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Temporal trends and cohort variations of gender-specific major depressive disorders incidence in China: analysis based on the age-period-cohort-interaction model

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ABSTRACT

Background Major depressive disorders (MDDs) impose substantial burdens on individuals and society; however, further detailed analysis is still needed for its long-term trends.

Aims This study aimed to analyse the gender-specific temporal trends and cohort variations of MDD incidence among Chinese residents over the past three decades.

Methods Employing the age-period-cohort-interaction model and leveraging data from the Global Burden of Disease Study 2019, this research identified and analysed incidence trends of MDD among Chinese males and females aged 5–94 years from 1990 to 2019 across three dimensions, encompassing age, period and birth cohort.

Results The analysis reveals age-related effects, indicating heightened MDD risk among adolescents and older adults. Specifically, individuals entering the older adulthood at the age of 65–69 significantly increased the risk of MDD by 64.9%. People aged 90–94 years witnessed a 105.4% increase in MDD risk for the overall population, with females and males in this age group experiencing a 75.1% and 103.4% increase, respectively. In terms of period effects, the risk of MDD displayed a decline from 1990 to 1994, followed by a rebound in 2008. Cohort effects demonstrated diverse generational patterns, with generation I and generation III manifesting opposing 'age-as-level' trends. Generation II and generation IV exhibited 'cumulative disadvantage' and 'cumulative advantage' patterns, respectively. Age effects indicated an overall higher risk of MDD incidence in females, while cohort effects showed greater variations of MDD incidence among females.

Conclusions The study underscores the substantial effects of age, period and cohort on MDD across genders in China. Priority interventions targeting vulnerable populations, including children, adolescents, older adults, females and the post-millennium birth cohort, are crucial to mitigate the impact of MDD.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Decomposing the time trend of disease onset into age, period and cohort effects helps reflect the underlying societal, economic, demographic, health outcome and behavioural changes. However, there is a deficiency in studying the variations in the onset of major depressive disorder (MDD) within the cohort and a significant gap in exploring and synthesising the generational patterns of MDD incidence.

WHAT THIS STUDY ADDS

⇒ The findings underscore the complex interplay of age, period and cohort effects in shaping generational patterns and shifts of MDD. Cohort effects revealed varied generational patterns and shifts, with generation I and generation III showing contrasting age-as-level trends. Meanwhile, generation II and generation IV displayed cumulative disadvantage and advantage trends, respectively.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The insights gained from this research have significant implications for tailoring mental health interventions and policies to address the unique needs of various population groups and advancing our understanding of the multifaceted nature of MDD.

INTRODUCTION

The onset of depressive disorders inflicts significant suffering on individuals, with major depressive disorders (MDDs) being a typical category characterised by one or more episodes. MDD was the fifth top cause of years lived with disability in 2016.[1] MDD also played a role in contributing to the burden associated with suicide and ischaemic heart disease.[2] The prevalence rates of MDD vary significantly across nations, but the overall rate is approximately 6%.[3] The lifetime risk of developing MDD is 15%–18%,[4] indicating the common occurrence of MDD that severely limits psychosocial functioning and diminishes the quality of life; nearly one-fifth of individuals experience it at some point in their lives.[5]

Since 2000, the visibility of depressive disorder in China has steadily increased. The cumulative incidence rate of MDD in rural areas of Northeast China is 3.9%, with a significantly higher rate among females (5.3%) than males (2.9%).[6] A study conducted between 2001 and 2005, based on epidemiological surveys in four Chinese provinces, reported a prevalence rate of depressive disorder at 6.1% (with MDD at 2.1% and dysthymia at 2.0%). Depressive disorder is more prevalent among females, rural residents and those aged 40 and above.[7] The 2013 China Mental Health Survey revealed a depressive disorder prevalence of 6.8% (with MDD at 3.4% and dysthymia at 1.4%), with a lifetime prevalence of 3.6% (MDD at 2.1% and dysthymia at 1.0%).[8] This research will focus on MDD, considering its more severe symptoms and higher prevalence rate.

