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Chinese burden of depressive disorders from 1990 to 2021 and prediction for 2030: analysis of data from the global burden of disease study 2021

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Abstract

Background This study aims to examine the temporal changes in the incidence, prevalence, and disability-adjusted life years (DALYs) of depressive disorders as well as its association with age, period, and birth cohort among Chinese from 1990 to 2021, and forecast the future trends of incidence rates and numbers from 2022 to 2030.

Methods Data for analysis were obtained from the Global Burden of Disease (GBD) 2021. Joinpoint analysis was used to calculate the annual percentage change (APC) and average annual percent change (AAPC) to describe the rates of depressive disorders. Age, period, and cohort model was utilized to disentangle age, period, and birth cohort effects on rates of depressive disorders. Bayesian age-period-cohort (BAPC) analysis was capitalized to forecast the incidence rates and numbers for different sexes and age groups from 2022 to 2030.

Results The age-standardized incidence (ASIR, AAPC: -0.35 [95%CI: -0.65, -0.04]), prevalence (ASPR, AAPC: -0.20 [95%CI: -0.24, -0.16]), and DAYLs (AAPC: -0.28 [95%CI: -0.51, -0.05]) rates of both sexes showed a downward trend from 1990 to 2021, despite a volatility growth in recent years (APC in 2019–2021 of ASPR: 0.96 [95%CI: 0.70, 1.23]). Females exhibited a higher burden of depressive disorders compared to males but experienced a more rapid rate of reduction changes. The burden of depressive disorders was most owing to the age effect and period effect in recent years. The ASIR was predicted to decrease in the whole population (males in 2030: 1,546.3 per 100,000 people; females in 2030: 2,465.8 per 100,000 people), but in children, adolescents, and the elderly demonstrate unfavorable trends in the future.

Conclusion The burden of depressive disorders decreased in China from 1990 to 2021 in terms of age-standardized rates, but increased in recent years. Children, adolescents, and the elderly are the risk groups for future depressive disorders. Considering the large population, the increasing fewer children, and the aging trend, as well as the possible long-term effects of COVID-19 on human psychological burden, more sex-age-sensitive social healthcare programs should be considered in the future to minimize the burden of depressive disorders in China.

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Keywords Depressive disorders, Disease burden, Joinpoint regression, Age-period-cohort model, Bayesian age-period-cohort analysis

Introduction

Depressive disorders are typified by a pervasive sense of melancholy, anhedonia, avolition, feelings of worthlessness, and a sense of hopelessness [1]. The burden of depressive disorders has been steadily increasing in recent decades. The number of incident cases of depressive disorders increased from 172 million in 1990 to 258 million in 2017, having an increase of 49.86% [2]. Since 2008, the disease has been listed as the third leading cause of global disease burden by the World Health Organization and is projected to be the largest cause by 2030 [3].

China, the second most populous country in the world, accounts for 18.4% of the global population, and the number of depression patients accounts for 21.3% globally [4]. A cross-sectional study of 31 provinces in China showed that the prevalence of depressive disorders in China is about 10.5% [5], and is on the rise over time [4]. Additionally, the economic and longevity burdens of depressive disorders are just as great. It is reported that in 2012, the medical expenses for depressive disorders among Chinese residents accounted for 14.7% of the total personal medical expenses [6]. The disability-adjusted life years (DALYs) of depressive disorders in China have risen from 15th place in 1990 to 11th place in 2019 with a 22.0% increase in prevalence and a 14.7% increase in DALYs in the past thirty years [7], which indicated that depressive disorders are an urgent concern in China.

As we all know, depressive disorders are not only affected by individuals but also by economic, cultural, and political influences [8]. From 1990 to 2021, China's social environment and political policy reforms brought about diversified social norms and values, and the aging population. These macro-level political, economic, and social changes may pose a huge challenge to the national mental health [9]. These indicate the changes in China over the past three decades are likely to have a potential impact on the trend in the disease burden of depressive disorders. Several studies have systematically reported on depressive disorders in China, but have not considered the confounding effects of period and cohort factors [4, 10]. Two other studies discussed age, period, and cohort effects for the incidence of major depressive disorder in China, but the trends of prevalence and disability-adjusted life years (DALYs) have not been adequately discussed [11, 12]. Not only that but also the COVID-19 pandemic has imposed an additional mental health burden on individuals, exacerbating existing mental health issues and creating new challenges after 2019 [13]. Lockdowns, social isolation, economic uncertainty, and the fear of illness have contributed to increased levels of depressive disorders, especially in children and adolescents [14]. However, no study has yet reported on overall depressive disorders trends and its disease burden in China after 2019. Based on these factors, this study aims to address this gap by analyzing the most recent data from the Global Burden of Disease (GBD) 2021 database, providing an updated examination of the incidence, prevalence, and DALYs associated with depressive disorders, and offering insights into the evolving landscape of mental health in the post-pandemic era.

Methods

Data source

Depressive disorders (ICD-10 codes F32.0-F33.9, F34.1) data were extracted from the Global Burden of Disease (GBD) 2021 on the website of the Institute for Health Metrics and Evaluation (IHME). The data was obtained using The Global Health Data Exchange (GHDx) to assess the global burden of disease across 371 diseases and injuries, and 88 risk factors for 204 countries and all years from 1990 to 2021 [15]. The Cause of Death Ensemble model (CODEm), spatiotemporal Gaussian process regression (STGPR), and Bayesian meta-regression tool DisMod-MR were the main methods of estimating the incidence, prevalence, mortality, DALYs, and other relevant data of various diseases [15].

