group[11].

Attribution decomposition analysis

To quantify the drivers underlying changes in ASD burden over time, we applied the Das Gupta decomposition method, which partitions the change in total DALYs and age-standardized prevalence from 1990 to 2021 into the independent contributions of population growth, population aging, and epidemiological changes. This approach enabled us to dissect the overall changes in burden into these key factors, offering clearer insights into how demographic and epidemiological shifts have shaped the trends over time. In the Das Gupta decomposition method, each component (population growth, population aging, and epidemiological change) is estimated independently by holding the other factors constant. As a result, the contributions are not constrained to sum to 100%, and individual components may exceed 100% or take negative values. This reflects their net effects rather than proportional shares of the total change. Unlike traditional methods such as linear regression, which primarily focus on establishing relationships between variables, decomposition analysis enables a detailed assessment of the independent contributions of each factor to the overall changes in disease burden. By dissecting these trends, we gained clearer insights into the underlying drivers of changes in the global burden of ASD.

Specifically, we calculated DALYs for each region using the following formula:

$$Outcome_y = \sum_{i=1}^{20}(a_{i,y} \times p_y \times e_{i,y})$$

where $a_{i,y}$ represents the proportion of the population in age group *i* out of 20 age groups in year *y*; p_y represents the total population in year *y*; and $e_{i,y}$ represents the prevalence or DALYs rate in age group *i* in year *y*. By isolating other variables, we quantified the unique impact of a single factor on the changes in prevalence and DALYs.

AutoRegressive Integrated Moving Average (ARIMA) model

The ARIMA model combines autoregressive (AR) and moving average (MA) components, was fitted to project prevalence and incidence of ASD in China for 2022–2036.

ARIMA is well-suited for long-term forecasting of non-seasonal epidemiological time series, provides stable performance with limited annual data points, and has been widely applied in disease burden studies using GBD data[12,13]. It operates on the premise that the data series are time-dependent random variables, with autocorrelation patterns that can be effectively captured within the ARIMA framework, which allows future values to be forecasted using historical data through specific equations. The time series in the ARIMA model should form a stationary and stochastic sequence with a zero mean. During the ARIMA modeling process, differencing is first applied to stabilize the time-series data. The *auto. arima()* function is then used to identify the optimal model based on the Akaike information criterion (AIC)[14].

Statistical analysis

Age-standardized incidence rates (ASIR), age-standardized prevalence rates (ASPR), and age-standardized DALYs rates were calculated using GBD global reference population. Additionally, 95% uncertainty intervals (UIs) were derived from 1,000 random samples drawn of posterior distribution. Analyses were conducted using R 4.3.0, with statistical significance defined as two-tailed *P*-value <0.05.

RESULTS

The burden of ASD in China from 1990 to 2021

The number of ASD individuals in China increased from 7.35 million (95% UI: 6,120,001–8,699,968) in 1990 to 9.08 million (95% UI: 7,559,642–10,816,937) in 2021, and the ASPR increased from 612.61 (95% UI: 509.84–724.96) to 655.75 (95% UI: 545.06–780.37). The AAPC of prevalence showed an upward trend (0.22%; 95% UI: 0.20%–0.24%). Males had higher ASD prevalence, with the age-standardized rates ratio of 3.05 (95% UI: 2.35–3.95) (**Table 1**). In contrast, the incidence remained relatively stable (ASIR: 14.4 in 1990 *vs* 14.6 in 2021, AAPC: −0.07%). Males had a higher incidence with the age-standardized rates ratio of male-to-female of 3.0 (95% UI: 2.31–3.88) (**Table 1**).

The DALYs increased from 1.39 million (943,870–1,971,071) in 1990 to 1.70 million (95% UI: 1,146,590–2,397,647) in 2021, with AAPC rising by 0.23% (95% UI: 0.21%–0.25%) annually. The age-standardized DALYs increased from 115.81 (95% UI: 78.58–163.69) to 124.19 (95% UI: 83.7–175.1) (**Table 1**). Males had a higher ASD DALYs with the age-standardized rates ratio of male-to-female of 3.06 (95% UI: 1.8–5.18).

Table 1. The number and ASR of prevalence, incidence and DALYs of autism spectrum disorders in China from 1990 and 2021, and its temporal trends from 1990 to 2021

Measure	1990		2021					1990-2021
	Number (95%UI)	ASR	Number (95%UI)	ASR	ASR (Male)	ASR (Female)	Male to female ratio (95%UI)	AAPC (95%UI)
Prevalence	7,347,264 (6,120,001–8,699,968)	612.61 (509.84–724.96)	9,078,613 (7,559,642–10,816,937)	655.75 (545.06–780.37)	968.95 (807.39–1,148.13)	318.17 (262.15–384.35)	3.05 (2.35–3.95)	0.22 (0.20–0.24)
Incidence	159,475 (133,375–188,028)	14.42 (12.06–17.01)	77,486 (64,597–91,917)	14.62 (12.19–17.34)	21.12 (17.68–24.96)	7.05 (5.80–8.53)	3.00 (2.31–3.88)	-0.07 (-0.14–0.28)
DALYs	1,392,966 (943,870–1,971,071)	115.81 (78.58–163.69)	1,700,739 (1,146,590–2,397,647)	124.19 (83.70–175.10)	183.4 (124.73–258.79)	60.01 (39.87–85.27)	3.06 (1.80–5.18)	0.23 (0.21–0.25)

ASR: age-standardized rate (per100,000 population); AAPC:average annual percentage change; DALYs: disability-adjusted life years.

