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Spatial and temporal patterns of self-harm indicators and their association with the socio-demographic index (SDI) in Iran: analysis of incidence, death, DALY, YLDs, and YLLs from 1990 to 2021 – results from the global burden of disease study 2021

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Abstract

Background Understanding the incidence, mortality, disability-adjusted life years (DALYs), years lived with disability (YLDs), and years of life lost (YLLs) due to self-harm and analyzing their trends over time is the first step towards designing an effective suicide prevention strategy. This study aims to investigate the trend of self-harm indicators at the national level and in the provinces of Iran, by gender and age groups.

Methods In this ecological study, the trend of self-harm indicators in Iran was examined during the period 1990 to 2021. Data were extracted from the Global Burden of Disease (GBD) database and their secondary analysis was performed with Joinpoint regression using Joinpoint 5.2 software. The spatial pattern of the indices was examined using Hot spot Analysis. The Pearson correlation coefficient was used to evaluate the correlation of indicators with the Socio-demographic index (SDI) in 1990, 2000, 2010, and 2021.

Results According to estimates, the incidence, death, DALY, YLDs, and YLLs due to self-harm in Iran decreased over 32 years. On average, the annual incidence rate decreased by 0.72% (AAPC = -0.72), death by 1.39% (AAPC = -1.39), DALY by 1.44% (AAPC = -1.44), YLDs by 2.07% (AAPC = -2.07), and YLLs by 1.41% (AAPC = -1.41). The incidence trend was upward in men (AAPC = 0.25) while it was downward in women (AAPC = -1.38). A downward trend was observed in all age groups, with the greatest decrease observed in the 10–19 age group. In most provinces, the indicators decreased. The largest decrease in incidence and YLDs was observed in Kurdistan Province (AAPC = -1.42 and AAPC = -2.94, respectively) and in the three indicators of death, DALY and YLLs in Chaharmahal and Bakhtiari Province (AAPC = -2.32, AAPC = -2.52 and AAPC = -2.49, respectively). Only in Sistan and Baluchestan Province, the death rate (AAPC = 0.09), DALY (AAPC = 0.18) and YLLs (AAPC = 0.22) increased. In addition, there was a significant relationship between subnational SDIs and YLDs (r = -0.401, *P* = 0.025) in 2021. Between 1990 and 2021, Kermanshah and Ilam consistently appeared as hot spots for all self-harm indicators. Khuzestan

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also exhibited significantly elevated values, except for YLD and YLL. Conversely, Qom, South Khorasan, and Semnan were identified as persistent cold spots for mortality, DALYs, and YLL.

Conclusion The increasing trend of some indicators in men and some regions such as Sistan and Baluchestan province requires special attention and implementation of targeted intervention programs.

Keywords Self-harm, Suicide, Spatial and temporal patterns, Socio-demographic index, Iran, Burden of disease

Background

Suicide is the act of intentionally causing one's own death and attempted suicide is surviving the act [1, 2]. Self-harm is also defined as harming or injuring oneself to reduce intense distress and anxiety, usually without the intention to kill [3, 4]. In 2021, suicide was the third leading cause of death among young people, and in 2024 it was projected that more than 720,000 people died by suicide annually [5]. According to the World Health Organization (WHO), one person in the world dies by suicide every 40 s [3]. Suicidal thoughts, attempts, and self-harm are also important concerns [6]. Because these behaviors can be strong predictors of suicide deaths [7].

DALYs are disability-adjusted life years, YLLs are years of life lost, and YLDs are years of life with disabilities [8]. These indicators allow us to examine the consequences of self-harm, including disability and premature death [8]. These indicators can be influenced by factors such as age, gender, geographical region, physical activity, and mental health care in the community [9]. In recent years, various studies have shown that suicide rates can be affected by economic and social inequalities that reflect regional differences in human development [10, 11]. One of the most important indicators for assessing these inequalities is the Socio-Demographic Index (SDI). The SDI is a composite index that shows the level of social and economic development that is strongly correlated with health outcomes [12]. This index ranges from 0 to 1 and is a composite of the total fertility rate index under 25 years of age, the average education for ages 15 and older, and the distributed lag per capita [13].

According to the latest population census conducted in Iran in 2016, the population of Iran was 79,926,270, but according to data from the WHO, the country's population of Iran in 2023 has been reported to be 90,608,707 [14, 15]. Depending on the population, period and the main outcome, published studies on the burden of suicide in Iran have reported different rates across Iranian provinces. For example, according to the results of a 2014 study, suicide rates vary widely across Iranian provinces [16]. A review study found that suicide rates across Iranian provinces ranged from 0.4 to 27.2 per 100,000 [17]. A meta-analysis in 2023 has found that; the suicide rate in Iran was 8.14 per 100,000 and the prevalence of attempted suicide was 131 per 100,000 people [18].