Original data on depressive disorders in China were mainly from national censuses, disease surveillance point systems, systematically reviewed published literature, etc. The age-standardized incidence rates (ASIR), age-standardized prevalence rates (ASPR), age-standardized DALY rates, crude incidence rates (CIR), crude prevalence rates (CPR), and crude DALY rates, age-specific rates, and 95% uncertainty interval (UI) data were freely available in the Global Health Data Exchange GBD Results Tool (https://vizhub.healthdata.org/gbd-results/).

Joinpoint regression analysis

Joinpoint regression program version 5.0.2 (Statistical Research and Applications Branch, National Cancer Institute) [16] was employed to identify the changes in ASIR, ASPR, and age-standardized DALYs of depressive disorders among the overall and sex-specific population for all ages. The basic principle of the Joinpoint regression

model is to divide the long-term epidemiological trend of a disease into several segments by identifying the model inflection point, and each segment is fitted with a straight line to describe the epidemiological characteristics of a disease in a certain period.

Based on the officially recommended joinpoint number, we set the maximum number of inflection points to six [16]. For each statistically significant segment of the time trend, the model gives the average percentage change (APC) reflecting the rates of change between the two connecting points. The model also gives values for the mean annual percentage change (AAPC), which describes the overall rates of change in depressive disorders. The Z test is used to determine whether AAPC or APC is different from 0. If APC/AAPC > 0, the trend is upward. If APC/AAPC < 0, the trend is downward.

Age–period–cohort analysis

We assessed the influence of age, period, and cohort effects on depressive disorders trends of incidence, prevalence, and DALYs through the age-period-cohort analysis. The age-period-cohort model independently estimates the effect coefficients of age, period, and cohort effects by using the intrinsic estimator (IE) sub-algorithm. The IE method adopts the principal component regression technique, and the robustness of its statistical properties has been verified by model validation studies [17, 18]. Age effects refer to the influence of physiological and social processes on an individual's aging. Period effects are the result of external factors that affect all age groups at a given time. Cohort effects are changes caused by unique experiences in different periods [19]. In the APC-IE model, the age-specific rates were recoded into successively 5-year age groups. Then we divided the period into 6 groups and used the intermediate year of data to represent the specific period of depressive disorders rates to improve the measurement precision [20]. Finally, 18 birth cohorts were obtained by age and period (a detailed schematic is in Supplementary Table 1). The relative risk (RR) of incidence, prevalence, and DALYs can be obtained by converting the natural logarithm of the effect coefficient. Age-period-cohort analysis was performed using STATA 15.0 software (StataCorp, College Station, TX, United States). The Wald's chi-square test was adopted to evaluate the significance of the estimable parameters and functions. Akaike information criterion (AIC) and Bayesian information criterion (BIC) were used to evaluate the degree of fitting [21]. Statistical tests were two-sided and $p < 0.05$ is considered significant.

Bayesian age-period-cohort (BAPC) analysis

Finally, we performed a Bayesian age-period-cohort (BAPC) analysis in R, using BAPC and INLA packages to predict the incidence rates and numbers from 2022 to 2030 by different sexes and age groups. The superior predictive performance of the BAPC model has been verified [22, 23]. The BAPC model is based on an integrated nested Laplacian approximation to approximate the marginal posterior distribution, avoiding some of the mixing and convergence problems introduced by the Markov chain Monte Carlo sampling technique traditionally used for Bayesian methods [24, 25]. The data analysis was performed using open-source software R (version 4.2.1; R Foundation for Statistical Computing, Vienna, Austria).

Results

Depressive disorders burden in China

Different from the fluctuating upward trends of the CIR, CPR, and age-standardized DALYs, the ASIR, ASPR, and age-standardized DALYs of both sexes showed a fluctuating downward trend from 1990 to 2021 in China (Fig. 1). Meanwhile, it is worth noting that all rates experienced an upward and then downward trend between 2019 and 2021, resembling an inverted "V" shape. The ASIR and ASPR in both sexes declined from 2,628.67 [95% UI: 2,315.01, 3,014.83] to 2,345.08 [95% UI: 2,070.08, 2,722.30] and from 3,071.84 [95% UI: 2,779.10, 3,404.49] to 2,875.68 [95% UI: 2,589.96, 3,203.43] per 100,000 people from 1990 to 2021. The age-standardized DALYs decreased from 473.32 [95% UI: 331.33, 639.58] per 100,000 people in 1990 to 430.61 [95% UI: 305.24, 586.21] per 100,000 people in 2021 (Supplementary Table 2). Additionally, females had a higher burden of depressive disorders in terms of incidence, prevalence, and DALYs than males during 1990–2019.

Figure 2 showed the age-specific numbers (A, C, E), and age-specific rates (B, D, F) of depressive disorders for the different age groups in 2021. The incidence of depressive disorders rose sharply between the age of 5 to 64 and continued to rise in males while leveling off in females after the age of 64. Prevalence rates peaked at the age of 65 to 69, and people with the age of 55 to 59 had the highest cases of depressive disorders. In terms of DALYs, similar tendencies are observed like prevalence rates and prevalence numbers. Similarly, females had higher rates and numbers than males in every age group.