Depressive disorder correlates with age, period and cohort factors. Adolescent depressive disorder raises the risk of depression and anxiety later in life.[9] Depressive disorder can contribute to medical diseases and expedite biological ageing, while diseases can heighten the likelihood of depressive disorder in older adults.[10] Historical events, especially in the context of globalisation, can profoundly affect individuals across borders. For instance, a study highlighted a period effect on depressive disorder prevalence among Canadians older adults, with peaks in 2001, 2008 and 2012, coinciding with the 'September 11 terrorist attacks', the global financial crisis and the volatility of the Canadian stock market.[11]

Besides, depressive disorder presents notable gender disparities. While its incidence generally rises from childhood to adolescence,[12] females face double the risk of diagnosis compared with males by early adulthood.[12] Women also experience heightened depressive disorder risk during pregnancy and postpartum.[13] Conversely, some studies suggest when males experience depression, they may exhibit symptoms different from current diagnostic criteria, potentially nullifying gender differences in depressive disorder prevalence when alternative symptoms are combined with traditional symptoms.[14] All the research underscores the importance of considering gender in MDD research for effective prevention and treatment strategies. Thus, this study will explore MDD trends by gender.

Decomposing the time trend of disease onset into age, period and cohort effects helps reflect the underlying societal, economic, demographic, health outcome and behavioural changes. Some research employing the age-period-cohort (APC) analysis tool, which is based on the decomposable and indecomposable parts of the APC model,[15] revealed a widespread decrease in the age-standardised incidence rate of depressive disorder but an increase in the incidence rate among the older adults in China.[16] Using a similar method, another study discovered an inverted U-shaped curve with the highest MDD risk observed in the 1951–1955 Chinese birth cohort.[17] However, there is a deficiency in studying the variations in the onset of MDD within the cohort and a significant gap in exploring and synthesising the generational patterns of MDD incidence.

The leading challenge of APC model implementation lies in the identification problem. Scholars have approached this issue from different perspectives, attempting to address it by imposing explicit or latent constraints on model parameters based on theoretical foundations or external information.[18] Some research pointed out the methodological and theoretical limitations of previous APC models, which solely focused on between-cohort differences and assumed that such differences remain fixed throughout the entire life course, overlooking the dynamic life course within cohorts.[19] Building on this, the age-period-cohort-interaction (APC-I) model was proposed.

Employing the APC-I model, we aimed to analyse the temporal trends and cohort variations of MDD within the general population and separately for females and males, considering age, period and birth cohort dimensions. We will also discuss the generational patterns and shifts in MDD.

METHODS

Data sources

This study used data from the 2019 Global Burden of Disease (GBD) Study[20] to analyse the APC effects of MDD. GBD 2019 offers global estimates for deaths, disability-adjusted life-years, years lived with disability, years of life lost, prevalence, incidence and maternal mortality ratios for 369 diseases, injuries and all-cause mortality across 204 countries and regions worldwide.[21] Many studies explore mental health using the GBD data.[22,23]

GBD 2019 represents a scientific and systematic evaluation of openly published and publicly available data, comprehensively reviewing existing health data related to diseases, injuries and risk factors.[21] This dataset covers aggregated data on the incidence of depressive disorder in China from 1990 to 2019. The study focuses on the incidence of MDD in individuals aged 5–94 of all genders in China within the GBD 2019 dataset. Figure 1 depicts the sample flowchart.

Measures

Gender-age-period-specific depressive disorder incidence

This study focused on the incidence of MDD diagnosed according to DSM-4 (The Diagnostic and Statistical Manual of Mental Disorders, DSM) and ICD-10 (also known as Recurrent Depressive Disorder in International Classification of Disease, ICD) criteria.[21] Therefore, the outcome variable is the gender-age-period-specific MDD incidence. Since the incidence of MDD follows a Poisson distribution and the risk of MDD is related to the exposure condition, the estimated population data for China from the GBD 2019 dataset are included in the model as an offset term. This offset term can be understood as the number of individuals per 100 000 in different genders, age groups and time periods who have experienced MDD.