Age and gender patterns

The prevalence and DALYs were concentrated in the age groups under 60 years old (**Fig. 1A** and **1C**). Across all age groups, males carried higher burdens than females (**Figs. 1B** and **1D**). With increasing age, the burden of prevalence and DALYs rate declined, especially after the age of 60 years old, with male decreasing more rapidly than females. The male-to-female ratios of the age-standardized rates of prevalence and DALYs were also decreasing (**Figs. 1B** and **1D**).

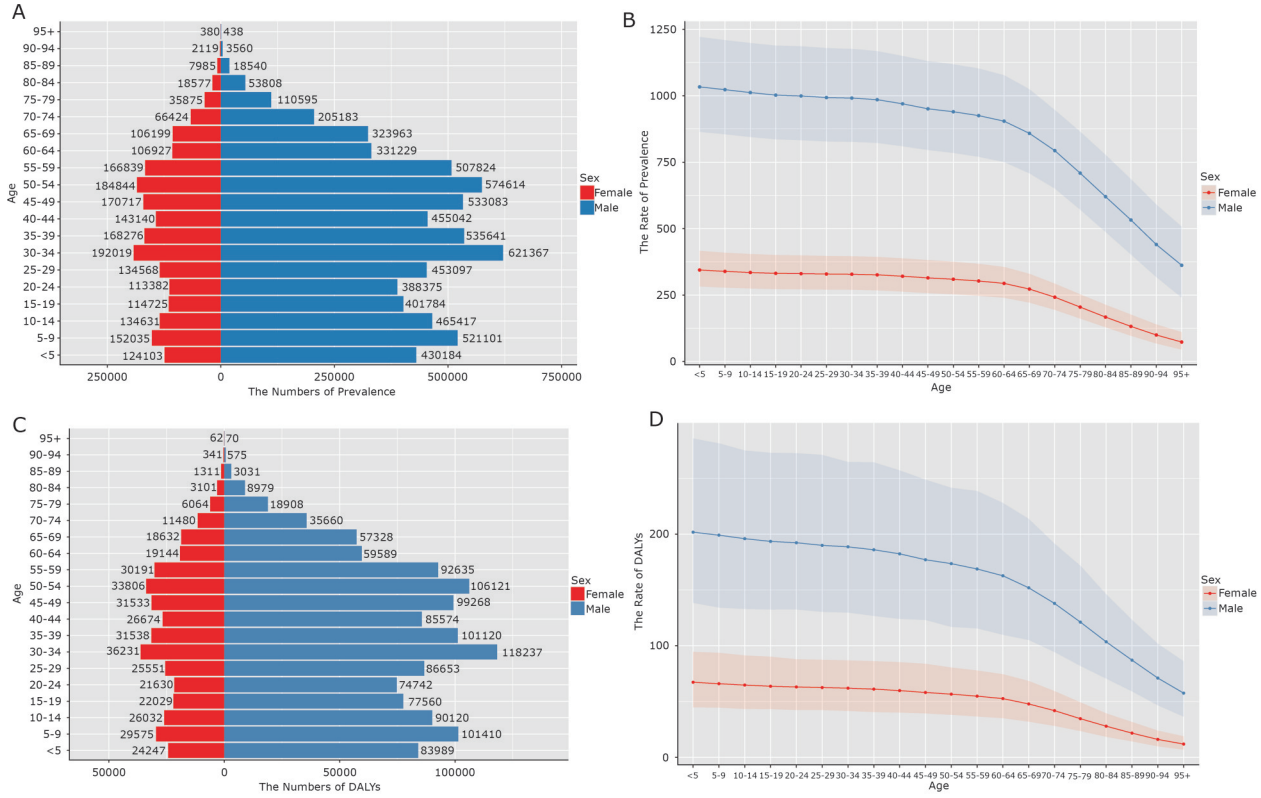

Figure 1. Age-specific numbers and age-standardized rates of ASD prevalence and DALYs in China, 2021.
(**A**) Numbers of ASD cases by age group. (**B**) Age-standardized prevalence rate of ASD. (**C**) Numbers of DALYs attributed to ASD by age group. (**D**) Age-standardized DALYs rate of ASD. DALYs: disability-adjusted life years.

The incidence and ASIR of males fluctuated over time, reaching a low point in 2011, but the overall trend remained stable (**Fig. 2A**). The measures gradually increased in males from 1990 to 2021, while remaining stable in females. The disease burden in females was consistently lower than in males (**Figs. 2B** and **2C**).

Temporal trends in incidence, prevalence, and DALYs

Incidence rates remained relatively stable overall but varied across specific intervals. Among males, the ASIR increased from 1990 to 1999 (APC = 0.42), decreased from 1999 to 2010 (1999-2007: APC = −0.17; 2007-2010: APC = −0.93), and increased again from 2016 to 2021 (APC = 0.57). Among females, the ASIR decreased from 1990 to 1994 (APC = −1.22), increased from 1994-2000 (APC = 0.70), decreased again from 2000 to 2011 (APC = −0.47), and then increased from 2011 to 2021 (APC = 0.16). The overall change trend of both sexes increased from 1990 to 2000 (APC = 0.35), decreased from 2000 to 2007 (APC = −0.23), and increased from 2016 to 2021. (**Fig. 3A**, **Table S1**, and **S2**)

For males, the ASPR continuously increased during the period from 1990 to 2021, with the fastest increase from 1995 to 2000 (APC = 0.63). For females, the ASPR decreased from 1990-1995(1990 – 1992: APC = −1.96; 1992 – 1995: APC = −0.75) and then persistently increased to 2021, with the fastest increase from 1995 to 2000 (APC = 0.91) (**Fig. 3B**, **Table S1**, and **S2**). The overall change trend of both sexes decreased from 1990 to 1992 (APC = −0.42) and increased from 1992 to 2021, with the fastest increase from 1995-2000 (APC = 0.68).

