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Original Article

A Spatial-Temporal Study of the Incidence of Fatal Suicide during the Years 2009 to 2023

Rezvan Feizi [1,2], Mohammad Hossein Panahi [1,2], Seyed Saeed Hashemi Nazari [2], Reza Hajmanouchehri [3], *Ali Delpisheh [1,2], Azadeh Nouhi Siahroudi [2]

1. *Safety Promotion and Injury Prevention Research Center, Research Institute for Health Sciences and Environment, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
2. *Department of Epidemiology, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
3. *Legal Medicine Research Center, Legal Medicine Organization, Tehran, Iran*

***Corresponding Author:** Email: alidelpisheh@yahoo.com

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Abstract

Background: This ecological cross-sectional study examines suicide incidence and identifies high- and low-risk clusters across Iranian districts from 2009 to 2023. This study aimed to determine district-specific suicide rates and map spatial risk patterns.

Methods: Overall, 52,665 suicide cases of recorded in forensic medicine were analyzed, with incidence rates calculated per 100,000 population. Spatial autocorrelation techniques were used to identify clusters of high and low suicide risk, and GIS software facilitated mapping. Hanging was the most prevalent method, accounting for 50.88% of cases. Temporal trends across months were also assessed.

Results: The average age of individuals who died by suicide was 33.98 years. High-incidence districts were located in parts of different provinces of Iran, including Eshtehard (Alborz), Firuzeh (Razavi Khorasan), Varzeghan (East Azerbaijan), Sahneh (Kermanshah), Famenin (Hamadan), and Miami (Semnan). High-risk clusters were primarily concentrated in the western provinces of Kermanshah and Hamadan, particularly in Sahneh and Famenin. Conversely, districts in Sistan and Baluchestan in southeastern Iran showed markedly lower suicide rates, possibly due to underreporting or systemic differences in data collection practices, which warrants cautious further investigation.

Conclusion: This study highlights substantial regional disparities in suicide incidence across Iran, with specific high-risk areas identified for targeted intervention. These findings have important implications for public health policy, emphasizing the need for regionally tailored suicide prevention strategies and improved surveillance systems. Further research is needed to understand better the low suicide rates that observed in some districts and to assess potential reporting inconsistencies.

Keywords: Suicide complete; Fatal suicide; Spatiotemporal analysis; Iran

Introduction

Suicide is a complex human behavior with serious public health and financial consequences (1,2). Each year, nearly 1 million people die by suicide globally, with one death for every 20 attempts (3–5). These attempts reflect severe personal distress and have widespread impacts on

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families and communities, with rates differing significantly between countries (6,7). Most suicides occur in low- and middle-income countries (8).

In Iran, suicide attempt rates exceed the Middle East average and have risen in recent years. Over the past 20 years, suicide mortality has increased, with an average annual rate of 9.9 per 100,000 (8–10). Due to temporal and regional variability and its occurrence across age groups, reliable national data on suicide characteristics are essential (11–16).

Geographic Information Systems (GIS) is widely used in public health for mapping disease distribution and identifying influencing factors (17–21). While effective in developed countries, its use in health research is still limited in countries like Iran (22,23). GIS can help identify high-risk areas, support evidence-based policies (24,25), and enhance suicide prevention through early detection and intervention (26).

Therefore, we aimed to analyze the spatial and temporal patterns of fatal suicide in Iran from 2009 to 2023 and identify regional clusters to inform targeted interventions.

Materials and Methods

The study was approved by the School of Public Health and the Neuroscience Research Center at Shahid Beheshti University of Medical Sciences, with ethical code IR.SBMU.PHNS.REC.1403.148.

This ecological cross-sectional study analyzed the spatial and temporal patterns of fatal suicide in Iran from 2009 to the end of Mar 2023.

Data on all registered suicide deaths were obtained from the Forensic Medical Organization of Iran, and annual population statistics were retrieved from the Statistical Center of Iran. Ethical approval was obtained prior to data collection.

The unit of analysis in this study was the district. After data cleaning to remove duplicates and incomplete records, the final dataset included demographic and contextual variables such as age, gender, date of death, method of suicide, and geographic location (district and province). Descriptive analysis was conducted based on suicide method, monthly patterns, and crude incidence rates (per 100,000 population).

Suicide incidence maps were created by aggregating the total number of cases in each district over the 14-year study period. The Jenks natural breaks classification method was applied to categorize suicide incidence into five levels. Annual suicide maps were also produced to explore temporal trends across different regions.