Joinpoint regression on time trends of depressive disorders burden analysis

Joinpoint regression analyses of ASIR, ASPR, and age-standardized DALYs for depressive disorders in China from 1990 to 2021 were shown in Table 1. The AAPC result of ASIR showed the incidence rates of depressive disorders were on a downward trend (AAPC: −0.35 [95%CI: −0.65, −0.04]). In the beginning, the change of ASIR increased from 1990 to 1995 (APC in 1990–1995:

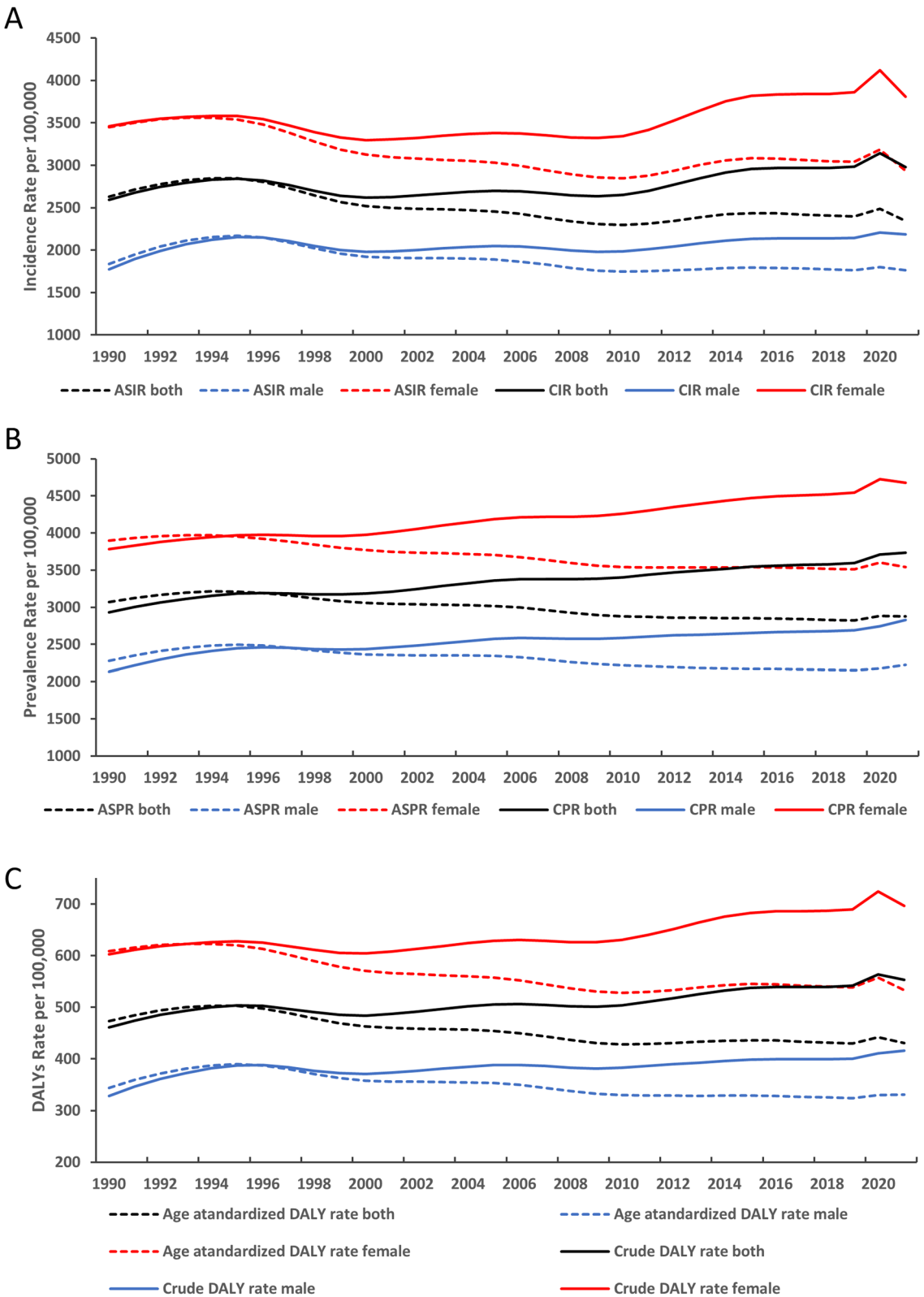

Fig. 1 Changes in the crude rates and age-standardized rates of the burden of depressive disorders among both sexes, males, and females in Chinese from 1990 to 2021. **A** Incidence. **B** Prevalence. **C** DALYs

