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Age-period-cohort analysis of self-harm incidence rates by gender in Iran among individuals aged 10–39 years, 1990–2019

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This study investigates trends and patterns in self-harm incidence rates among individuals aged 10–39 years in Iran from 1990 to 2019. Using Age-Period-Cohort (APC) analysis, it aims to identify significant age, period, and cohort effects, and to highlight gender-specific trends for effective prevention strategies. Utilizing data from the Global Burden of Disease (GBD) study, we performed an APC analysis to assess trends in self-harm incidence rates by gender. Data was stratified into six age groups and six five-year periods, and analyzed using the APC Web Tool from the National Cancer Institute. The average incidence rates of self-harm attempts and deaths among individuals aged 10–39 years were 93.87 and 7.55 per 100,000 individuals, respectively. Females had 1.75 times higher attempt rates than males, while males had 1.62 times higher death rates. The APC analysis revealed that males experienced stable self-harm rates over time, while females showed a significant decline. Peak incidence for both genders occurred at age 22.5 years. Self-harm incidence rates show younger females are more vulnerable to self-harm, but there has been a general decline in incidences over time, particularly for more recent cohorts but the stability of rates across ages and the lower rates in more recent cohorts highlighted in male.

Keywords APC analysis, Self-harm, Trends, Suicide, Incidence rates, Iran

Self-harm is a significant public health concern that affects individuals, families, and communities worldwide[1,2]. It is one of the leading causes of death, particularly among young people, and its impact transcends demographic boundaries, affecting people of all ages, genders, and backgrounds. The World Health Organization (WHO) estimates that close to 800,000 individuals die by self-harm each year, making it a critical issue that demands urgent attention and action. Globally, self-harm rates vary significantly across regions. In 2021, the European Region reported the highest new case rate of self-harm at 91.16 (80.64-103.11) per 100,000 individuals. In the Eastern Mediterranean Region, Pakistan recorded the highest rate at 55.01 (42.39–69.25). These figures underscore the diverse epidemiological patterns of self-harm worldwide and highlight the importance of region-specific prevention strategies[3,4].

Suicide prevention is crucial not just for lowering death rates but also for improving mental health and well-being. Comprehensive programs can help identify at-risk people, offer essential support, and create environments that encourage mental wellness. Early intervention and community awareness are key to dismantling the stigma around mental health, and motivating individuals to seek help before experiencing a crisis[5,6].

Self-harm has become an increasingly critical issue in Iran, reflecting a complex web of socio-cultural, economic, and psychological factors[7,8]. Recent studies indicate a worrying trend, with rising self-harm rates, particularly among the youth and vulnerable populations. This phenomenon poses significant challenges to public health, social stability, and community well-being[9].

In Iran, traditional cultural norms often stigmatize mental health issues, leading to a lack of open discussion about self-harm and its underlying causes. This silence can exacerbate feelings of isolation and despair among

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those at risk. Furthermore, rapid urbanization, economic hardships, and social pressures contribute to heightened stress and mental health struggles, making it essential to address these issues comprehensively[2,10].

Analyzing self-harm through the Age-Period-Cohort (APC) framework reveals the intricate relationships between age, historical context, and generational influences on self-harm rates, highlighting trends often overlooked by traditional studies[11]. The age effect refers to the change in the rate of a condition according to age, regardless of birth cohort and calendar time. The cohort effect is defined as the change in the rate of a condition according to the year of birth, regardless of age and calendar time. The period effect pertains to changes in the rate of a condition that are associated with specific periods or events in time, affecting individuals across all ages and cohorts[12]. This article focuses on Iran, emphasizing the critical need to understand how these factors uniquely impact suicidal behavior in the country. By applying APC analysis, we can identify specific risk factors and trends across different age groups, shedding light on the distinct challenges they encounter. This approach is vital for crafting culturally sensitive prevention strategies that aim to enhance mental health outcomes and effectively reduce self-harm rates among diverse populations in Iran.

Methods

Data sources

This secondary study was conducted using data collected in the Global Burden of Disease (GBD) study, which reports incidence, prevalence, mortality, and disability-adjusted life years (DALYs) for 369 diseases and 84 risk factors across 204 countries from 1990 to 2021. Managed by the Institute for Health Metrics and Evaluation, GBD provides comprehensive and comparable data on cause-specific mortality. The dataset is accessible for research and modification under the Open Data Commons Attribution License via the GBD Data Tool repository, supporting further investigation and analysis (http://ghdx.healthdata.org/gbdresults-tool)(1).