To assess spatial clustering, Global Moran's I was used to measure the overall spatial autocorrelation of suicide incidence across counties. Additionally, Local Moran's I was applied to detect specific high- and low-risk clusters. The Getis-Ord Gi statistic was also used to identify statistically significant hot and cold spots of suicide incidence.

A Queen contiguity spatial weights matrix was used in all spatial analyses, which defines neighboring counties as those sharing a common border or corner. All spatial analyses and mapping were performed using ArcMap GIS software (ver. 10.8.2).

In this study, crude suicide data were used intentionally to preserve local variation and avoid the potential smoothing effect that adjusted rates can introduce. Since the primary aim was to identify precise spatial and temporal clusters, relying on crude data enabled more accurate detection of high-incidence areas and better captured the true spatial heterogeneity of suicide distribution.

To further investigate the spatial autocorarelation of the data and determine whether lower values tend to cluster together more than higher values, the Generalized Getis-Ord (GOGG) test was employed (to examine the spatial patterns of the data) using the formula:

$$Gi = \sum jwijXj \,/\, \sum jXj + Z \times \sum jwij \,/\, \sum jwij$$

For examining high-risk and low-risk areas, Local Moran's I analysis was used (to determine the common characteristics of nearby points) with the formula:

$$Morans\ I = (X - \bar{X})\ (X - \bar{X})\ /\ (\sum i \sum jwij) \times (\sum (Xi - \bar{X})^{2} / N^{2})$$

This methodology was established to determine the spatial patterns of suicide incidence.

Results

In this study, 52,665 cases of fatal suicide across the country were examined. The average age of the individuals studied was 33.98±15.16 years. Out of the total suicide cases during these years, 45,092 (70.9%) were related to men and 18,473 (29.1%) were related to women. The overall trend in suicide cases showed a steady increase over the 14-year period, with a more pronounced rise beginning around 2016. The highest number of suicides was recorded in 2023, indicating a growing public health concern (Fig. 1).