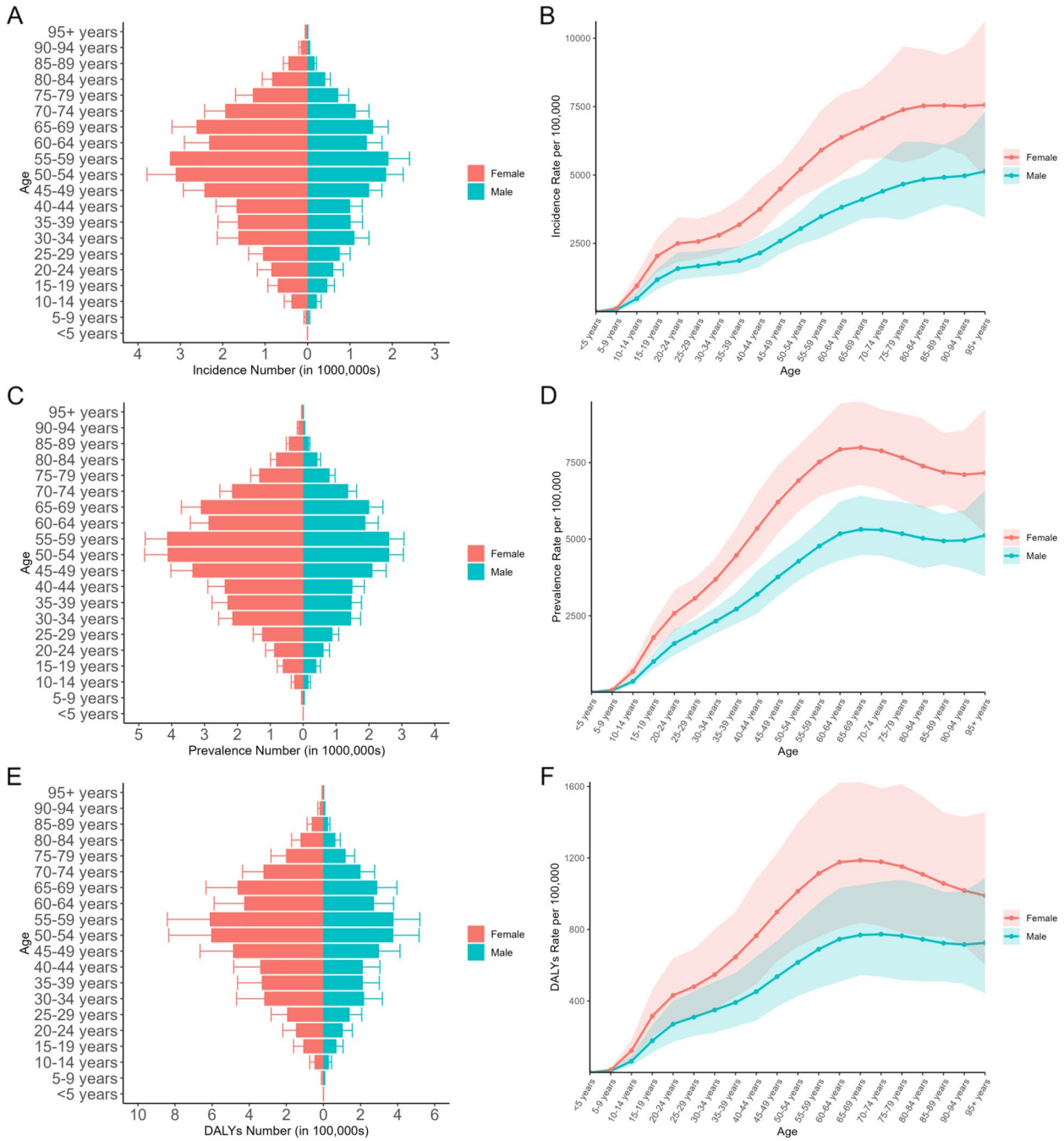

Fig. 2 Age-specific numbers and age-standardized incidence, prevalence, and DALYs of depressive disorders in China, 2021. **A** Age-specific incidence number. **B** Age-standardized incidence rates. **C** Age-specific prevalence number. **D** Age-standardized prevalence rates. **E** Age-specific DALYs number. **F** Age-standardized DALYs rates

1.57 [95%CI: 0.83, 2.32]), then declined to 2010, though the downward trend from 2000 to 2005 was not significant (APC in 1995–2000: −2.74 [95%CI: −3.66, −1.82]; APC in 2000–2005: −0.41 [95%CI: −1.31, 0.49]; APC in 2005–2010: −1.45 [95%CI: −2.32, −0.58]). After 2010, the ASIR experienced the fastest increasing trend in the next five years (APC in 2010–2015: 1.37 [95%CI: 0.45, 2.29]). The subsequent trend remained stable till 2021 (APC in 2015–2021: −0.36 [95%CI: −0.91, 0.20]). On

Table 1 Joinpoint regression analysis: trends in age-standardized incidence, prevalence, and DALYs of depressive disorders among both sexes, males, and females in China, 1990–2021