Among males, the age-standardized rate of DALYs continuously increased during the period 1990–2021, with the fastest increase from 1995 to 2000 (APC = 0.64). Among females, the age-standardized rate of DALYs decreased from 1990 to 1995 (1990 – 1992: APC = −1.92; 1992 – 1995: APC = −0.70) and then persistently increased to 2021, with the fastest increase from 1995 to 2000 (APC = 0.90). (**Fig. S1B**, **Table 1**, and **S1**) The overall change trend of both sexes decreased from 1990 to 1992 (APC = −0.40) and increased from

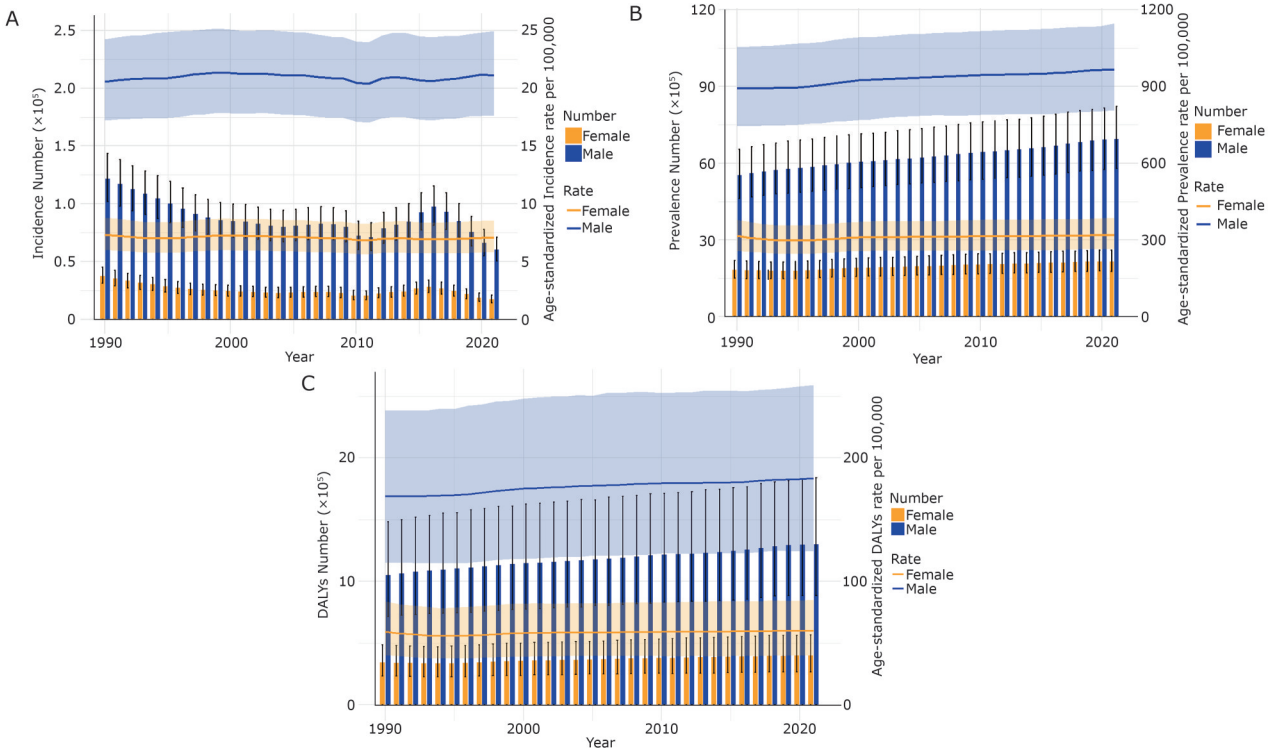

Figure 2. Differences in all-age cases and age-standardized rates of incidence, prevalence, and DALYs between males and females in China from 1990 to 2021.

(**A**) Incidence cases alongside age-standardized incidence rates (ASIR). (**B**) Prevalence cases alongside age-standardized prevalence rates (ASPR). (**C**) DALYs numbers alongside age-standardized DALYs rates. Bar charts illustrate the total counts, while lines depict the age-standardized rates. DALYs: disability-adjusted life years.