Data cleaning and processing

For data processing, age groups were organized in 5-year intervals. To calculate the incidence and mortality rates over these intervals, we aggregated the data into five-year periods from 1990 to 2019. We then divided these aggregated totals by five to obtain the average rate for each five-year period and each age group. Due to the requirement for precise population counts in the online tool and the use of incidence rates, we substituted a population count of 100,000 for all cells in the tool's population section. This adjustment allowed us to perform the analysis effectively and to mitigate errors arising from minor variations in raw data[13,14].

Study population and sampling

The study population focuses on incidence and mortality rates per 100,000 population for individuals aged 10 to 39 years in Iran. This age range was further divided into six 5-year age groups: 10–14, 15–19, 20–24, 25–29, 30–34, and 35–39 years. Additionally, the time period from 1990 to 2019 was divided into six 5-year intervals: 1990–1994, 1995–1999, 2000–2004, 2005–2009, 2010–2014, and 2015–2019. This stratification allows for a detailed analysis of trends within specific age and time cohorts, providing a nuanced understanding of self-harm dynamics within the specified demographic[13].

Statistical analysis

The Age-Period-Cohort (APC) model was employed to analyze trends in self-harm rates over time, distinguishing the influences of age, period, and birth cohort on self-harm incidence. This model, essential in fields such as demography, sociology, and epidemiology, facilitates an understanding of how these factors impact demographic and health trends. By utilizing extensive data from the Global Burden of Disease (GBD) 2021, the analysis highlights age-specific risks, temporal trends, and generational influences on self-harm rates, thereby offering deeper insights into the complexities of self-harm[13,15].

To estimate the percentage of annual change (PAC) and identify significant trend shifts, the study utilized the Age-Period-Cohort Web Tool from the Biostatistics Branch of the National Cancer Institute (NCI), available at https://analysistools.cancer.gov/apc/. This tool differentiates between age effects—reflecting varying risks across different age groups; period effects—capturing fluctuations impacting all ages simultaneously; and cohort effects—illustrating changes among groups born in the same year. The age effect is calculated by subtracting the cohort effect from the period effect (Age = Period - Cohort). The cohort effect is calculated by subtracting the age effect from the period effect (Cohort = Period - Age). Finally, the period effect is calculated as the sum of the age and cohort effects (Period = Age + Cohort)[13]. It generates local drifts, known as PACs, for each age group through log-linear regressions. Local drift is defined as the estimated annual percentage change (EAPC) over time specific to each age group. The tool also provides other estimable parameters, including the longitudinal age trend (age trend + period trend) and the cross-sectional age trend (age trend – period trend). Additionally, the net drift is the analogue of the Estimated Annual Percentage Change, adjusted for cohort effects, and determines the ratio between longitudinal and cross-sectional age curves[13,14,16].

Additionally, the tool calculates the relative rate for any specified calendar period or birth cohort compared to a reference period or cohort, adjusting for age and non-linear cohort or period effects. Typically, the central age group, period, and birth cohort are defined as references, with the lower of two central values set as the reference in cases of an even number of categories. Microsoft Excel 2016 was used for plotting the incidence rate of self-harm by age group and birth cohort. This comprehensive approach enables a nuanced understanding of how age, time, and generational factors interact to influence trends in self-harm rates[14,17].

Result

The incidence rates of self-harm attempts and self-harm deaths for both sexes in the age group of 10 to 39 years were, on average, 93.87 and 7.55 per 100,000 individuals, respectively. The rates of self-harm attempts among females were 1.75 times greater than those in males, while the death rates for males were 1.62 times higher than for females. Longitudinal age curves for self-harm rates in males show that the risk increased from age 10 to 22.5 years, reaching a peak at 22.5 years (110.63 per 100,000 individuals), before gradually declining. Similarly, for females, the risk of self-harm also increased with age, reaching a peak at 22.5 years (208.91 per 100,000 individuals) before declining steadily. Longitudinal age curves for self-harm-related deaths in males indicate a gradual increase, peaking at 22.5 years (12.36 per 100,000 individuals) before declining. In contrast, females exhibit a slightly different pattern, with rates increasing steadily until reaching a peak at 17.5 years (9.80 per 100,000 individuals), after which they begin to decrease (Fig. 1).