Age, period and birth cohort variables

The study centred on three temporal dimensions for the predictor variables: age, period and birth cohort. The APC-I model necessitates uniform successive time intervals for its

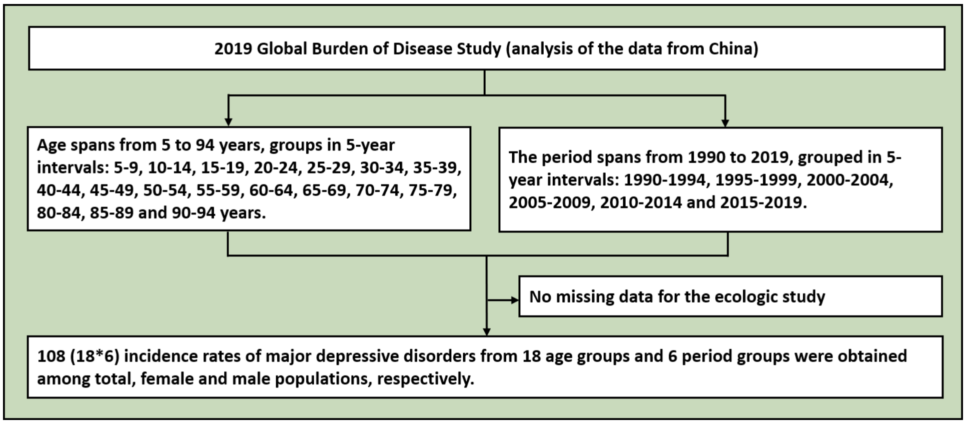

Figure 1 Flowchart of the samples selected.

three variables. Therefore, we use a 5-year interval, consistent with prior research,[16 17] and the range of periods and ages.

Age spans from 5 to 94 years, grouped in 5-year intervals: 5–9, 10–14, 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, 85–89 and 90–94 years. Age-standardised incidence rates are calculated using direct standardisation based on the age structure of the world population in the GBD 2019 dataset.

The period spans from 1990 to 2019, grouped in 5-year intervals: 1990–1994, 1995–1999, 2000–2004, 2005–2009, 2010–2014 and 2015–2019. This results in 23 birth cohort groups, derived from 18 age groups and 6 period groups, including cohorts born in every 5 years from 1900, 1905, 1910, 1915, 1920, 1925, 1930, 1935, 1940, 1945, 1950, 1955, 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005 and 2010.

Statistical models

The APC-I model applies to both cross-sectional and panel data, accommodating both individual and aggregated data.[19] As defined by prior research,[24] we can obtain the estimated main effects for each age group, estimated main effects for each observation period and cohort effects from the APC-I model. Cohort effects are represented as age-by-period interactions (detailed analysis can be seen in online supplemental appendix), which generates the intercohort average deviation facilitating intercohort comparison and the intracohort life-course linear slope demonstrating trends within cohorts. Significant F-statistics suggest the potential presence of cohort effects.

Data analysis

This paper began by introducing the characteristics of the study sample. Subsequently, using the APC-I model, the study decomposed and visualised the age, period and cohort effects for MDD in China, stratified by gender. Finally, we delved into the generational patterns and shifts of MDD incidence.

All analyses were conducted in R V.4.2.2. The analysis code for the APC-I model of aggregated data was developed by prior research.[24] $P<0.05$ (two-tailed) indicated a statistically significant difference.

RESULTS

Crude and age-standardised incidence of MDD

Online supplemental figure 1 presents the crude incidence rates and age-standardised incidence rates of MDD by gender from 1990 to 2019. The incidence rates of MDD for females were significantly higher than those for males, highlighting the pronounced vulnerability of females in this context. Besides, looking at the beginning and end of the 30-year observation period, the crude incidence rate of MDD decreased slightly. However, a concerning trend is observed: the incidence of MDD steadily increased after reaching its lowest point in 2005–2014 for both genders. This increase is particularly prominent among females.

Age and period main effects on MDD incidence

Online supplemental table 1 displays the coefficients and incidence rate ratios (IRRs) of MDD incidence for different age groups and periods by gender. The intercept of all models reflects the global mean of MDD incidence for the respective group, and the coefficients indicate the deviation of different age groups and periods from the global mean. The global mean incidence of MDD per 100 000 individuals was 2573 ($e^{-3.66} \times 100\,000$, calculated the same way for intercepts) for the total population, 3206 for females and 1925 for males. The age and period main effects of MDD for all genders were significant.