Studies during the years 2001–2014 showed that the rate of suicide is higher in western provinces than in other provinces [17, 19]. Based on the examination of bodies referred to forensic medicine for suspected suicide in all provinces of Iran, Ilam, Hamadan, Lorestan, and Kermanshah provinces had the highest rate [20]. The highest rate of suicide among men was found in Ilam province and the highest rate of suicide among women was found in Khorasan Razavi province [16]. In general, in previous studies, DALYs, YLLs, and YLDs have not been given as much attention as incidence and mortality rates, and fewer studies have been conducted in this field. Among these studies; a study investigating the rate of YLL in Ilam province was found to be 522 per 100.000, which was highest in men and adolescents [21].

Categorizing provinces based on the socio-economic indicators can provide a clear picture of geographical and social differences in suicide patterns. This approach helps to identify areas with a high suicide burden and can guide the designing of effective health policies and social interventions to reduce suicide deaths and to promote mental health in the community. Given the differences in multiple studies across Iranian provinces, the Global Burden of Disease (GBD) dataset was considered for this study as one of the most comprehensive and reliable sources on the burden of disease and as one of the advanced statistical approaches for a detailed and systematic examination of the aforementioned indicators in men and women. Therefore, this study aims to examine the trend of self-harm indicators at the national level and in the provinces of Iran, by gender, age groups and also to examine the correlation of these indicators with the SDI in 1990, 2000, 2010, and 2021.

Methods

Data source

In this ecological study, data on incidence, mortality, disability-adjusted life years (DALYs), years lived with disability (YLDs), and years of life lost (YLLs) due to self-harm, as well as data on the SDI, were obtained from the GBD Study 2021 database, developed by the Institute for Health Metrics and Evaluation (IHME) [22, 23].

As mentioned before the SDI is a composite indicator of socio-demographic development constructed by the GBD research team. It is calculated as the geometric

mean of three rescaled components: total fertility rate under age 25, mean educational attainment in individuals aged 15 years and older, and lag-distributed income per capita. The index ranges from 0 (lowest development) to 1 (highest development) [13, 23].

All incidence, mortality, DALY, YLD, and YLL indicators used in this study were obtained as age-standardized estimates based on the GBD world standard population, allowing for valid comparisons across time and regions. A detailed description of the calculation methods for these indicators, as well as the methods for age standardization, SDI construction, can be found in the GBD 2021 methodological framework [23–25].

The extracted data were structured and prepared for analysis by sex and across three age groups (10–19, 20–54, and ≥55 years) at both the national and provincial levels in Iran for the period 1990–2021.

Statistical analysis

Joinpoint regression was used to analyze time trends and identify changes in incidence, mortality, DALYs, YLDs, and YLLs due to self-harm in Iran from 1990 to 2021. This method uses iterative algorithms to identify points of change in the trend. To describe the identified trends, the average annual percentage change (AAPC) was calculated as the geometric weighted mean of different APCs with weights equal to the length of each segment in a given time interval, as $APC_i = [(exp(\beta_i) - 1)] \times 100$, where β_i represents the slope of the trend segment. This value indicates the annual increase or decrease, with negative values indicating a decreasing trend and positive values indicating an increasing trend [26, 27]. Trend analysis was performed with Joinpoint Software (version 5.2.0.0). The maximum number of change points was six and the significance level of the tests was set at 0.05. Given the absence of sudden increases or declines over short periods and the relatively stable trends in the data, a model with constant variance was used. Additionally, to account for potential autocorrelation among observations, First-order autocorrelation was applied estimated from the data to ensure more reliable statistical inferences.

To evaluate the use of SDI as a standard for comparing the burden of self-harm and suicide in Iran, the correlation between SDI and incidence, death, DALY, YLDs, and YLLs in 31 provinces for the years 1990, 2000, 2010, and 2021 was examined using Pearson's correlation coefficient at a significance level of 0.05. Finally, Hot spot Analysis was employed to examine the spatial patterns of incidence, mortality, DALY, YLDs, and YLLs related to self-harm over time. Hot spot Analysis is a spatial statistical method used to identify clustered patterns in geospatial data. In this analysis, the Getis-Ord Gi* statistic was applied to determine whether a region exhibited statistically significant high-density clusters (hot spots) or low-density clusters (cold spots) compared to neighboring areas. High and significant Z-scores indicate the presence of hot spots, while low and significant Z-scores denote cold spots. Values close to zero suggest a random spatial distribution of the data [28]. All analyses were performed using R statistical software (version 4.4.2).