The gender-specific age-period-cohort (PAC) analysis of self-harm incidence rates in Iran between 1990 and 2019 indicates that the net drift for females was −2.0627 (95% CI: -2.4419 to -1.6821) percent per year ($p < 0.01$), whereas for males, it was 0.0269 (95% CI: -0.4716 to 0.5278) percent per year ($p = 0.92$). The local drift values indicate that for males, there was an upward trend across various age groups, starting below zero at age 12.5 and reaching a peak at 32.5 years (0.59% per year). In contrast, the local drift values for females remained consistently below zero across all age groups, with a lowest at 37.5 years (-2.7148% per year)(Fig. 2).

The estimated age, period, and cohort effects by gender are displayed in Fig. 3. For males, the age, period, and cohort effects exhibited less variation over time, with rate ratios remaining relatively stable across all cohorts ($p = 0.86$) and all periods ($p = 0.98$), according to Wald tests. In contrast, the period and cohort effects for females showed a continuous decline in self-harm rates, particularly in recent years, across all cohorts ($p < 0.01$) and all periods ($p < 0.01$). For males, the longitudinal versus cross-sectional age curves are generally stable across different age groups, with slight variations around a rate ratio of 1. However, for females, the longitudinal versus cross-sectional age curves display a decreasing trend with age.

In our analysis of self-harm incidence rates by birth cohort, age group, and gender, distinct patterns emerged. Among males, the highest incidence rates were observed in younger age groups, peaking in the 20–24 years age group within the cohort born around 1980, with a rate of 109.95 per 100,000 person-years. The 25–29, 30–34,