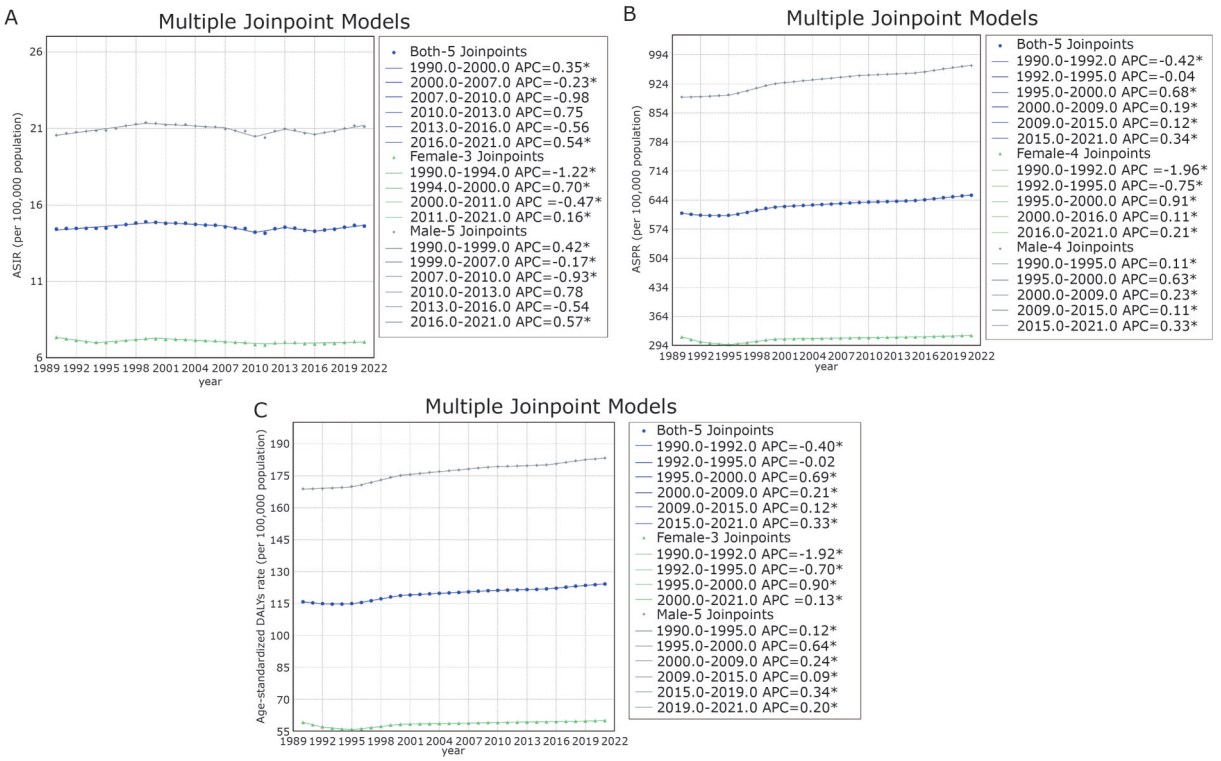

Figure 3. Trends of ASIR, ASPR, and age-standardized rate of DALYs in China from 1990 to 2021.
(**A**) Trends of ASIR by sex from 1990 to 2021; (**B**) trends of ASPR by sex from 1990 to 2021; (**C**) trends of age-standardized rate of DALYs by sex from 1990 to 2021. ASIR: age-standardized incidence rate; ASPR: age-standardized prevalence rate; DALYs: disability-adjusted life years.

1992 to 2021, with the fastest increase from 1995 to 2000 (APC = 0.69) (**Fig. 3C**, **Table S1**, and **Table S2**).

Age-period-cohort effects

The prevalence and DALYs of ASD peaked at 0 – 5 years and decreased rapidly after the age of 60 years. After controlling the effects of period and cohort, the risk of prevalence and DALYs in the 0 – 5 years group was 4.12 and 4.96 times the risks in the 95+ years. The prevalence was relatively stable among younger age groups, while a downward trajectory was observed in individuals aged 60 and above (**Fig. 4A**, **4D**, and **Table S3**).

Both the relative risk (RR) of prevalence and DALYs value increased from 0.94 (95% UI: 0.93, 0.95) in 1992 to 1.07 (95% UI: 1.06, 1.08) in 2021 (**Fig. 4B**, **4E**, and **Table S3**). From 1992 to 2021, ASD prevalence and DALYs have increased across all age groups, particularly among individuals aged 65 and older, where this upward trend was most pronounced (**Figs. 5B** and **5E**). Periods effect showed between 1992 and 2021, with the rates of prevalence and DALYs of ASD showing a consistent annual decline with increasing age (**Fig. 5A** and **5D**).

The analysis of birth cohorts revealed that the individuals born in earlier cohorts exhibited substantially lower risk, including the earliest birth cohort (1897 – 1901), which had an RR of 0.45 (95% UI: 0.20 – 1.02) for prevalence and 0.48 (95% UI: 0.21 – 1.10) for DALYs. The latest cohort (2017 – 2021) showed higher risk, with RR of 1.14 (95% UI: 1.11 – 1.14) for prevalence and 1.13 (95% UI: 1.13, 1.14) for DALYs (**Fig. 4C**, **4F**, and **Table S3**). Birth cohorts consistently demonstrated that individuals born earlier exhibited lower prevalence and DALYs, whereas those born more recently showed comparatively higher rates (**Figs. 5C** and **5F**).