Compared with the global mean, the turning point where the age effect shifts from reducing to increasing risk was in the 35–39 age group. Before the age of 35–39, individuals in the 20–24 age group reduced the risk of MDD by 3.0% ($(1-e^{-0.03})$, calculated the same way for negative coefficients) for the total population compared to the mean, 2.0% for females compared to the mean and 2.0% for males compared to the mean. It can be observed that the reduction in the risk of MDD decreased as children and adolescents grew older from the 5–9, 10–14, 15–19 to 20–24 age groups. This indicates that as children and adolescents grew older, their risk of experiencing MDD continuously increased, reaching a minor peak at ages 20–24 and then decreasing slightly after that. After the age of 35–39, the risk of MDD for

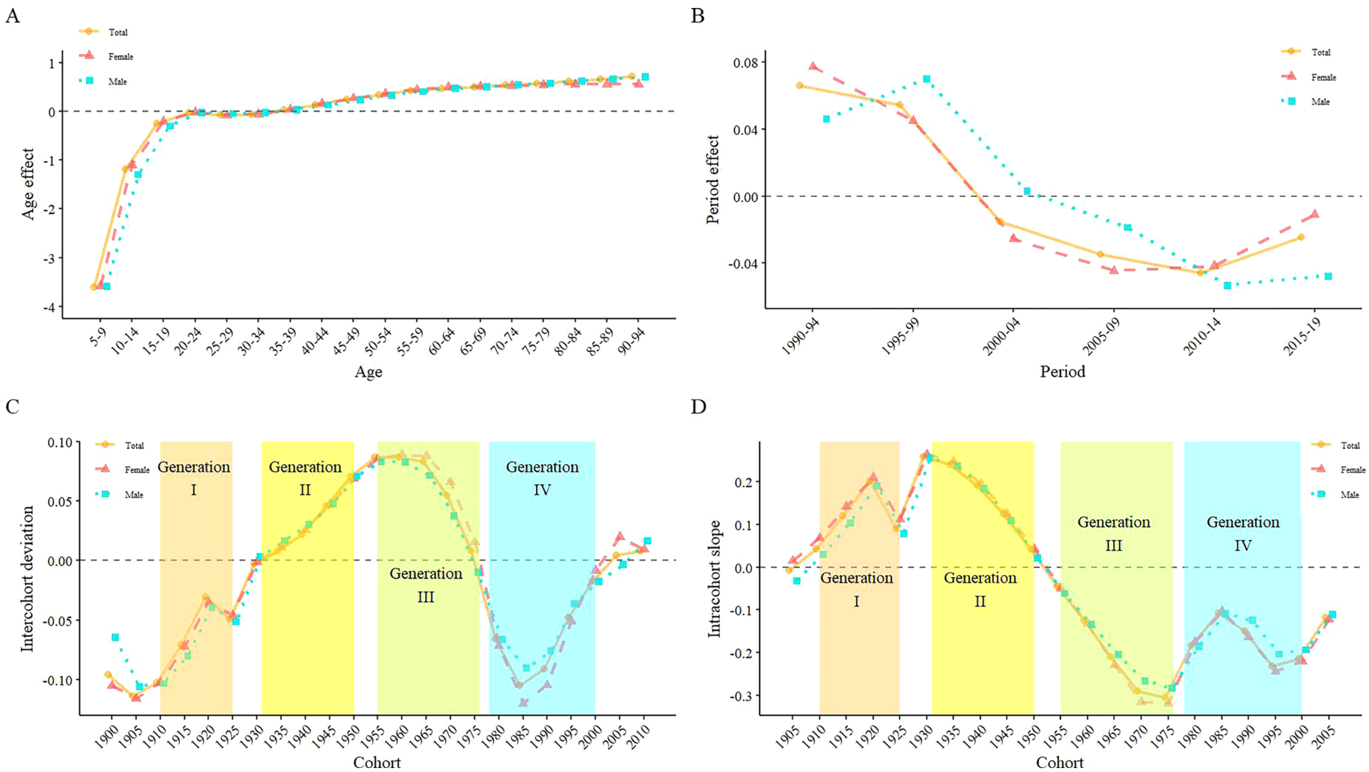

Figure 2 Age, period and cohort effects of major depressive disorder (MDD) incidence by gender. (A) Estimated age main effects on MDD incidence by gender (B). Estimated period main effects on MDD incidence by gender. (C) Estimated intercohort deviation on MDD incidence by gender. (D) Estimated intracohort life-course dynamics on MDD incidence by gender. Orange (generation I) represents the 'Republic of China' generation, yellow (generation II) represents the 'War' generation, green (generation III) represents the 'Cultural Revolution' generation, and blue (generation IV) represents the 'Reform and Opening Up' generation.