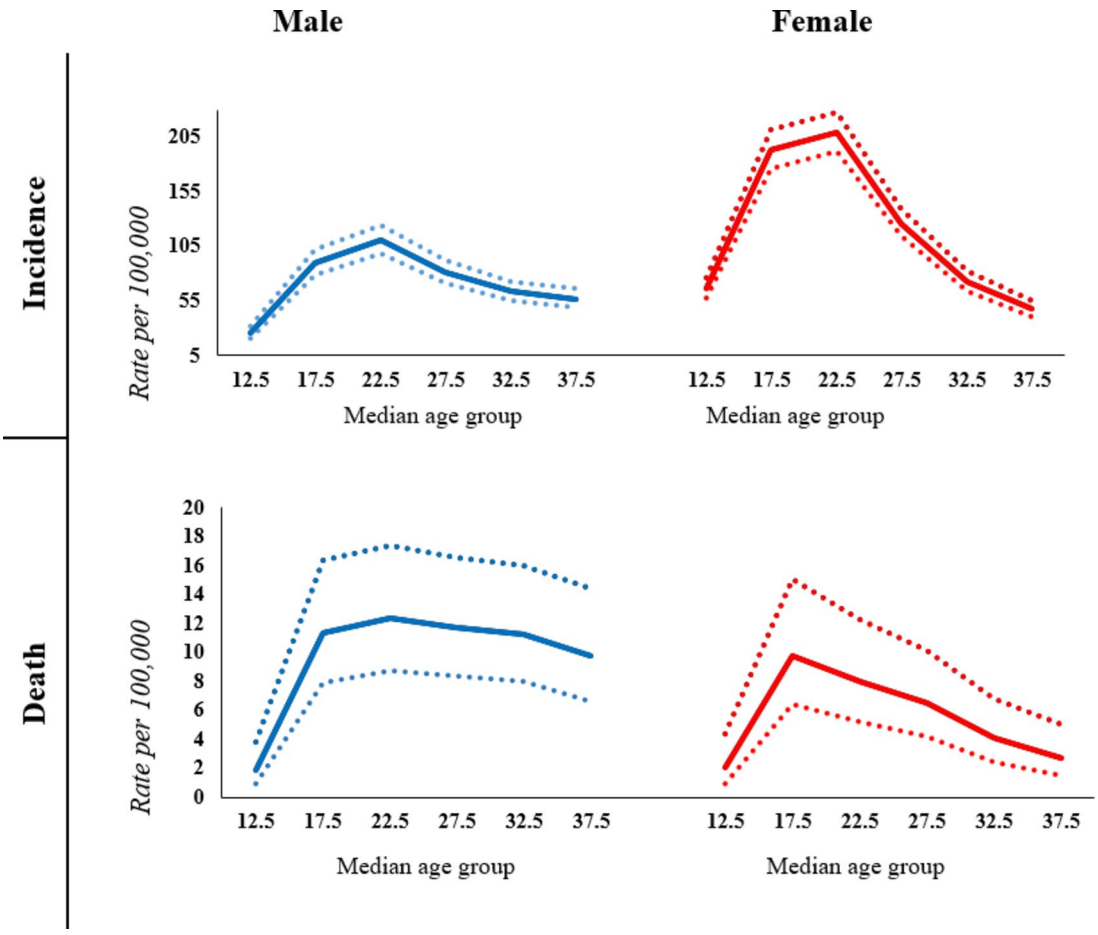
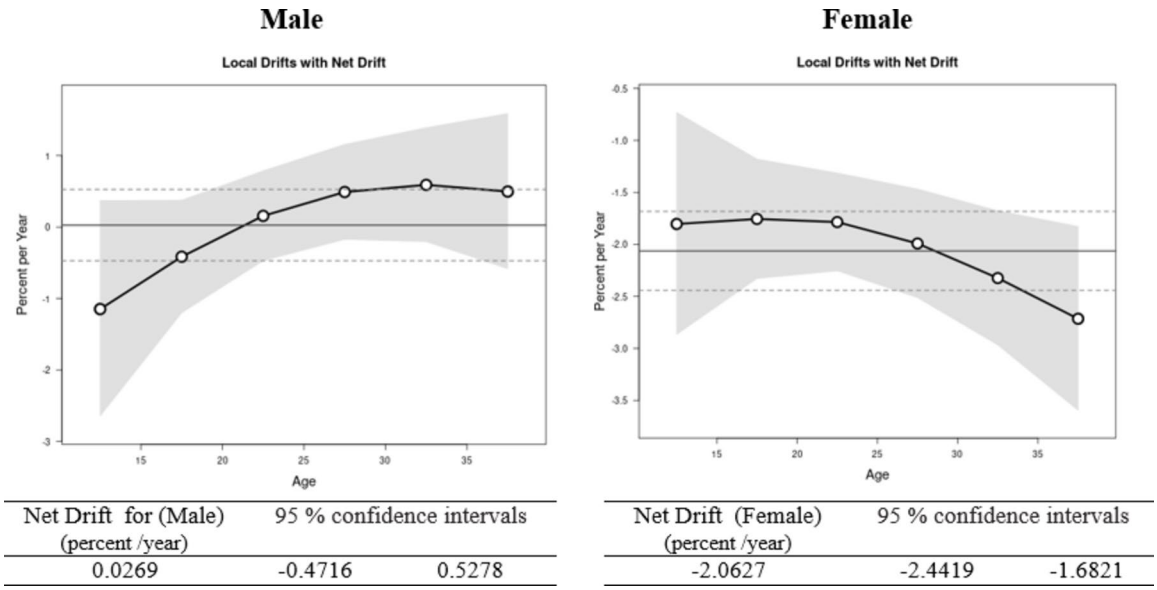


Fig. 1. Longitudinal age curves of the incidence and death rates of self-harm (per 100,000) and the corresponding 95% confidence intervals by gender in Iran.



Net Drift for (Male) (percent /year)	95 % confidence intervals	
0.0269	-0.4716	0.5278

Net Drift (Female) (percent /year)	95 % confidence intervals	
-2.0627	-2.4419	-1.6821

Fig. 2. Fig. 2 Local and net drift values of self-harm incidence rates and 95% confidence intervals by gender in Iran.

and 35–39 years age groups demonstrated a consistent increasing trend throughout the study period. In contrast, the 10–14 and 15–19 years age groups initially showed an increase and then a subsequent decrease (Fig. 4).

For females, a significant decline in self-harm rates was observed across the cohorts. The highest rates were found in the 20–24 years age group within the cohort born around 1975, with a rate of 237.78 per 100,000 person-years. In all age groups, females had higher self-harm rates compared to males, especially in earlier cohorts. Notably, in females, the 10–14 years age group in the 1980 cohort had a higher rate of self-harm compared to the 35–39 years age group, whereas in males, the same age groups within the 1980 cohort showed a much smaller difference in self-harm rates (Fig. 4).