Decomposition of ASD burden

The growth of disease burden in terms of prevalence is primarily attributed to population growth (89.73%) and epidemiological changes (32.62%). The aging effect had a negative impact, reducing the growth by 22.36%. Sex-specific decomposition showed similar patterns: among males, the population growth, epidemiological changes, and aging

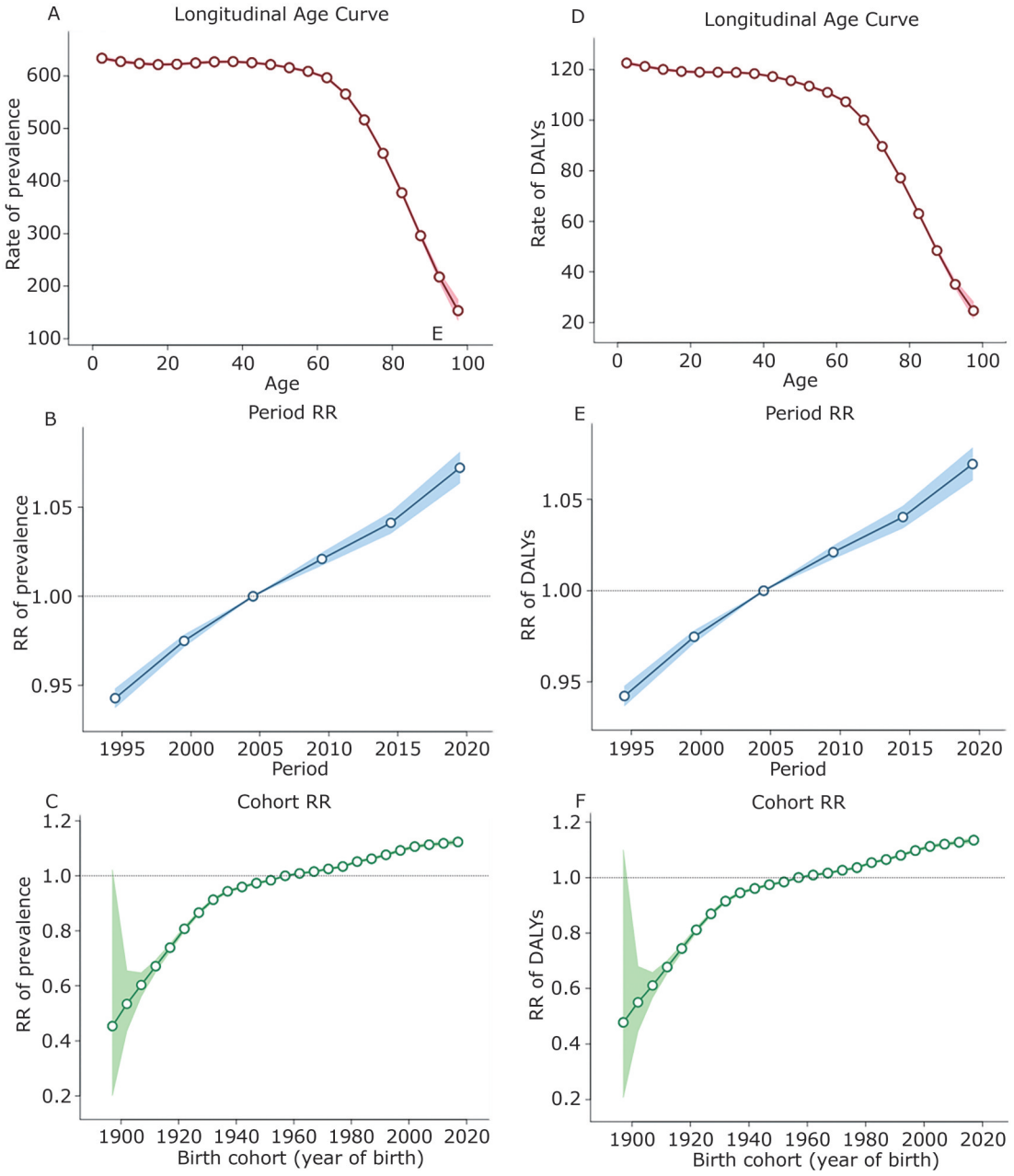

Figure 4. Age, period and cohort effects on ASD prevalence (4A, 4B and 4C) and DALYs (4D,4E and 4F) rate in China during 1990–2021.

DALYs: disability-adjusted life years; RR: relative risk.

contributed 79.85%, 36.17%, and −16.02%, respectively; among females, the corresponding contributions were 122.76%, 9.17%, and −31.93% (**Fig. S1A** and **Table S4**).

Similar patterns were observed for DALYs, where population growth (95.17%) and epidemiological changes (35.37%) were the drivers, while aging had a negative impact, reducing the growth by 30.54%. Among males, population growth, epidemiological changes, and aging contributed 84.38%, 38.55%, and 22.93%, respectively; among females, the corresponding contributions were 132.66%, 12.00%, and −44.66%. For males, population growth explained 84.38% of the increase in DALYs, with epidemiological changes contributing 38.55%. However, the aging effect had a negative impact, reducing the growth by 22.93%. In contrast, for females, population growth contributed 132.66% to the rise in DALYs, with epidemiological changes increasing it by 12.00%. Similarly,