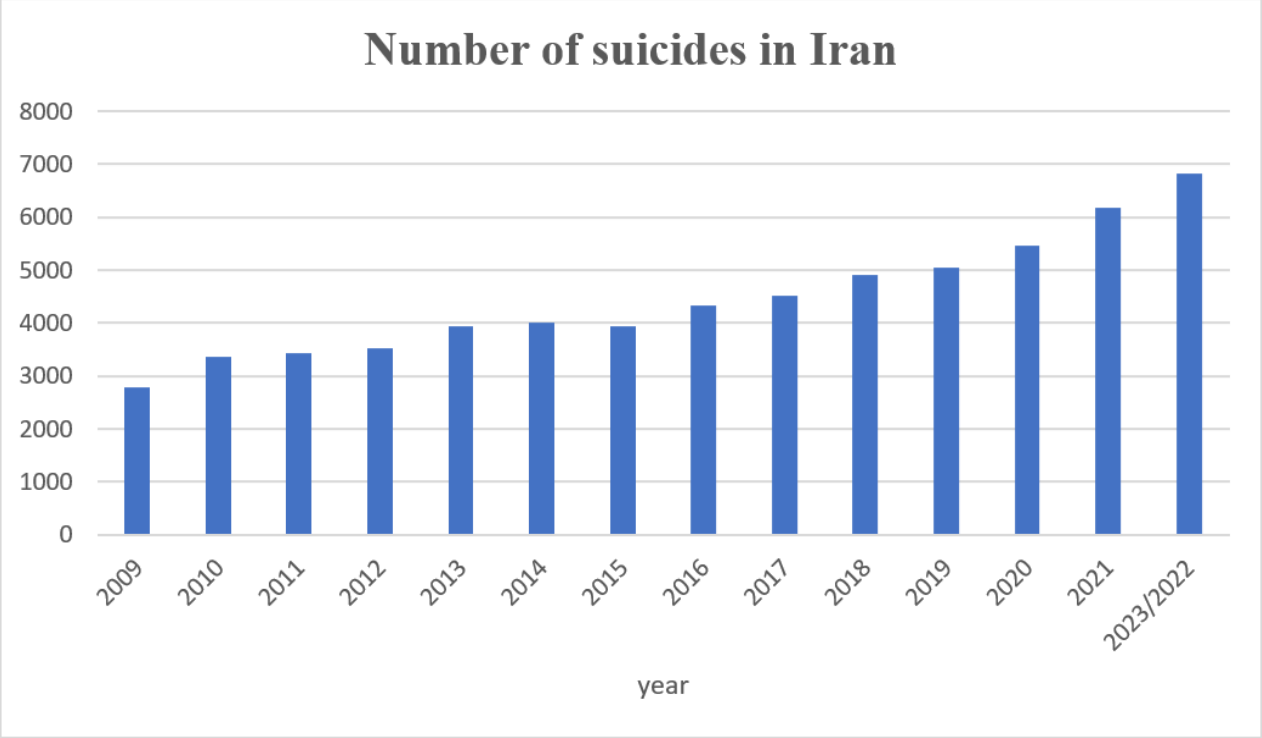


Fig. 1: Number of suicide cases in Iran from 2009 -2023

There was no statistically significant difference in suicide rates across different months of the year (P>0.05) (Fig. 2). Hanging was the most commonly used method of suicide, with 31,662 cases (50.88%) reported, while electrocution was the least used method, with only 178 cases (0.28%) (Table 1).

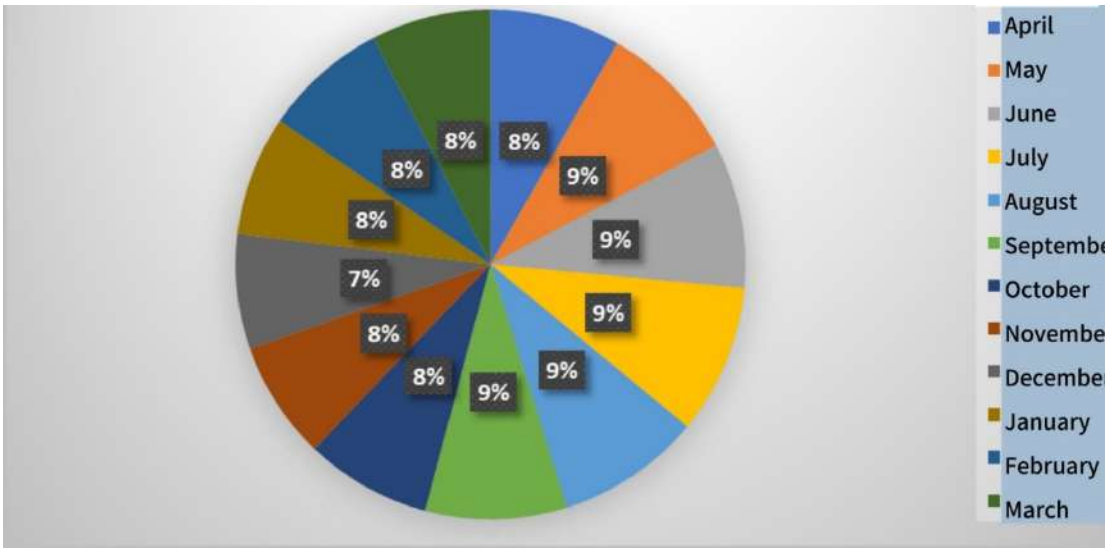


Fig. 2: Percentage of suicide cases estimated for the years 2009-2023 in different months of the year in Iran

Table 1: Number (percentage) of suicides by various methods during the years 2009-2023.