Gender	ASIR			ASPR			Age-standardized DALY rates		
	Period	APC (95%CI)	AAPC (95%CI)	Period	APC (95%CI)	AAPC (95%CI)	Period	APC (95%CI)	AAPC (95%CI)
Both	1990–1995	1.57 (0.83, 2.32)	−0.35 (−0.65, −0.04)	1990–1992	1.67 (1.41, 1.93)	−0.20 (−0.24, −0.16)	1990–1994	1.75 (1.09, 2.42)	−0.28 (−0.51, −0.05)
	1995–2000	−2.74 (−3.66, −1.82)		1992–1995	0.48 (0.23, 0.73)		1994–2000	−1.55 (−2.00, −1.09)	
	2000–2005	−0.41 (−1.31, 0.49)		1995–2000	−1.06 (−1.14, −0.98)		2000–2006	−0.46 (−0.91, 0.00)	
	2005–2010	−1.45 (−2.32, −0.58)		2000–2005	−0.22 (−0.30, −0.15)		2006–2009	−1.58 (−3.53, 0.41)	
	2010–2015	1.37 (0.45, 2.29)		2005–2010	−1.02 (−1.10, −0.94)		2009–2021	0.11 (−0.01, 0.23)	
	2015–2021	−0.36 (−0.91, 0.20)		2010–2019	−0.15 (−0.17, −0.12)				
				2019–2021	0.96 (0.70, 1.23)				
Male	1990–1992	5.62 (3.90, 7.37)	−0.12 (−0.34, 0.10)	1990–1992	3.04 (2.52, 3.56)	−0.09 (−0.16, −0.01)	1990–1992	4.2 (3.58, 4.82)	−0.12 (−0.21, −0.04)
	1992–1995	2.22 (0.61, 3.86)		1992–1995	1.23 (0.74, 1.72)		1992–1995	1.68 (1.08, 2.29)	
	1995–2000	−2.64 (−3.1, −2.18)		1995–2000	−1.19 (−1.34, −1.05)		1995–2000	−1.86 (−2.05, −1.68)	
	2000–2005	−0.29 (−0.73, 0.16)		2000–2005	−0.14 (−0.29, 0.01)		2000–2005	−0.24 (−0.42, −0.05)	
	2005–2010	−1.69 (−2.11, −1.25)		2005–2010	−1.18 (−1.33, −1.03)		2005–2010	−1.39 (−1.57, −1.21)	
	2010–2014	0.76 (0.05,1.47)		2010–2019	−0.32 (−0.38, −0.27)		2010–2019	−0.13 (−0.19, −0.06)	
	2014–2021	−0.14 (−0.36, 0.08)		2019–2021	1.65 (1.14, 2.16)		2019–2021	0.82 (0.22, 1.41)	
Female	1990–1995	0.56 (−0.38, 1.51)	−0.45 (−0.80, −0.09)	1990–1994	0.50 (0.07, 0.94)	−0.32 (−0.44, −0.20)	1990–1995	0.38 (−0.27, 1.04)	−0.37 (−0.59, −0.14)
	1995–1999	−2.88(−4.74, −0.99)		1994–2000	−0.95 (−1.24, −0.66)		1995–1999	−1.91 (−3.33, −0.48)	
	1999–2010	−1.01 (−1.28, −0.73)		2000–2005	−0.33 (−0.75, 0.10)		1999–2010	−0.75 (−0.97, − 0.53)	
	2010–2015	1.68 (0.50, 2.87)		2005–2010	−0.97 (−1.38, −0.56)		2010–2021	0.24 (0.05, 0.44)	
	2015–2021	−0.36 (−1.06, 0.35)		2010–2021	0.04 (−0.05, 0.14)				

AAPC Average annual percent change, *APC* Annual percent change, *CI* confidence interval

average, the trend for ASIR was similar between males and females. ASIR of males declined 0.12% per year, and ASIR of females declined 0.45% per year.

The Joinpoint result of ASPR and age-standardized DALYs were similar to the result of ASIR, except for a significant growth between 2019 and 2021, especially in males (APC in 2019–2021 of ASPR: 1.65 [95%CI: 1.14, 2.16]; APC in 2019–2021 of age-standardized DALYs: 0.82 [95%CI: 0.22, 1.41]). Generally speaking, the AAPC of ASPR showed the prevalence rates of depressive disorders were on a downward trend (AAPC: −0.20 [95%CI: −0.24, −0.16]). The ASPR of males decreased by 0.09% per year, and the ASPR of females decreased by 0.32% per year. The DALYs of depressive disorders in China were in a downward trend as well (AAPC: −0.28 [95%CI: −0.51, −0.05]). The age-standardized DALYs of males decreased by 0.12% per year and the age-standardized DALYs of females decreased by 0.37% per year. Taken together, the depressive disorders burden was higher in females from 1990 to 2021 than in males, but the decline changes were faster in females compared with males.

The effects of age, period, and cohort on incidence, prevalence, and DALY rates

Supplementary Fig. 1 (A), 2 (A), 3 (A) showed the changes in age-period incidence, prevalence, and DALYs of depressive disorders in Chinese from 1990 to 2021. The incidence, prevalence, and DALYs of depressive disorders in different age groups during the six periods were similar. The age-period rates rose with the increase of age, showing an "S"-shaped upward trend. The subpeak appeared in the age group of 20 to 24, and the peak appeared in the age group of 65 to 69. The more recent the period, the lower the rates before the age of 25 and the more obvious the rising trend when getting older. Supplementary Fig. 1 (D), 2 (D), and 3 (D) show the changes in age-birth cohort incidence, prevalence, and DALYs of depressive disorders in Chinese from 1990 to 2021. The age-cohort incidence gradually decreased with the passage of the birth cohort. In terms of age groups, the incidence of the age group over 55 increased with the passage of the birth cohort, the age group of 10 to 54 was exactly the opposite. Age-cohort prevalence and DALYs both increased first and then decreased with the passage of the birth cohort. The variations of the period-age and birth-age of incidence, prevalence, and DALYs are shown in Supplementary Fig. 1 (B, C), 2 (B, C), 3 (B, C).

The estimated RR of age, period, and cohort effects of depressive disorders incidence, prevalence, and DALYs for both sexes were shown in Fig. 3 and Supplementary Tabel 3, 4, 5. Generally speaking, the burden of depressive disorders was most owing to the age effect and period effect. In terms of incidence, the age effect of incidence exhibits an "N" shape, which showed an increase before the age of 20–24, and then rose again slowly after the age of 30–34. The difference with the age effect of incidence, the effect of prevalence, and DALYs peaked again at the age of 60–64 and then declined subsequently, generally like an "M" shape. The period effect of incidence was like a "V" shape, which experienced a fluctuation change from 1994 to 2009, then rose significantly from 2009 to 2019. The upward effect in females was more obvious from 1999 to 2019 and eventually surpassed that of males in 2014. The period effects of prevalence and DALYs were roughly similar, which rose steadily during the past three decades. The cohort effects for incidence and DALYs were little changed before 1950–1954, after which they began to decline rapidly. In terms of the cohort effect of prevalence, the fluctuating trend was relatively flatter than that of prevalence and DALYs, which declined steadily from 1900 to 1994 to 2010–2014.