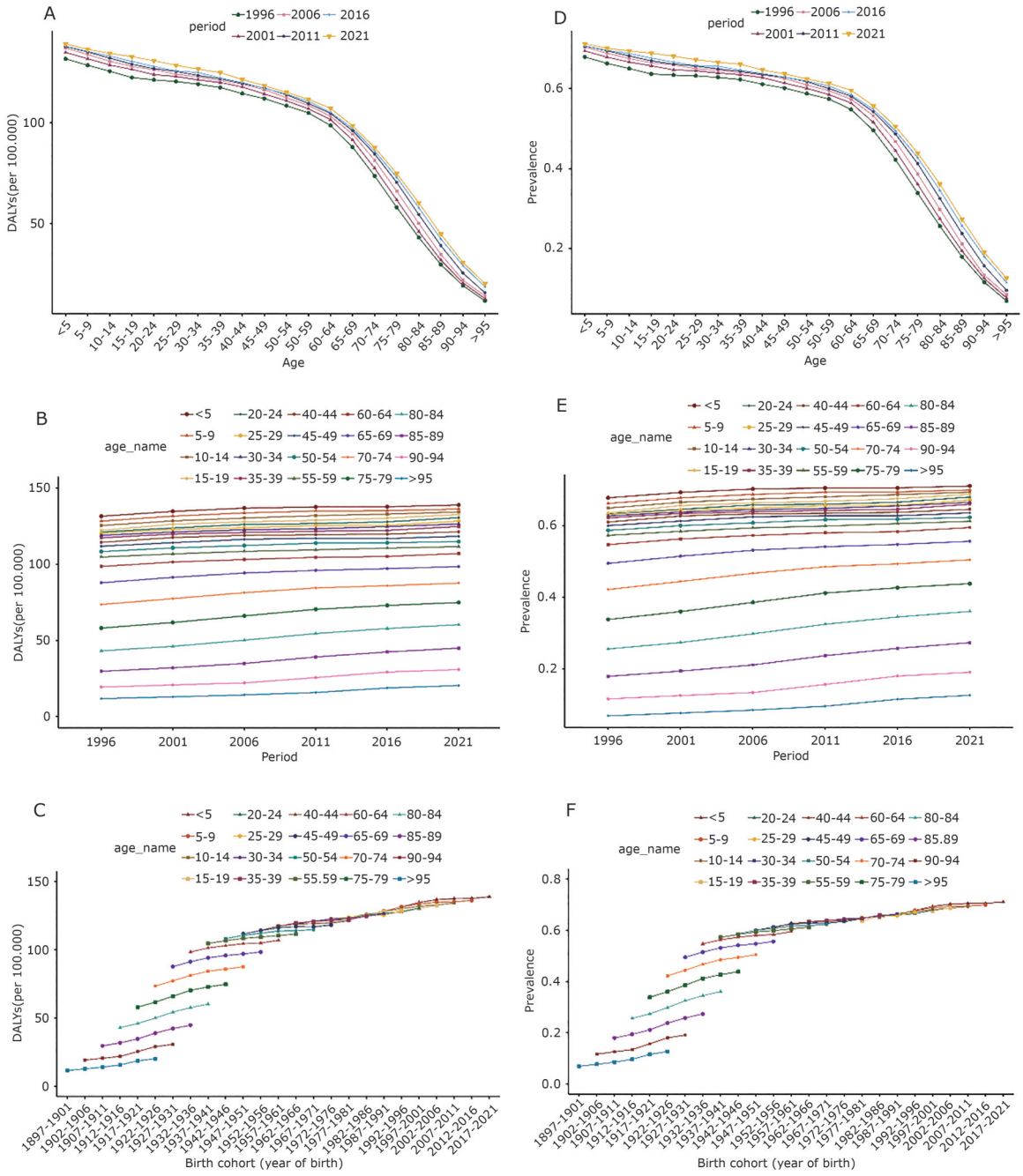

Figure 5. Trends in ASD Prevalence and DALYs Rates in China Across Age, Period, and Cohort Dimensions.
(**A**) Age-specific ASD DALYs rate; (**B**) period-based ASD DALYs rate; (**C**) cohort-based ASD DALYs rate; (**D**) age-specific ASD prevalence rate; (**E**) period-based ASD prevalence rate; (**F**) cohort-based ASD prevalence rate. DALYs: disability-adjusted life years.

the aging effect reduced the growth of DALYs by 44.66% (**Fig. S1B** and **Table S4**)

Forecasted prevalence and incidence (2022-2036)

From 2022 to 2036, incidence was expected to remain stable for both sexes (2036 ASIR: male 20.92, female 7.00, both sexes 14.54) (2022 ASIR: male 21.00, female 7.01, both sexes 14.55). Prevalence was expected to remain high, with a slight increase in males (ASPR: 969.18 to 997.25) and a small decline in females (ASPR: 317.41 to 311.56), leading to a modest decrease in overall rates (ASPR: 656.16 to 650.63) (**Fig. 6** and **Table S5**). These results demonstrated a good model fit. Residual diagnostics showed that both