Discussion

Self-harm is a profound tragedy impacting families and communities, ranking as the fourth leading cause of death among 15–30-years. It affects all regions, with over 77% of suicides occurring in low- and middle-income countries. Despite being a serious public health issue, suicides are preventable through evidence-based interventions[18]. According to recent global studies, the burden of self-harm and suicide remains alarmingly high, with over 720,000 deaths attributed to suicide worldwide each year, a number that continues to increase. This burden disproportionately affects low- and middle-income countries, which account for the majority of suicide deaths[1,19]. In Iran, self-harm has been identified as a growing concern, with a notable increase in suicide attempts, particularly among women and younger populations[20]. Other studies have highlighted that the incidence of self-harm in the region is significantly higher than global averages, further underlining the urgent need for targeted prevention strategies[1].

A comparison of self-harm rates in Iran and global averages reveals significant disparities. Generally, self-harm attempts are roughly 10–20 times more frequent than completed suicides, with an average global rate of 10.5 per 100,000. In contrast, this study estimates Iran's suicide death rate at approximately 7.55 per 100,000, while the rate of attempts is around 93 per 100,000. The age-standardized suicide rate in Iran was higher than the global average but lower than that of Qatar and Bahrain compared to other countries in the Middle East and North Africa. This notable difference in Iran's statistics may be attributed to variations in data quality and availability, indicating a higher prevalence of attempts relative to completed suicides. This discrepancy is likely influenced by factors such as method selection and access to lethal means, as well as sociocultural dynamics that shape suicidal behavior in the region[1].

Almost all research in the area of self-harm indicates higher rates of suicide attempts in females, particularly in younger age groups, highlighting the need for targeted mental health interventions. Additionally, the cohort analysis suggests that societal changes over time may influence self-harm trends, emphasizing the importance of ongoing research and support tailored to different age groups and genders. Understanding these dynamics is crucial for developing effective prevention and intervention strategies[21,22]. Suicide risk evolves, influenced by changes in mood, growing hopelessness, and specific actions like making plans or acquiring means. These signs indicate increasing risk, which can range from low to high. A key factor in this progression is the loss of fear of death, enabling someone to move from thoughts to actual attempts[23]. To justify the high rate of suicide among women, Women are more likely to experience homelessness, substance abuse, and mental illness—factors that are well-known predictors of suicide. Additionally, they often face gender-specific risks, such as a history of childhood sexual abuse, trauma, and intimate partner violence, which are more common among them than in the general population or among men[24]. In the Iranian population, both being female and having lower education