Incidence forecasts for 2030 by bayesian age-period-cohort analysis

The BAPC analysis results are summarized in Fig. 4. Generally, the ASIR will decrease in the following years. The ASIR will continue to decrease at a moderate rate among males and is estimated to be down to 1,546.3 per 100,000 people by 2030. The downward trend in the ASIR among females is faster than males and estimated to decrease to 2,465.8 per 100,000 people in 2030. The prediction also indicates that by 2030, the number of depressive disorders will drop to 15,365,419 in males, and 25,263,300 in females. What is interesting is that the prediction among different age groups (Supplementary Fig. 4) indicates the projected incidence in children and adolescents at the age of 5 to 19 and the elderly at the age of 75 to 94 in 2030 is higher than in 2021. Meanwhile, the number of cases among the 60 to 94 years elderly will rise significantly in the future. It suggests the burden of depressive disorders will increase in children, adolescents, and older people in the future.

Discussion

To our knowledge, this is the first study that added and reported the trends in the burden of depressive disorders in China after the COVID-19 pandemic. We comprehensively reported trends in the national burden of depressive disorders, including incidence, prevalence, and DALYs for the whole population in China from 1990 to 2021. We also try to predict the incidence rates and numbers of depressive disorders with the whole population and specific age and sex patterns. Our findings provide valuable insights into potential methods for mitigating the disease burden associated with depressive disorders in China.

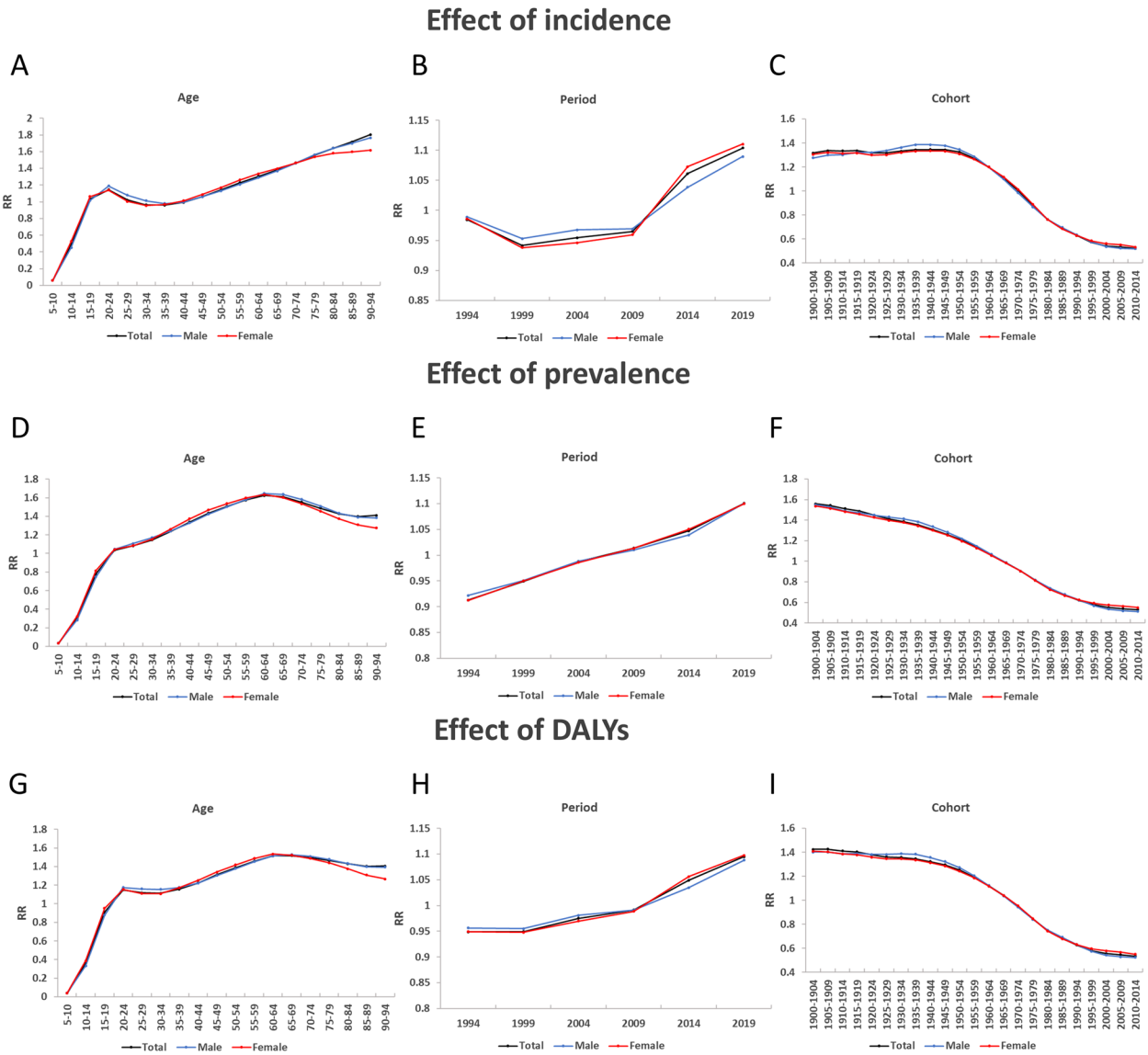

Fig. 3 Parameter estimates of age, period, and cohort on depressive disorders from 1990 to 2021. **A**, **D**, **G** Age relative risk of depressive disorders. **B**, **E**, **H** Period relative risks of depressive disorders and the corresponding 95% CI. **C**, **F**, **I** Cohort relative risks of depressive disorders and the corresponding 95% CI