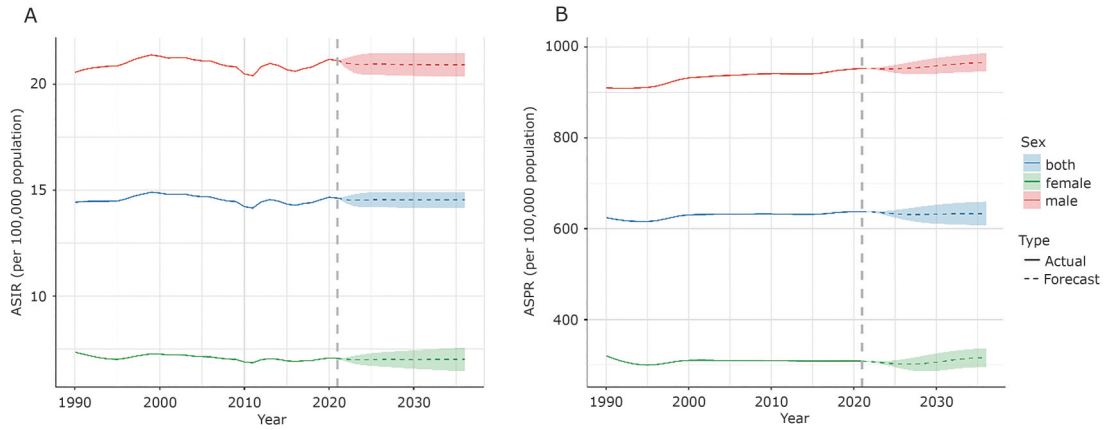

Figure 6. Forecasted trends of ASIR (A) and ASPR (B) for ASD in China from 2022 to 2036.
Solid lines in red, blue, and green depict the historical trends of ASIR and ASPR from 1990 to 2021. Dotted lines and shaded regions in corresponding colors represent the predicted trends and their 95% confidence intervals (CIs). ASIR: age-standardized incidence rate; ASPR: age-standardized prevalence rate.

KPSS and Ljung–Box tests supported well-behaved residuals (KPSS $P > 0.1$; Ljung–Box $P = 0.338$–0.890), and the models exhibited low forecasting errors (MAPE < 0.10), indicating good overall model fit (**Table S6** and **Table S7**).

DISCUSSION

This study, using GBD 2021 data, comprehensively assessed the ASD burden in China from 1990 to 2021 and provided forecasts through 2036. We found that ASD prevalence and DALYs increased steadily over the past three decades despite a relatively stable incidence, with the burden disproportionately higher among males and young children. Population growth and epidemiological changes were the main contributors to this rising burden, while aging offset part of the increase. Looking forward, our forecasts suggest that incidence will remain stable, but prevalence will stay high, particularly among males, underscoring the long-term public health significance of ASD in China. These findings highlight the need for targeted interventions, gender-specific strategies, and further research to address the growing impact of ASD on China's public health system.

Monitoring ASD burden trends is crucial for addressing emerging challenges and adapting health systems. Our findings are generally consistent with global evidence showing increases in ASD prevalence and disability burden[4], but the upward trend in China appears more pronounced[4,15]. For example, the United States[16] and the South Korea[17] have all reported rising prevalence in recent decades, largely driven by greater public awareness, broader diagnostic concepts, improved surveillance systems, and wider use of standardized assessment tools.

The incidence in China remained relatively stable. This pattern had also been observed in several other countries where improved awareness and diagnostic expansion have led to rising prevalence without a corresponding increase in incidence[18,19]. The continued rise in prevalence—despite stable incidence—likely reflects better case detection rather than a true increase in ASD. In China, expanded developmental screening within maternal and child health services, enhanced training for pediatricians and child psychiatrists, and greater public awareness have substantially strengthened the early identification system. Wider use of standardized assessment tools has improved diagnostic capacity, enabling the recognition of milder or previously overlooked cases. These factors explain the rising AAD prevalence despite stable incidence.

The marked gender imbalance observed is consistent with international studies reporting a male-to-female ratio of around 3:1[14,15,20], though this gap narrows with age. The well-documented male predominance in ASD is attributed to complex factors including environmental, genetic, hormonal, and epigenetic influences[21-23]. Female patients with autism may experience more internalized difficulties due to their greater tendency to "masking" autistic traits, potentially leading to misdiagnosis. "Masking" —minimizing autistic behaviors socially—is a key feature of the female autism phenotype[24,25]. Consequently, while

males outnumber females at younger ages, the male-to-female ratio for ASPR and DALYs decreases with age, which underscores the need for societal awareness. Accurate diagnosis and targeted support for females with autistic traits are crucial to prevent mental health deterioration and reduce the increased suicide risk associated with masking behavior[26].

The APC analysis revealed that the ASD burden in China was highest among young children, peaking at 0–5 years, and declined with age, consistent with prior studies showing that ASD was primarily diagnosed in childhood and adolescence[14,18]. Although the ASD symptoms often emerge early, they may not become fully apparent until school age or later. This variability may reflect earlier diagnosis of severe cases, while milder ones may remain undiagnosed until adulthood[27,28]. This highlights the critical importance of early detection and intervention. Concentrating ASD burden in young children suggests that expanding preschool screening, improving parental and pediatrician awareness, and ensuring access to early intervention services could substantially reduce long-term disability and social costs associated with ASD in China.

The burden of the total population's ASD prevalence and DALYs is mainly driven by population growth. Concurrently, epidemiological shifts contribute significantly. The increase in prevalence and DALYs due to epidemiological changes may be affected by environmental and lifestyle changes in modern society, which may also affect the incidence of ASD[25]. However, aging has a negative impact on the increase in prevalence and DALYs, as ASD is mainly diagnosed in children and adolescents, while prevalence among individuals aged 60 years and older remains low. Therefore, although population growth and changes in disease patterns have promoted the growth of DALYs and prevalence, aging has offset this growth to some extent. As age increases, aging has a reducing effect on the overall prevalence and DALYs[14,18]. From 1990 to 2021, a marked ASPR increase was observed in individuals aged 75 and older, reflecting China's rapid demographic aging and underscoring the need to pay more attention to older adults with ASD. The offsetting effect of population aging also carries important public health implications for China. Even though aging reduces the overall increase in ASD prevalence and DALYs at the population level, it does not diminish the long-term need for ASD-related services. Instead, it draws attention to a growing challenge: many ASD individuals will continue to require lifelong support, while their primary caregivers—often parents—are themselves aging and may face declining caregiving capacity. As China's demographic transition accelerates, health and social care systems will need to strengthen long-term support arrangements, including adult service pathways and caregiver support programs, to meet the needs of both the aged ASD individuals and their families.