Year/How to commit suicide	Electric shock	Drowning	Hit by a hard object	Fall	Cold weapon	Firearm	Selfish	Poisoning	Hanging	Other cases
2009	-	15(0.5)	3(0.1)	70(2.5)	-	206(7.4)	508(18.3)	491(17.7)	1423(51.2)	62(2.2)
2010	-	18(0.5)	2(0.1)	80(2.4)	-	212(6.3)	478(14.3)	684(20.4)	1806(53.8)	74(2.2)
2011	-	22(0.6)	4(0.1)	75(2.2)	-	207(6.1)	381(11.1)	835(24.4)	1832(53.6)	65(1.9)
2012	13(0.4)	15(0.4)	-	78(2.2)	49(1.4)	236(6.7)	380(10.8)	943(26.8)	1755(49.9)	45(1.3)
2013	4(0.1)	20(0.5)	6(0.2)	114(2.9)	48(1.2)	283(7.2)	365(9.3)	1079(27.4)	1970(49.9)	55(1.4)
2014	3(0.1)	20(0.5)	4(0.1)	123(3.1)	68(1.7)	269(6.7)	373(9.3)	1062(26.5)	2027(50.5)	63(1.6)
2015	5(0.1)	23(0.6)	7(0.2)	126(3.2)	40(1.0)	287(7.3)	287(7.3)	979(24.8)	2117(53.6)	75(1.9)
2016	7(0.2)	18(0.4)	4(0.1)	182(4.2)	65(1.5)	284(6.6)	285(6.6)	1122(26.0)	2250(52.1)	103(2.4)
2017	4(0.1)	26(0.6)	8(0.2)	239(5.3)	72(1.6)	290(6.4)	319(7.1)	1183(26.2)	2295(50.9)	73(1.6)
2018	9(0.1)	20(0.4)	14(0.3)	259(5.3)	52(1.1)	275(5.6)	255(5.2)	1352(27.5)	2559(52.0)	129(2.6)
2019	3(0.1)	25(0.5)	13(0.3)	264(5.2)	52(1.0)	283(5.6)	299(5.9)	1377(27.3)	2583(51.3)	140(2.8)
2020	3(0.1)	41(0.8)	7(0.1)	251(4.6)	55(1.0)	281(5.1)	323(5.9)	1404(25.7)	3048(55.8)	46(0.8)
2021	3(0.08)	37(0.6)	4(0.1)	352(5.7)	68(1.1)	389(6.3)	312(5.1)	1746(28.3)	3203(51.9)	59(1.0)
2022/2023	124(1.8)	50(0.7)	211(3.1)	748(11.0)	55(0.8)	386(5.7)	411(6.0)	1915(28.0)	2794(40.9)	137(2.0)

To create a map of the incidence of fatal suicide in Iran, the total number of suicide cases for each district over the 14-year study period was summed, and the combined incidence rate for each district per 100,000 population was estimated. The incidence of suicide in this study was classified into five categories based on the Jenks natural breaks method, and a map illustrating the incidence of fatal suicide during the study years was drawn.

The total number of suicide cases, after mapping the incidence of fatal suicide, indicated that five districts—Eshtehard (Alborz Province), Firoozeh (Razavi Khorasan Province), Varzeqan (East Azerbaijan Province), Sahneh (Kermanshah Province), and Famenin (Hamadan Province)—exhibited the highest incidence of suicide. In contrast, 17 districts, including Jowin (Razavi Khorasan), Talesh (Gilan Province), Qaemshahr (Mazandaran Province), Mashhad (Razavi Khorasan Province), Boyerahmad (Kohgiluyeh and Boyer-Ahmad Province), Urmia (West Azerbaijan), Semnan (Semnan Province), Qom (Qom Province), Bandar Abbas (Hormozgan Province), Sirjan (Kerman Province), Qainat (South Khorasan Province), Savojbolagh (Alborz Province), Birjand (South Khorasan Province), Khaf (Razavi Khorasan), Sirik (Hormozgan Province), Nahbandan (South Khorasan Province), and Qasr-e Qand (Sistan and Baluchestan Province)—recorded the lowest incidence of suicide. The map depicting the estimated total incidence of fatal suicide per 100,000 population in Iran during the study years is shown in Fig. 3.