Overall, the ASIR, ASPR and age-standardized DALYs of both sexes in China decreased from 1990 to 2021. This may be due to the encouraging social medical intervention policies enacted by the Chinese government in recent decades, which have the initial achievements [26, 27]. However, the CIR, CPR, and crude DALYs increased, which shows that the gradually aging population of China and the elderly are more likely to suffer from depressive disorders. Given the rapidly growing elderly population and the fact that depressive disorders show gravity in this age group, depressive disorders may have a dramatic impact on our health system [28]. Notably, a significant upward in the age-standardized prevalence of depressive disorders occurred between 2019 and 2021. After the COVID-19 pandemic, the global prevalence of major depressive disorders increased by 27.6% in 2020 [13], and the change in China was consistent with the global trend. This implies that the COVID-19 pandemic negatively impacted the psychological burden of the Chinese population. Despite a downward trend in the prevalence of depressive disorders in 2021, considering the short observation period since the pandemic, more time may be required to observe the potential long-term impact

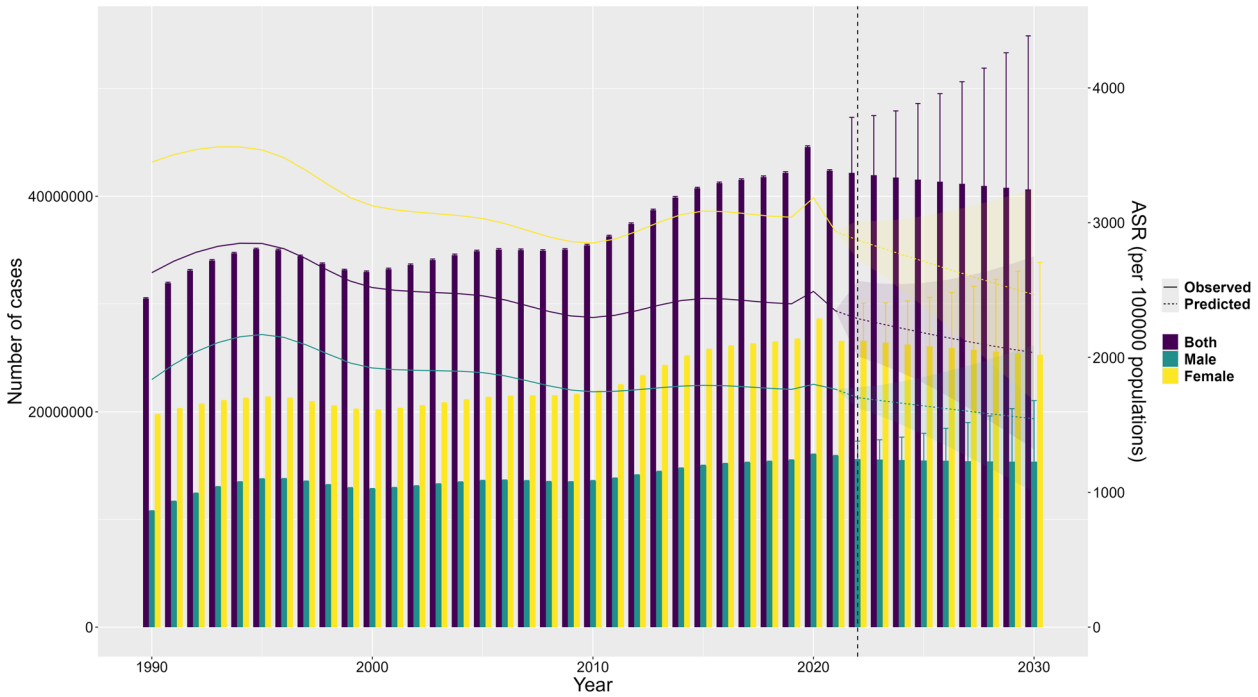

Fig. 4 Trends in ASIR from 1990 to 2030 among males, females, and both sexes predicted by the Bayesian age-period-cohort (BAPC) model. ASIR: age-standardized incidence rates

of the COVID-19 pandemic on the disease burden of depressive disorders.

The incidence, prevalence, and DALYs of females are higher than those of males in both crude rates and age-standardized rates, suggesting females are at higher risk than males. This may be because females experience several special periods in their lives, such as menstruation, pregnancy and childbirth, and menopause, during which drastic changes in hormones in the female body are more likely to cause depressive disorders [29]. The social structure theory also suggests gender inequality in work life leads to gender differences in depressive disorders [30]. These are possible reasons why females are more likely to suffer from depressive disorders. Furthermore, females experienced a more rapid rate of reduction changes in the burden of depressive disorders. This may be because females are more likely to reach out for psychological help when they face an unfavorable psychological situation [31, 32]. Considering the gap in the disease burden of depressive disorders between females and males, more health care and social support should be provided to females.

APC model analysis showed there was a significant relationship between the age effect and the burden of depressive disorders after controlling the time effect and cohort effect. The effect on incidence between children and adolescents from 5 to 24 is soaring, which may be because of the traditional parenting styles and various pressures experienced by Chinese adolescents [33]. Moreover, the incidence effect among middle-aged and elderly increased rapidly over the age of 45. The possible explanation is that some of the policies used to improve the mental health of citizens are mainly aimed at youth or the elderly, so the middle-aged population are difficult to receive enough attention [34, 35]. Many reasons account for the high incidence of depressive disorders in the elderly. Chronic diseases and disability disorders are often seen in elderly people, thus increasing the risk of depressive disorders [36]. Additionally, the change in social roles and social environments, such as family problems, intergenerational rearing, and poor economic conditions may cause the elderly more sensitive to depressive disorders [35, 37]. It is worth mentioning that between the ages of 65 and 89, there is a significant decline in the effect of prevalence and DALYs. This phenomenon may be due to the achievements of China's increasingly improved elderly care system and medical care. The concept of filial piety is a fundamental value and cultural stance of Chinese people, which motivates individuals to be filial and love their kinship [38]. The active cooperation and support of family members also play a crucial role in the recovery of depressive elderly.