The cohort effect highlights the socioeconomic, behavioral, and environmental exposures and risks associated with early life in different birth cohorts[29,30]. Analysis of birth cohort data spanning various age groups reveals a significant decrease in the prevalence and DALYs risk of ASD for earlier cohorts, contrasted with a marked increase in risk for more recent cohorts. This trend is likely attributed to advancements in diagnostic accuracy and screening methodologies, heightened public and professional awareness, and shifts in environmental and social determinants. Over the past decade, there has been a continuous enhancement in the diagnostic criteria and screening technologies for ASD, facilitating the identification and confirmation of additional cases and consequently elevating the reported prevalence[4,18]. Concurrently, a gradual increase in awareness of ASD among both the general public and healthcare professionals has enabled earlier recognition of the disorder's symptoms, thereby enhancing the documentation and statistical representation of ASD cases[31]. Changes in the environment and lifestyle of modern society may also affect the incidence of ASD[32].

Forecasts using the ARIMA model indicate that a growing number of affected individuals in this demographic for males from 2022 to 2036, which could be attributed to various factors such as population growth, improved diagnostics, increased awareness, or other environmental and genetic influences[31,32]. The slight decrease in the ASPR for females over the same period may require further investigation to understand the underlying causes. It could be related to differences in help-seeking behaviors in females[24,25]. Females with autism often engage in camouflaging behaviors, such as masking or compensating for autistic traits in social situations, which can delay recognition and reduce the likelihood of seeking formal support[24]. Interestingly, the ASPR for both sexes combined is also projected to decrease, which contrasts with the increase seen for

males alone. Thus, the overall impact of ASD on the population may be stabilizing or even slightly decreasing, possibly due to a combination of improved interventions, better support systems, decreasing birth rate, and other potential factors. While the stability in incidence rates is encouraging, the increasing prevalence rates, particularly among males, highlight the ongoing public health significance of ASD. These projections underscore the importance of ongoing research into the causes of ASD, as well as the need for sustainable investment in support services, educational accommodations, and therapeutic interventions for ASD individuals and their families.

These findings have key policy implications. Above all, they highlight the need for enhanced early intervention strategies for children with ASD, given the high burden in young age groups. This could involve increasing funding for early screening programs and specialized educational services. Then, the marked gender difference in ASD burden suggests the need for gender-specific approaches. For instance, in China, gender-sensitive ASD interventions should focus on improving recognition of female presentations, which frequently involve camouflaging behaviors. Practical strategies include providing clinician training on female-specific behavioral patterns, and developing psychosocial support programs tailored to adolescent girls. These measures could help reduce delayed diagnosis females with ASD, ultimately improving early identification and access to appropriate services. Additionally, the increasing burden in recent birth cohorts points to the importance of monitoring and research into environmental and social risk factors that may be influencing ASD rates. Lastly, the predicted decline in overall prevalence by 2036 should not lead to complacency but rather serve as a prompt to ensure sustainable systems are in place to support the growing number of individuals with ASD with population aging.

Our present study had several limitations. Firstly, the data relied heavily on the accuracy and completeness of the surveillance systems and registries from which it is derived. Secondly, the study's reliance on the GBD 2021 database means that the findings were subject to the same limitations as the GBD study, including potential biases in data collection and the use of modeling techniques to estimate missing or incomplete data. Thirdly, although the join-point regression model, age-period-cohort analysis, and ARIMA model are powerful tools for trend analysis and prediction, their reliability hinges on the quality and consistency of the input data. Any inaccuracies or inconsistencies in the data could compromise the precision of the model predictions. ARIMA-based forecasts assume that historical temporal patterns will continue unchanged, and they do not account for potential future shifts in diagnostic criteria, screening practices, service availability, or public health policies, which might affect the actual trajectory of ASD burden.

In conclusion, ASD persists as a significant public health issue in China, with a growing prevalence that disproportionately affects young children and males. It is crucial for public health officials and policymakers to implement more detailed early intervention strategies, particularly for children, and to develop gender-specific approaches to address the unique challenges faced by males. Additionally, further epidemiological research is necessary to better understand the scope and impact of ASD. Healthcare systems must prepare for the aging ASD population, ensuring that they are equipped to provide appropriate care and support. Concurrently, enhancing community awareness is vital to foster greater acceptance and inclusivity for ASD individuals and their families.

ARTICLE INFORMATION

Supplementary materials

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Competing interests

The authors declare no competing interests.

Authors' contributions

Li M: methodology, data curation, and writing – original draft. Meng ZY: investigation, data curation, and writing – original draft. Li Q: conceptualization and supervision. Yang JT: conceptualization, writing–reviewing and editing, and supervision. Min KY: conceptualization and writing- reviewing and editing. Hu ZM: project administration and writing- reviewing and editing. All authors read and approved the final version of the manuscript to be published.

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Data availability

Data at national level can be found at http://ghdx.healthdata.org/gbd-results-tool. All subnational level data in the current study can be available from the corresponding author on reasonable request.

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