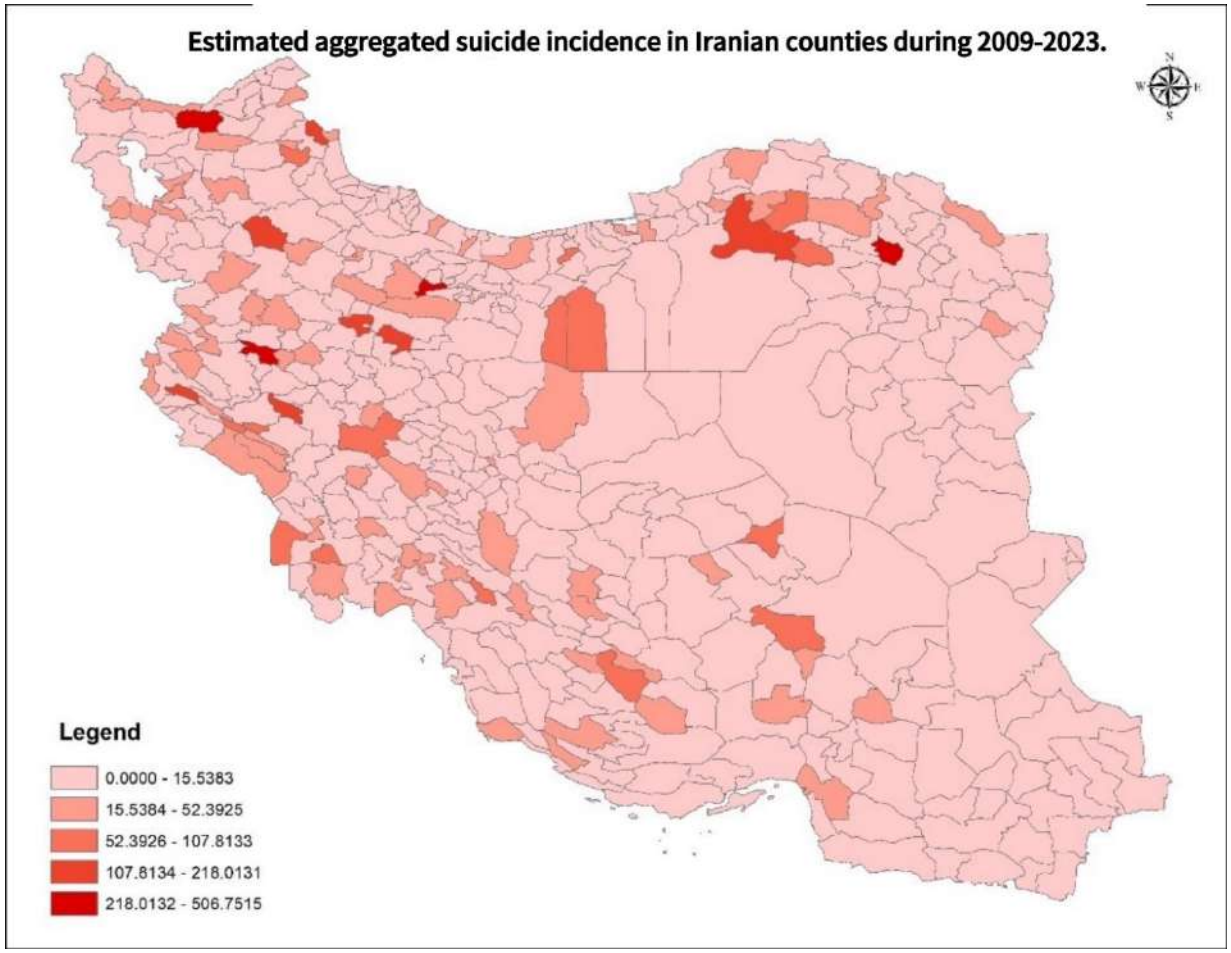
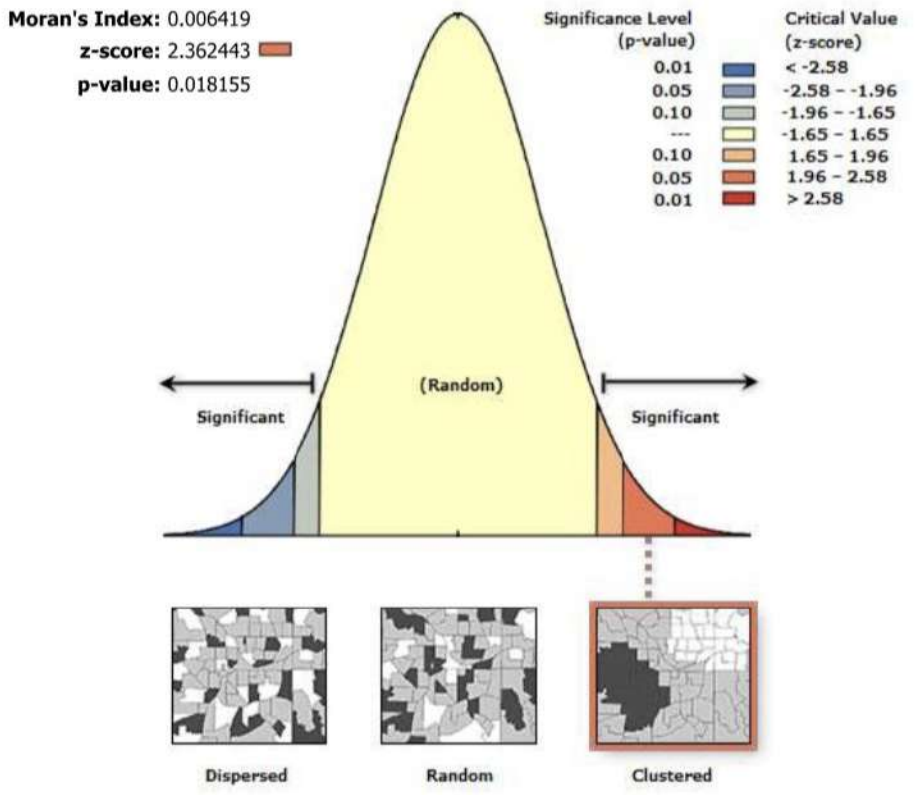