individuals sharply increased, almost in a linear pattern (see figure 2A). Individuals entering the elderly stage at the age of 65–69 significantly increased the risk of MDD by 64.9% (($e^{0.50}-1$), calculated the same way for positive coefficients), with an increase of 66.5% for both females and males. Those aged 90–94 showed an even greater increase in risk: 105.4% for the total population, 75.1% for females, and 103.4% for males, representing a substantial rise. In terms of gender differences, the risk of MDD for females was higher than that for males in most age groups (from 5 to 24 and from 35 to 69), while the risk of MDD for males sharply increased after the age of 70.

The period effects for MDD generally followed a 'U'-shaped pattern, with a decrease in the risk of MDD starting from 1990 to 1994 (see figure 2B). Individuals in the 1990–1994 period increased the risk by 7.3%, 8.3% and 5.1% for the total, female and male populations, respectively, compared with the global mean. The risk of MDD rebounded, starting from 2005 to 2014, with individuals in the 2005–2009 period reducing the risk by 3.0%, 4.0% and 2.0%, respectively, for the total, female and male populations. Individuals in the 2010–2014 period reduced the risk of MDD by 4.9%, 3.9% and 4.9%, respectively. The risk of MDD was on the rise from 2015 to 2019. Besides, the risk of MDD for females was lower than that for males from 1995 to 2009, but starting from 2010, the risk for females surpassed that for males.

Cohort effects on MDD incidence

Intercohort deviations

Online supplemental table 2 shows the coefficients and IRRs for intercohort average deviation of MDD incidence. The coefficients represent the deviation in MDD incidence compared with the expected incidence determined by age and period main effects. A positive deviation indicates a higher incidence than expected, while a negative deviation indicates a lower incidence than expected.

The cohort effects for MDD were significant except for a very small number of birth cohorts. The intercohort deviation for MDD generally exhibited a 'W'-shaped pattern with a prominent peak in the middle (see figure 2C). The risk of developing MDD was lowest for cohorts born in 1905 and 1985, with a minor peak for the 1920 birth cohort. A significant peak in MDD risk was observed for cohorts born from 1955 to 1965. Though subsequent cohorts born since 1985 showed an upward linear trend, none of the later cohorts surpassed the MDD risk of the 1955–1965 birth cohorts. Both genders showed a similar pattern in MDD incidence. Notably, in the cohorts with the two peaks in incidence, females had a higher risk of MDD compared with males. Conversely, in the cohorts with the two troughs in incidence, females had a lower risk of MDD than males, indicating greater fluctuations in MDD risk for females across different birth cohorts.

The cohort effect in the APC-I model is represented as an interaction term between age and period. Further analysis can be found in online supplemental tables 3–5 and online supplemental figure 2.

Intracohort life-course dynamics

Online supplemental table 2 also presents the coefficients for the intracohort life-course dynamics of MDD incidence. The life-course dynamics were measured by the slope within the cohort, representing the change in MDD incidence among different age groups within the cohort. The positive slope represented the increase in risk with the cohort's ageing, and the negative slope represented the decrease in risk with the cohort's ageing.

The intracohort variations in MDD incidence were all significant. The intracohort life-course dynamics for all genders showed a pattern resembling a left 'M' and a right 'W', with positive slopes ('M') before the mid-20th century and negative slopes ('W') after (see figure 2D). As cohorts aged, the risk of MDD within earlier cohorts (born before the mid-20th century) steadily increased, primarily among people born in 1910–1925 and 1935–1950. Conversely, for later cohorts (born after the mid-20th century), the risk of MDD within cohorts steadily decreased, including the birth cohorts from 1955 to 1975 and from 1980 to 2000. Like intercohort deviation, females experienced greater fluctuations in intracohort life-course dynamics of MDD risk across different birth cohorts, and they displayed more pronounced variations in the life-course dynamics of MDD risk compared with males.