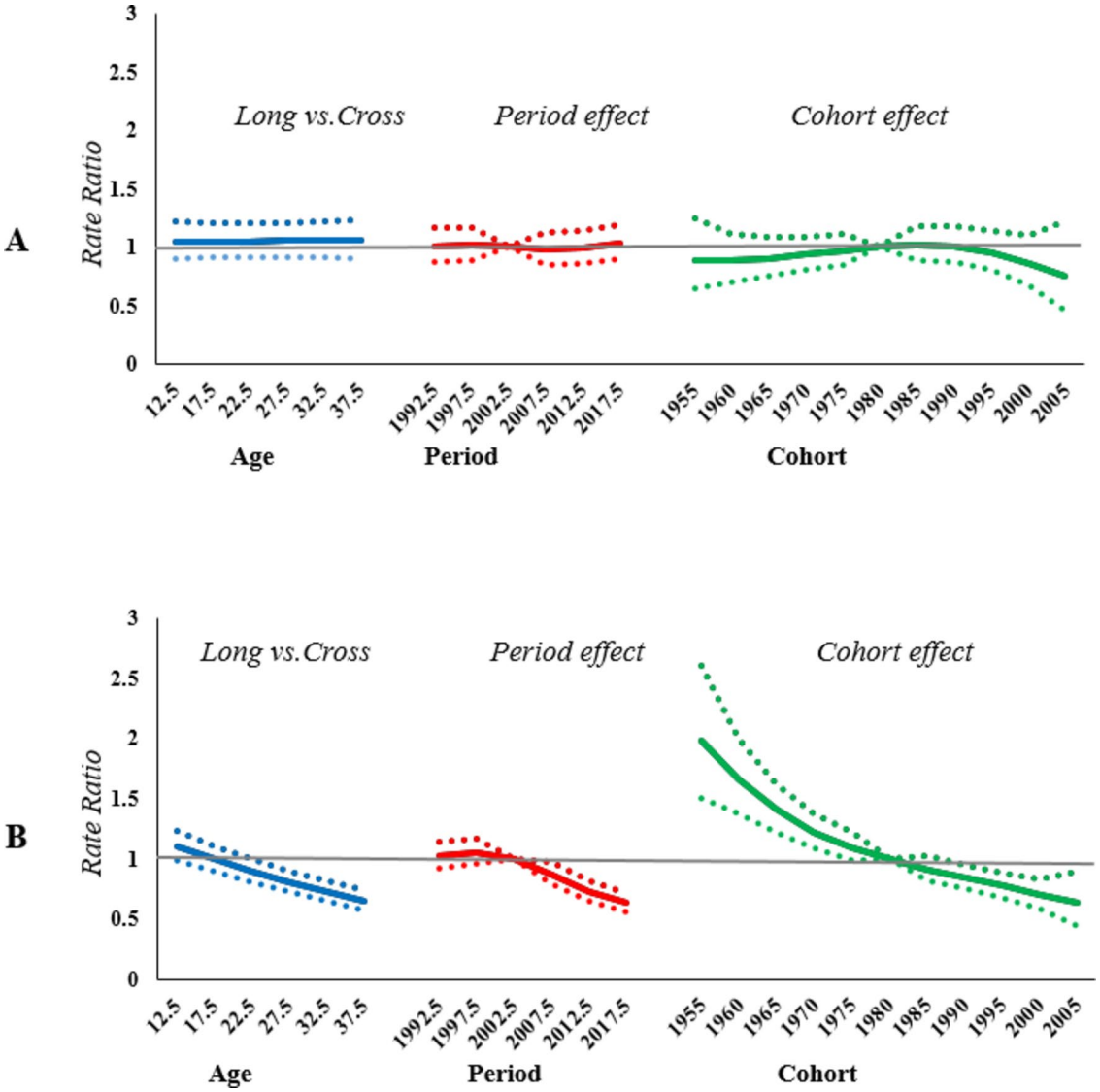


Fig. 3. Age-period-cohort analysis of self-harm. (**A**) The incidences of self-harm in males. The blue line indicates the ratio of longitudinal versus cross-sectional age curves and the 95% confidence interval, the red line indicates the period effect and the 95% confidence interval, and the green line indicates the cohort effect and the corresponding 95% confidence interval. (**B**) The incidences of self-harm in females. The blue line indicates the ratio of longitudinal versus cross-sectional age curves and the 95% confidence interval, the red line indicates the period effect and the 95% confidence interval, and the green line indicates the cohort effect and the corresponding 95% confidence interval. (The reference values are as follows: the longitudinal versus cross-sectional ratio is 22.5, the period effect is 2002.5, and the cohort effect is 1980).

levels are linked to an increased risk of suicide attempts, this may be attributed to high major depression, bipolar, anxiety, and mode disorders, that has been affected by socio-economic factors[25].

Females have higher rates of suicide attempts, while males experience higher completion rates. This disparity may stem from differences in mental health disorders, coping mechanisms, and societal pressures. Effective prevention strategies must be gender-specific, enhancing support for females and addressing barriers to help-seeking behaviors in males to reduce overall Self-harm rates[26,27]. Females have a consistently higher incidence rate of self-harm compared to males across most age groups, particularly in the younger age brackets[15–25]. The peak incidence for females is significantly higher than that for males, indicating a greater vulnerability among young women. This finding aligns with similar studies conducted in Australian children[28], Canada[29], European countries and almost more countries[9,22]. Several factors might contribute to the higher rates of completed suicides among men compared to women in Iran. Societal expectations often impose strict norms on masculinity, discouraging men from expressing vulnerability or seeking help. This emotional suppression can heighten their risk of suicide. Additionally, men may develop a greater capability for suicide due to exposure to violence, substance abuse, or previous suicidal behavior. Economic pressures and financial difficulties also place