Fig. 3: Mapping of the incidence of fatal suicide in the districts of Iran during the years 2009-2023.

To identify high-risk and low-risk clusters of suicide incidence in the districts of Iran, it is first necessary to assess the spatial autocorrelation of the suicide rates, and then to determine the low-risk and high-risk clusters. The Global Moran's I index was used to evaluate the level of spatial autocorrelation.

The results of the Global Moran's I analysis are presented in Fig. 4. The value of this index was 0.006419, and the *P*-value was 0.018, indicating a significant spatial clustering at a 95% confidence level for the suicide rates in the districts of Iran.



Global Moran's I Summary

Moran's Index:	0.006419
Expected Index:	-0.002132
Variance:	0.000013
z-score:	2.362443
p-value:	0.018155

Fig. 4: The amount of spatial aspect of suicidal incidence

To further investigate the spatial autocorrelation of the data and whether low values tend to cluster together more than high values, we used the General Getis-Ord test (GOGG). The results from the estimation of the General Getis-Ord index for the incidence of suicide were found to be 0.002294, indicating a greater tendency for high suicide incidence values to cluster, with a significant level of autocorrelation for high incidence rates (Z=2.111042) (P=0.034769).

Local Moran's I analysis was used to identify high-risk and low-risk areas. According to the results of the Local Moran's index (Fig. 5), the districts of Khangavar, Tafresh, Zarandieh, Bouin Zahra, Avaj, and Davarzan were identified as High-High clusters, indicating a clustering of high values and the formation of high-risk clusters in these areas. In other words, the incidence of the disease in these clusters was higher than the national average, and the incidence was also high in the neighboring districts. On the other hand, the districts of Bushehr, Dashtestan, Jarqariyeh, Kashan, Meybod, Khusf, Birjand, Qaenat, Sarayan, Ferdows, Bashruyeh, Gonabad, Darmian, Zirakuh, Khalilabad, Mohalat, Fariman, Qasr-e Qand, Dashtyari, Chabahar, Zarabad, Konarak, Rask, Sarbaz, Mehrestan, Sib and Suran, Saravan, Khash, Iranshahr, Bampoor, Nikshahr, Lachar, Fonuj, and Delgan were identified as Low-Low clusters, indicating a clustering of low values and the formation of low-risk clusters in these areas. In other words, the incidence of the disease in these clusters was below the national average, and the incidence in the surrounding districts was also low. The districts of Minab, Bakharz, Kalat, and Savadkuh North were identified as High-Low outliers, indicating that these districts have high rates of suicide surrounded by districts with low suicide rates. Finally, the districts of Kuhdasht, Kermanshah, Harsin, Sanqur, Saveh, Jafarabad, Dargazin, Razan, Nazarabad, Malard, Shashtamd, Nishapur, Khoshab, and Joayin were identified as Low-High outliers, indicating that these districts have low rates of suicide but are surrounded by districts with high suicide rates.

The results of the hot spot analysis are shown in Fig. 6.