Generational patterns and shifts

Considering the historical, social and political contexts, we examined four generations: generation I (cohorts born in 1910, 1915, 1920 and 1925), generation II (cohorts born in 1935, 1940, 1945 and 1950), generation III (cohorts born in 1955, 1960, 1965, 1970 and 1975) and generation IV generation (cohorts born in 1980, 1985, 1990, 1995 and 2000). As demonstrated in table 1, when considering intercohort differences and the life-course dynamics within cohorts, we observed opposing age-as-level trends in the incidence of MDD for generation I and generation III. Meanwhile, generation II and generation IV exhibited cumulative disadvantage and cumulative advantage, respectively, in terms of MDD incidence (the detailed description can be seen in online supplemental appendix).

DISCUSSION

Main findings

Using the APC-I model, this study comprehensively analysed the trends over time and cohort differences of MDD across age, period and birth cohort groups in China. The research findings underscore significant age, period and cohort effects in MDD across different genders in China.

In terms of age effects on MDD, the senior population exhibited the highest risk of MDD, corroborating previous studies highlighting the multifaceted association between depressive disorders and ageing.[10] Additionally, children and adolescents had a higher risk of MDD. MDD in this demographic often co-occurs with other psychiatric disorders and is typically linked to unfavourable psychosocial and academic outcomes, as well as an elevated risk of substance abuse, bipolar disorder and suicide.[25] Although most individuals in this group recovered from their initial depressive episodes, many experienced recurrences in adulthood.[9] The risk of MDD was consistently higher in females across most age groups, aligning with prior research.[12] Women with MDD typically had an earlier onset, experienced more frequent episodes and displayed a greater number of symptoms compared with men.[26]

Regarding period effects on MDD, the incidence of MDD began a steady decline in the 1990s, coinciding with China's rapid economic growth after the reforms initiated in 1978. The intense stress resulting from economic changes and job competition had a greater impact on males than females, leading to a relatively larger risk of MDD among males compared with females during the decline. However, a rebound in MDD incidence was observed from 2008 onwards, potentially associated with significant events such as the 2008 Wenchuan earthquake and the global financial crisis, which were linked to an increased risk of depressive disorder and post-traumatic stress disorder among survivors.[27] Moreover, the economic turbulence and rising unemployment during 2008 and 2009 were associated with higher rates of MDD,

Table 1 Generational patterns and shifts of major depressive disorder incidence

Generation	Cohort	Sign of intercohort deviation for total, female and male population	Sign of intracohort slope for total, female and male population	Generational patterns and shifts
Generation I	1910, 1915, 1920, 1925	<0	>0	Age-as-level
Generation II	1935, 1940, 1945, 1950	>0	>0	Cumulative disadvantage
Generation III	1955, 1960, 1965, 1970, 1975	>0	<0	Age-as-level
Generation IV	1980, 1985, 1990, 1995, 2000	<0	<0	Cumulative advantage

Orange (generation I) represents the 'Republic of China' generation, yellow (generation II) represents the 'War' generation, green (generation III) represents the 'Cultural Revolution' generation, and blue (generation IV) represents the 'Reform and Opening Up' generation. The 'Republic of China' was the official name of China after the Revolution of 1911 until the establishment of the People's Republic of China (1912–1949). The 'War' includes the Chinese War of Resistance against Japanese Aggression (1937–1945) and the Kuomintang-Communist Party of China Civil War (1927–1949). The 'Cultural Revolution' was a sweeping social and political movement across the People's Republic of China (1966–1976). The 'Reform and opening-up' includes a series of economic reforms in the People's Republic of China (1978–).

underscoring the detrimental effect of unemployment on mental health.[28] The traumatic events and economic instability disproportionately affected females, resulting in an increased risk of MDD compared with males. The period from 2015 to 2019 witnessed a noticeable uptick in the risk of MDD, particularly among females, and the coronavirus disease 2019 global pandemic that began in 2020 is likely to amplify this upward trend further. The newly revealed GBD 2021 data released on 20 March 2024 may provide potential insights into the pandemic's impacts. The recent rebound in MDD incidence, especially in the latest years and among the more recent birth cohorts, is particularly concerning.