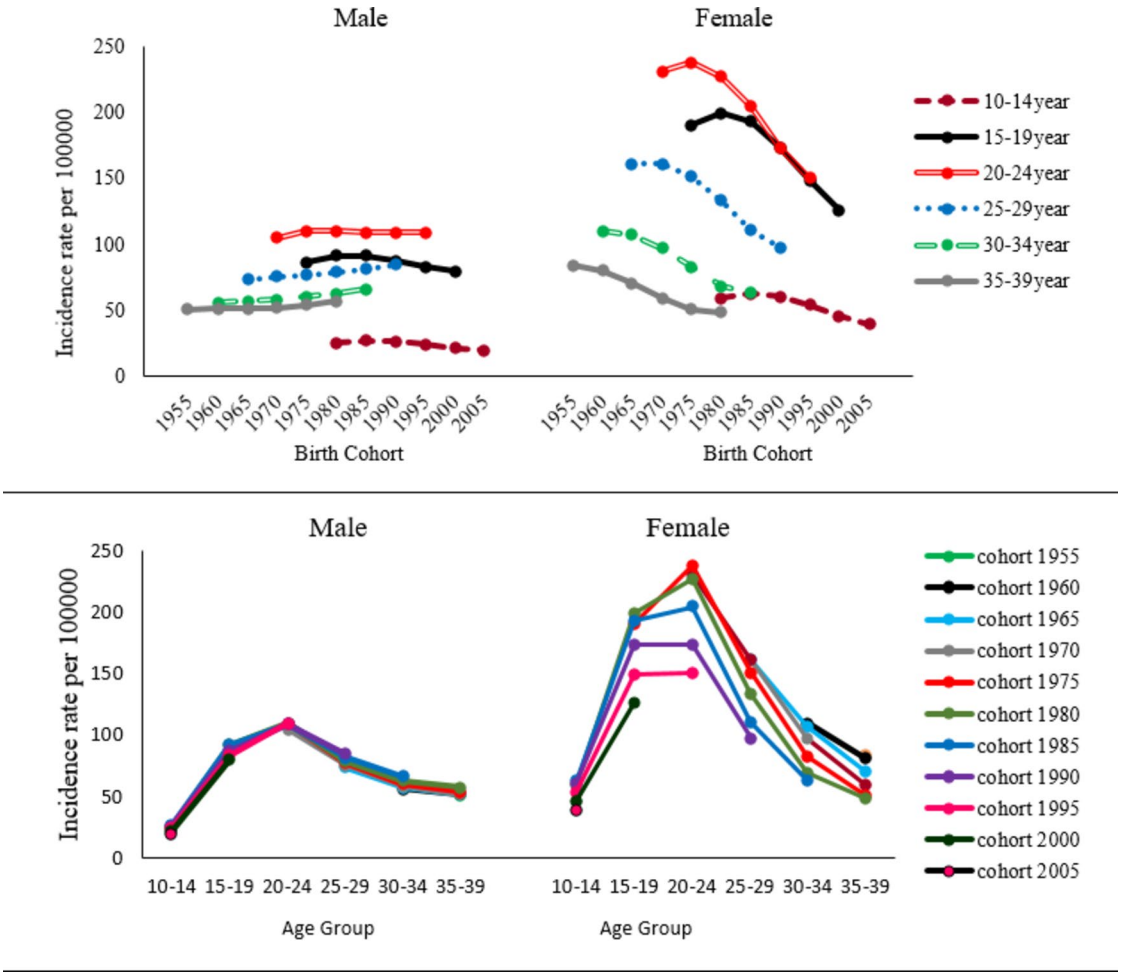


Fig. 4. Incidence rate per 100000 of Self-Harm in Males and females by Age Group and Birth Cohort.

significant stress on men, who may experience less support during crises. These issues highlight the need for further research to better understand and address the complex factors contributing to this disparity.

We did not observe any changes in the trend of self-harm among males, while the self-harm trend in female shows that more recent cohorts (those born after 1980) have lower rates of self-harm compared to older cohorts and the slight downward trend from around 1995 to 2017 indicates a decrease in self-harm incidences over these years. However, the findings of this study, along with similar research and noticeable community-level changes, indicate a decline in the Self-harm rate among Iranian women, contrasted by a slight increase among men, although this change was not statistically significant. Several factors may explain the reduction in suicide attempts among Iranian women. Firstly, heightened awareness and education regarding mental health, alongside improved access to mental health services and psychological counseling, play crucial roles. Additionally, shifting social and cultural norms that have lessened the stigma associated with mental health issues have encouraged more women to seek help. Increased social engagement and participation in group activities can further mitigate feelings of loneliness. Moreover, economic improvements and enhanced job opportunities have alleviated financial and social pressures, while emotional support from families has strengthened relationships and reduced feelings of hopelessness[30–32]. Together, these factors offer a comprehensive understanding of the observed decrease in suicide attempts within this population.