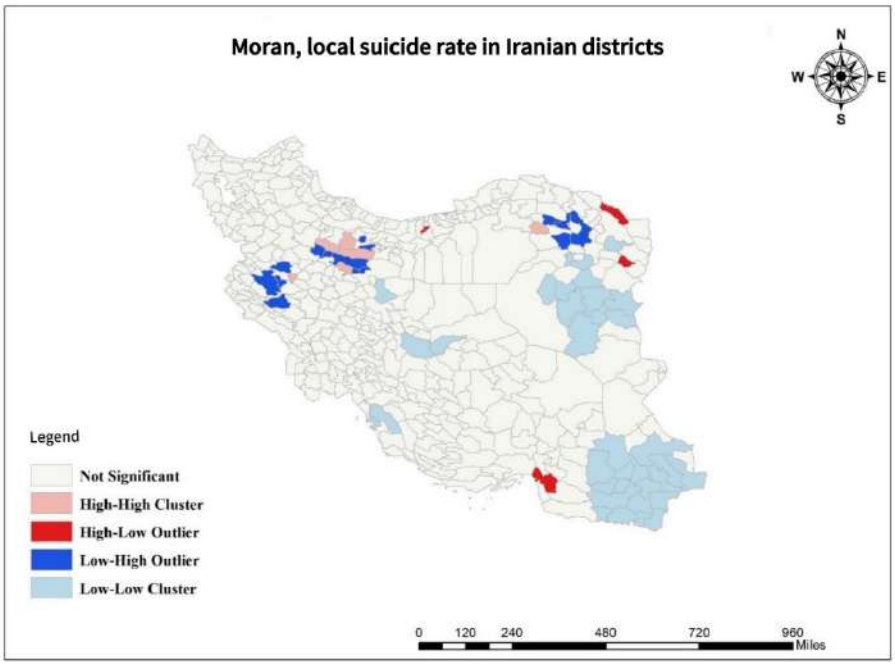


Fig. 5: High-risk and low-risk districts in terms of suicide incidence in Iran during the years 2009-2023

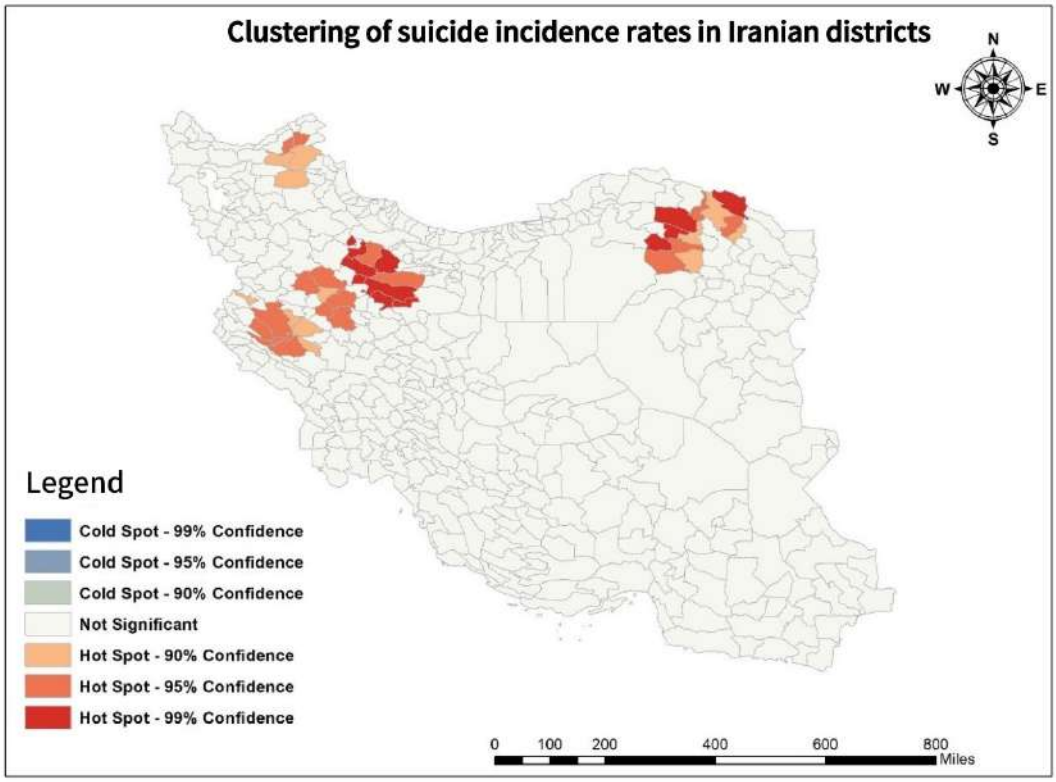


Fig. 6: High-risk suicide points during the years 2009-2023 with different confidence percentages

This analysis identified high-risk clusters (Hot spots) in the districts of Tafresh, Saveh, Jafarabad, Dargazin, Avaj, Bouin Zahra, Davarzan, Jovin, Esfarayen, and Dargaz with a confidence level of 99%. The districts of Kuhdasht, Sirvan, Chardavol, Islamabad-e Gharb, Kermanshah, Malayer, Toyserkan, Qorveh, Kabudarahang, Hamadan, Angout, Hoorand, Sabzevar, Chenaran, and Farooj were identified with a confidence level of 95%. Additionally, the districts of Chagni, Delfan, Harsin, Javankrud, Bahar, Sarab, Meshginshahr, Ahar, Shashtamd, Khoshab, Quchan, and Golbahar were identified with a confidence level of 90%. In this study, no low-risk clusters (cold spots) for suicide occurrences were found, and the remaining locations were not significant according to this analysis. This study was primarily exploratory and descriptive in nature. While no inferential statistical modeling was performed to identify determinants, the spatial findings can guide future hypothesis-driven analyses.