Additionally, we examine the generational patterns and shifts in the incidence of MDD based on previous research. In terms of cohort effects on MDD, generation II showed a significantly higher risk of MDD compared with other cohorts. Undoubtedly, war represents one of the most adverse atrocities in history and today, and individuals affected by conflict and violence have significantly higher rates of depressive disorder, anxiety and post-traumatic stress disorder.[29] Particularly noteworthy is that the observations from previous APC analyses of MDD in China did not directly observe a negative impact of the Cultural Revolution on the cohort risk of MDD.[17] However, our study found a higher risk of MDD in generation III, indicating the enduring repercussions of political upheaval. Previous studies have found that harsh political events had long-term adverse effects on physical health and exacerbated mental health issues, triggering suicidal tendencies and behaviours.[30] In contrast, generation I and generation IV had a lower risk of MDD compared with other cohorts. The periods of upheaval and stability in these cohorts correspond to changes in institutions, cultural shifts, economic development, technology and healthcare advancement, and the reshaping of hopes, all correlated with positive mental health. Our finding underlines the profound impact of historical events on the mental well-being of a generation, validating the advantages of the APC-I model in analysing cohort effects in detail.

Furthermore, while the cohorts of generation III consistently had higher risks of MDD than other cohorts, fortunately, with the cohorts' ageing, the risk of MDD steadily decreased. This indicates a gradual alleviation of the depressive condition in the later stages of their life course. However, as generation II advances in age, the risk of MDD still accumulates over their life course, in addition to the already higher MDD incidence compared with other cohorts. This underscores the enduring and detrimental effects of war on people's mental health. Moreover, although the cohorts of generation I had a consistently lower risk of MDD than other cohorts, with the cohorts' ageing, their risk of MDD steadily increased, implying various risk factors in the later stages of their life course. Intercohort deviations and intracohort life-course dynamics present different antagonistic and synergistic effects. This suggests that the risk of MDD for different cohorts is not homogeneous; each cohort has unique protective and risk factors specific to their context. The risk of MDD for each cohort requires tailored attention and care based on their particular circumstances.

The incidence of MDD among Chinese residents warrants increased attention, especially among vulnerable populations, including children, adolescents and older adults, from a life course perspective. Moreover, females continue to be a high-risk population for MDD, necessitating heightened support and resources for women. The study also found that the incidence of MDD is associated with different periods of economic development and catastrophic events, both natural and human-caused. Economic upturns correspond to decreasing incidences of MDD. In contrast, economic downturns and disastrous occurrences forecast an increase in MDD rates, particularly highlighting the importance of monitoring mental health during times of economic fragility or crisis.[28]

Limitations

This study is subject to several limitations. First, the paper primarily relied on aggregated data, thus lacking individual-level control variables associated with demographic and socioeconomic characteristics. Additionally, it did not comprehensively delve into the diversity within MDD. Furthermore, the research findings in this paper pertained to macrolevel estimates, raising the possibility of ecological fallacy, and their applicability to individual-level analysis is uncertain. Second, the GBD data are based on modelling estimates, and inaccuracies, such as under-reporting, misclassification and improper disease diagnosis, can introduce biases into the analysis. Third, the absence of more granular data beyond the 5-year age groups restricted a more detailed analysis of MDD onset. Fourth, this study primarily concentrated on a macro-level comparison and analysis of MDD by gender in China, leaving the exploration of the underlying pathological and physiological mechanisms for future research and analysis.

Implications

In conclusion, the analysis based on the total population revealed the risk of developing MDD across age, period and birth cohort groups, regardless of gender, while the gender-specific analysis illustrated the incidence patterns of MDD over time, accounting for gender as a confounding factor. The findings underscore the complex interplay of these factors in shaping generational patterns and shifts of MDD. The insights gained from this research have significant implications for tailoring mental health interventions and policies to address the unique needs of various population groups and advancing our understanding of the multifaceted nature of MDD.

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Contributors XH was involved in conceptualisation, study design, data analyses, drafting and revising the manuscript. CG was involved in study design, data curation, revising the manuscript and supervision. XH and CG are responsible for the overall content as guarantors.

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Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

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