From 1994 to 1999, the period effect of depressive disorders incidence declined rapidly. Remarkable

achievements have been made in economic construction, and large-scale urbanization since China's reform and opening up in 1978 [39], these factors can reduce the risk of depressive disorders [40, 41]. But as a whole, the period effect of depressive disorders increased over the past three decades, especially the rapid upward trend between 2009 and 2019, which is similar to the incidence trend of major depressive disorders in China [12], but contrary to the findings published by *He* et al [11]. The reason for this may be due to the differences in the choice of APC model and the variance of period point selection. We believe that the rise in the cohort effect of depressive disorders in China remains well documented. The booming economy brought competition in all walks and social pressure in recent decades, which may have increased the risk of mental health [4]. Furthermore, social development may help reduce the stigma of mental health, thus improving the detection rates of depressive disorders [42]. Besides, the effect on females initiated a gradually increasing trend from 1999 to 2019. Rising divorce rates, gender power inequality, and the trend toward dual employment force females to take on multiple social and family responsibilities, these increase the disease burden of depressive disorders in females to some extent [43].

We found out that people born before the cohort of 1950–1954 had no significant decline in risk of depressive disorders incidence and DALYs. It may be due to the developmental period, which leads to higher social stress and a higher burden of mental health problems [44, 45]. People born after 1954 had a rapidly decreasing risk of depressive disorders. The establishment of the People's Republic of China in 1945, has freed people from war and displacement and has supplied people with rapid economic growth, continuous enhancement of health services, and a happier and healthier life than before. Studies have shown that economic development improves people's living environment and health status, which can effectively reduce the degree of depressive disorders [46]. The widespread implementation of mandatory schooling and the revival and enlargement of higher education have enhanced the quality of life and health, leading to augmenting the educational attainment of the Chinese population and also having a significant effect on alleviating the burden of depressive disorder [47].

In contrast to previous studies [4, 48], we also predicted the incidence rates and numbers for 2030 among both sexes and age groups through the BAPC model. The result shows the ASIR and incidence numbers for males and females in the whole population will continue to decline after 2022. Besides, the incidence is predicted to rise among children and adolescents between the age of 5 to 19, and elderly between the age of 75 to 94. A gradual increase in the number of incident cases will occur between 60 and 95 years elderly people. This suggests the burden of depressive disorders in these two groups will continue to rise in the future. The phenomenon of fewer children and the aging population in China pose a barrier to depressive disorder prevention. Ongoing monitoring of the differences in disease burden and establishing sex-age-sensitive health policies would be needed to cope with their negative effects.

To our knowledge, this is the first study that represents the initial examination of the epidemiological patterns of depressive disorders in China, employing a combined approach of Joinpoint analysis, APC model, and BAPC model, and provides the most comprehensive and up-to-date information about the burden of depressive disorders, but some limitations should be acknowledged: Firstly, the detection rate of depressive disorders may be underestimated due to stigma, unequal distribution of healthcare resources (especially the lack of mental health services in western rural areas) [49], and the fact that some depressed patients tend to consult local tertiary or secondary general hospitals or seek help from traditional Chinese medicine practitioners, resulting in a diagnosis of "mental disorder" [5]. On top of that, due to the lack of provincial-level data, there are still some biases in the completeness and accuracy of the burden of depressive disorders, making it difficult to analyze spatial distribution. Furthermore, future real-world cohorts have different healthcare utilization patterns, disease processes, and treatment strategies, which may result in the actual incidence of depressive disorders being different from our predicted outcomes. Finally, the DALYs of depressive disorders may be underestimated due to the DALYs of other chronic diseases caused by depressive disorders were not attributed to depressive disorders themselves.

Conclusion

The burden of depressive disorders decreased in China from 1990 to 2021 in terms of age-standardized rates, despite a slight increase from 2019 to 2021. A higher burden of depressive disorders was observed in females than in males, but the declining changes were faster in females. The burden of depressive disorders was mostly due to the age effect and period effect in recent years. The incidence burden of depressive disorders among children, adolescents, and the elderly will be on the rise in the future. Due to the large population, increasing fewer children, the aging trend, and the pandemic of COVID-19, more sex-age-sensitive social healthcare programs should be considered in the future to minimize the burden of depressive disorders.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
N.Y. and C. Z. participated in data curation and writing, original draft preparation; Y. W., Y. W., and Y. L. checked the original manuscript for grammatical issues, supervised and validated the study; Y. W., B. S., L. M., J. W., J. T., Q. W. participated in writing, reviewing, and editing; X. G. and W. W. were involved in conceptualization and methodology.

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Data availability
The data presented in this study are available in the Institute for Health Metrics and Evaluation (IHME) website, https://vizhub.healthdata.org/gbd-results/.

Declarations

Ethics approval and consent to participate
The experimental protocol was established, according to the ethical guidelines of the latest revision of the Declaration of Helsinki and was approved by the Human Ethics Committee of Xuzhou Medical University. Written informed consent was obtained from individual or guardian participants.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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