Discussion

While previous studies examined fatal suicide in Iran (27–29), this is the first to use spatiotemporal analysis at the district level over a 14-year period (2009–2023).

The average age of suicide deaths was 33.98 years, aligning with national data (30-33), indicating a greater impact on young and middle-aged adults in their productive years.

This study found higher fatal suicide rates among men, consistent with prior studies (31-35). Cultural norms, job stress, and substance abuse may contribute to this gender disparity.

Hanging was the most common suicide method, aligning with prior Iranian studies (29, 36-43). Its lethality and accessibility may explain its prevalence. Unlike fatal cases, suicide attempts often involve less lethal methods like poisoning (10), possibly reflecting different intentions.

Spatial analysis revealed that high-risk suicide clusters are concentrated in western provinces such as Kermanshah, Hamadan, and Gilan, consistent with prior studies (14,32). These areas may be affected by a convergence of risk factors, including economic deprivation, chronic unemployment, reduced access to mental health services, and in some areas, lingering trauma from past conflicts such as the Iran-Iraq war. Conversely, districts in Sistan and Baluchestan were identified as low-risk or low-low clusters. However, these findings should be interpreted cautiously. This province suffers from systemic underdevelopment and may lack effective surveillance systems. Moreover, cultural taboos, religious stigma, and fear of legal consequences may lead families and institutions to conceal suicide cases. Underreporting is therefore a plausible explanation should be critically examined in future studies.

The overall increasing trend in suicide over the study period is deeply concerning. This rise may be driven by a combination of economic crises, growing income inequality, inflation, high unemployment rates, political instability, sanctions, and rising living costs, all of which contribute to psychological distress and hopelessness. Additionally, urbanization and the weakening of traditional family support systems have intensified feelings of social isolation, particularly among youth. Changes in self-perception and self-esteem may also play a role, as individuals increasingly face internalized failure and lack of personal value under intense societal pressure (44,45).

Social and cultural factors also play a significant role. In some regions, patriarchal values, honor-based norms, and gender discrimination place disproportionate pressure on women and girls, sometimes resulting in fatal outcomes such as self-immolation. The pressure to conform to rigid societal roles—such as succeeding academically, marrying early, or fulfilling family expectations—can become overwhelming, especially when coupled with poor access to mental health support (46-49).

Identifying high-risk clusters highlights the urgent need for targeted public health actions. Key strategies include expanding community mental health services, enhancing suicide surveillance, integrating prevention into educational and workplace settings, training health workers, reducing stigma through public campaigns, and offering socio-economic support like employment and housing aid.

Taken together, the spatial and temporal disparities in suicide incidence revealed in this study point to the urgent need for region-specific, culturally appropriate, and evidence-informed prevention strategies. Addressing the suicide burden in Iran requires not only strengthening mental health infrastructure but also implementing broader socio-economic reforms that target the root causes of despair, particularly in high-risk districts.

Key study limitations include possible underreporting, lack of a national system for identifying at-risk individuals, and limited mental health access in underserved areas. Future prevention should integrate education, mental health, social services, and economic support tailored to regional needs.

Conclusion

The rising suicide trend highlights a major public health concern requiring coordinated, multisectoral action. Effective prevention needs collaboration among the health ministry, education, welfare systems, mental health services, and local authorities.

This study highlights spatial disparities in suicide, with provinces like Kermanshah and Hamadan requiring urgent, targeted interventions. Suggested strategies include expanding community mental health services, boosting socioeconomic support, and launching localized awareness efforts.

Districts like those in Sistan and Baluchestan showed low suicide rates, which may reflect underreporting linked to stigma or weak surveillance, highlighting the need for better data systems and transparency in health reporting.

Some areas lacked significant clustering but may still be important for public health. Continuous surveillance and local assessments are essential.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interests.

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