Results

The results show that the incidence, mortality, DALYs, YLDs, and YLLs due to self-harm in Iran have decreased during the 32-year study period (1990–2021). The incidence rate has decreased from 57.34 per 100,000 in 1990 to 46.01 in 2021, which represents a 19.8% decrease, and the death rate has decreased by 34.2% from 6.26 to 4.12. Examining the incidence and mortality rates by gender at the beginning and end of the period shows that the incidence rate in men increased by 8% (from 39.72 to 42.90), while in women it decreased by 34.6% (from 75.31 to 49.28). The death rate in men decreased by 18.6% (from 7.42 to 6.04) and in women by 57.6% (from 5.04 to 2.14).

The DALY rate has decreased from 350.18 per 100,000 in 1990 to 226.63 in 2021, a decrease of 35.3%, the YLDs rate has decreased from 13.34 to 6.99, a decrease of 47.6%, and the YLLs rate has decreased from 336.85 to 219.64, a decrease of 34.8%. Examining the DALY, YLDs, and YLLs by gender at the beginning and end of the period shows that the DALY rate in men has decreased by 17.6% (from 394.97 to 325.29), and in women by 58.9% (from 303.11 to 124.44). The YLDs rate in men has decreased by 25.7% (from 9.05 to 6.73) and in women by 59.2% (from 17.82 to 7.27). YLLs decreased by 17.5% in men (from 385.93 to 318.57) and by 58.9% in women (from 285.29 to 117.17). These changes are clearly shown in Fig. 1. All percentage changes were calculated using the formula: $(FinalValue - InitialValue)/InitialValue \times 100$. Furthermore, the number of cases for incidence, death, DALYs, YLDs, and YLLs in 1990 and 2021 are provided in Supplementary Table S1.

Fitting the data on incidence, death, DALY, YLDs, and YLLs due to self-harm in Iran during the period 1990–2021 using Joinpoint regression showed that, on mean, the incidence, death, DALY, YLDs, and YLLs due to self-harm decreased by 0.72, 1.39, 1.44, 2.07, and 1.41% annually, respectively. In addition, trend analysis by gender showed that; the incidence rate increased in men (AAPC = 0.25) while it decreased in women (AAPC = −1.38). The mortality rate decreased by 0.68% annually for men and 2.70% for women. The DALY rate decreased by 0.64% annually for men and 2.84% for women. YLDs decreased by a mean of 0.95% per year for men and 2.88% per year