Overall, in order to effectively reduce self-harm rates in Iran, a comprehensive strategy should be implemented that focuses on enhancing mental health services, increasing access to trained professionals in schools and communities, and launching public awareness campaigns to combat the stigma associated with mental health issues. Additionally, it is vital to provide healthcare providers with training to more effectively recognize and address self-harm behaviors.

Limitations

Our analysis is subject to several limitations that should be noted. The use of the Age-Period-Cohort (APC) analysis tool on this website required precise population definitions and data. In Iran, population data segmented into 5-year age groups for specific periods such as 1990–1994, 1995–1999, and up to 2015–2019 were not available. Consequently, to meet the requirements of this website, we utilized a standard population of 100,000

for each age group, based on incidence rates per 100,000 individuals derived from the Global Burden of Disease (GBD) data.

Additionally, the website did not allow for the inclusion of other risk factors such as socioeconomic status and other social determinants, which could have provided a more comprehensive understanding of self-harm trends. Moreover, the GBD data for age group classifications were based on 5-year intervals, which did not perfectly align with the website's requirements for matching age group and time period classifications. As a result, we had to use 5-year time intervals from 1990 to 2019 and were unable to include data from the year 2021. These methodological constraints and data limitations should be considered when interpreting the findings of this study.

Furthermore, it is important to note that the burden of disease data used in this study may include underestimations due to differences in disease reporting across provinces in Iran and other regions. These data are not 100% accurate, and variations in reporting standards may contribute to discrepancies in self-harm and suicide statistics. These limitations should be taken into account when interpreting the results of this analysis.

Conclusion

In summary, our Age-Period-Cohort (APC) analysis of self-harm rates in Iran from 1990 to 2019 offers important insights into how self-harm behaviors differ across age groups, time periods, and generational cohorts. We observed that females have higher rates of self-harm attempts compared to males, while males experience higher rates of self-harm deaths. Our analysis highlights that self-harm rates among males have remained relatively stable over time, whereas females have seen a notable decline. This suggests that various factors are influencing self-harm rates differently for each gender and age group. These results underscore the need for prevention strategies tailored to these demographic variations. To effectively reduce self-harm, efforts should be directed at understanding and addressing the unique needs and risks associated with different genders and age groups, thereby improving mental health outcomes and support.

Data availability

We applied publicly available data from the Global Burden of Disease (GBD) website for this present study. Use the following to cite data included in this download: Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2021 (GBD 2021) Results. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2022. Available from https://vizhub.healthdata.org/gbd-results/."

Received: 22 September 2024; Accepted: 6 January 2025
Published online: 15 January 2025

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Acknowledgements

We would like to acknowledge the Global Burden of Disease (GBD) project for providing the data used in this research. The authors also wish to express their gratitude to their colleagues and institutions for their support and assistance throughout the study.

Author contributions

M M and YR contributed substantially to the conception and design of the project. M M , YR, A A, F N and S R were responsible for the acquisition of data and the analysis. All authors contributed to the interpretation of data. All authors contributed to drafting the article and revising it critically for important intellectual content. All authors have provided the final approval of the version to be published, and agree to be accountable for all aspects of the work.

Funding

This research was supported by Kermanshah University of Medical Sciences (KUMS). The ethics committee code for this project is IR.KUMS.REC.1403.362. The full details of the ethical approval can be accessed online at https://ethics.research.ac.ir/EthicsProposalView.php? id=501125.

Declarations

Competing interests

The authors declare no competing interests.

Participant consent form

This study utilized publicly available data from the Global Burden of Disease (GBD) website. As such, no direct participant consent was required for this research. The data used were sourced from public databases, and there was no direct interaction with or collection of personal information from individuals.

Ethics approval

This study utilized data from the Global Burden of Disease (GBD) website. As the data were obtained from publicly available sources, no specific ethical approval was required for this research.

Additional information

Correspondence and requests for materials should be addressed to M.M.