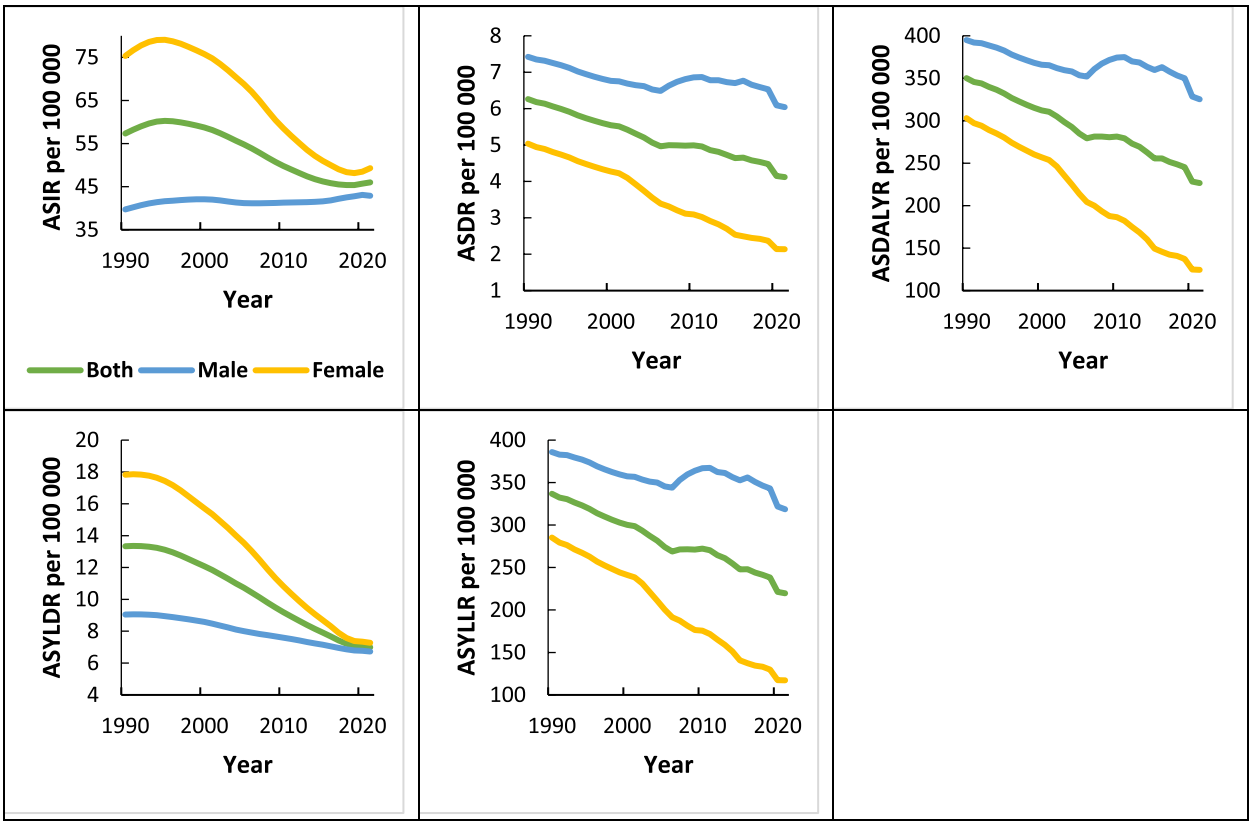

Fig. 1 The trend of self-harm age-standardized incidence, death, DALYs, YLDs and YLLs in Iran by sex, 1990–2021

for women. YLLs decreased by a mean of 0.63% per year for men and 2.87% per year for women (Table 1).

Analysis of trends in incidence, mortality, DALYs, YLDs, and YLLs due to self-harm by age group showed a decrease in all age groups during the study period (Table 2). The largest annual decrease in all indicators was recorded in the 10–19 year age group.

Analysis of the trend in incidence and mortality rates due to self-harm in the province of Iran showed that incidence and mortality rates decreased in most provinces during the study period (1990–2021) (Table 3). The largest decreases in incidence and mortality rates were in Kurdistan (AAPC = −1.42) and Chaharmahal and Bakhtiari (AAPC = −2.32) provinces, respectively. In Qazvin province, the incidence rate was almost constant over 32 years (decreasing between 1990 and 2014 and increasing from 2014 to 2021). Sistan and

Table 1 Joinpoint trend analysis of self-harm age-standardized incidence, death, DALYs, YLDs and YLLs in Iran by sex, 1990–2021

Measure	Both sexes			Male			Female		
	1990	2021	AAPC (95% CI)	1990	2021	AAPC (95% CI)	1990	2021	AAPC (95% CI)
Incidence	57.34	46.01	−0.72* (−0.74, −0.7)	39.72	42.90	0.25* (0.24, 0.26)	75.31	49.28	−1.38* (−1.4, −1.35)
Death	6.26	4.12	−1.39* (−1.46, −1.33)	7.42	7.42	−0.68* (−0.74, −0.64)	5.04	5.04	−2.70* (−2.77, −2.62)
DALYs	350.18	226.63	−1.44* (−1.5, −1.39)	394.97	325.29	−0.64* (−0.7, −0.6)	303.11	124.44	−2.84* (−2.92, −2.76)
YLDs	13.34	6.99	−2.07* (−2.09, −2.05)	9.05	6.73	−0.95* (−0.96, −0.95)	17.82	7.27	−2.88* (−2.91, −2.85)
YLLs	336.85	219.64	−1.41* (−1.48, −1.36)	385.93	318.57	−0.63* (−0.69, −0.59)	285.29	117.17	−2.87* (−2.97, −2.8)

DALYs Disability-Adjusted Life Years, *YLDs*: Years Lived with Disability, *YLLs*: Years of Life Lost

AAPC Average Annual Percent Change, *CI* Confidence Interval

* Significantly different from 0 at alpha = 0.05 ($p < 0.05$). There are 1 + (number of trend) joinpoints for each mode

Table 2 Joinpoint trend analysis of self-harm incidence, death, DALYs, YLDs and YLLs in Iran by age groups, 1990–2021

Measure	10–19 Year			20–54 Year			≥ 55 Year		
	1990	2021	AAPC (95% CI)	1990	2021	AAPC (95% CI)	1990	2021	AAPC (95% CI)
Incidence	80.53	54.26	−1.20* (−1.26, −1.14)	96.95	68.05	−1.16* (−1.19, −1.13)	20.83	19.88	−0.23* (−0.34, −0.17)
Death	6.28	3.20	−2.12* (−2.17, −2.07)	9.26	6.02	−1.46* (−1.55, −1.38)	6.18	3.98	−1.44* (−1.51, −1.38)
DALYs	464.90	235.58	−2.14* (−2.19, −2.09)	561.76	343.76	−1.65* (−1.73, −1.57)	188.23	110.87	−1.71* (−1.77, −1.66)
YLDs	3.03	1.39	−2.43* (−2.48, −2.38)	18.90	10.19	−1.97* (−1.99, −1.96)	21.77	13.22	−1.61* (−1.64, −1.59)
YLLs	461.87	234.19	−2.14* (−2.19, −2.09)	542.86	333.57	−1.63* (−1.72, −1.55)	166.46	97.65	−1.73* (−1.8, −1.67)

DALYs Disability-Adjusted Life Years, *YLDs* Years Lived with Disability, *YLLs* Years of Life Lost

AAPC Average Annual Percent Change, *CI* Confidence Interval

* Significantly different from 0 at alpha = 0.05 ($p < 0.05$). There are 1 + (number of trend) joinpoints for each mode

Table 3 Joinpoint trend analysis of self-harm age-standardized incidence and death in Iran by provinces, 1990–2021

Provinces	Incidence			Death		
	1990	2021	AAPC (95% CI)	1990	2021	AAPC (95% CI)
Alborz	58.75	54.12	−0.22* (−0.26, −0.18)	9.26	6.64	−1.08* (−1.15, −1.02)
Ardebil	66.26	48.96	−0.97* (−0.99, −0.96)	7.30	5.52	−0.91* (−1, −0.83)
Bushehr	62.26	45.30	−1.03* (−1.05, −1)	6.15	3.29	−2.03* (−2.11, −1.96)
Chaharmahal and Bakhtiari	71.82	48.59	−1.26* (−1.28, −1.24)	7.28	3.49	−2.32* (−2.42, −2.24)
East Azarbayejan	55.48	47.45	−0.49* (−0.52, −0.47)	7.38	4.89	−1.34* (−1.41, −1.28)
Fars	69.82	52.91	−0.87* (−0.92, −0.83)	7.21	5.62	−0.84* (−0.9, −0.79)
Gilan	55.97	47.72	−0.52* (−0.54, −0.5)	6.71	4.56	−1.24* (−1.33, −1.17)
Golestan	75.49	51.35	−1.21* (−1.26, −1.16)	8.59	5.67	−1.37* (−1.46, −1.3)
Hamadan	66.09	55.26	−0.50* (−0.56, −0.42)	9.97	7.56	−0.95* (−1.05, −0.86)
Hormozgan	52.50	42.75	−0.68* (−0.72, −0.66)	6.47	4.65	−1.11* (−1.24, −0.96)
Ilam	94.06	67.71	−1.03* (−1.14, −0.87)	16.24	10.68	−1.47* (−1.61, −1.3)
Isfahan	43.51	41.00	−0.23* (−0.31, −0.19)	3.12	2.57	−0.64* (−0.71, −0.59)
Kerman	52.94	44.85	−0.55* (−0.57, −0.53)	6.75	4.20	−1.60* (−1.67, −1.54)
Kermanshah	98.99	62.73	−1.40* (−1.5, −1.27)	14.09	8.64	−1.62* (−1.71, −1.55)
Khorasan-e-Razavi	54.11	42.95	−0.76* (−0.78, −0.73)	6.40	3.67	−1.78* (−1.83, −1.73)
Khuzestan	61.47	49.07	−0.71* (−0.74, −0.68)	6.14	4.53	−1.00* (−1.05, −0.95)
Kohgiluyeh and Boyer-Ahmad	75.31	60.50	−0.64* (−0.74, −0.5)	9.71	7.41	−0.93* (−0.99, −0.87)
Kurdistan	71.16	45.70	−1.42* (−1.44, −1.4)	7.42	4.09	−1.84* (−1.93, −1.75)
Lorestan	83.76	63.28	−0.84* (−0.94, −0.7)	13.20	7.28	−1.95* (−2.06, −1.84)
Markazi	51.66	39.46	−0.90* (−0.97, −0.85)	5.23	3.14	−1.67* (−1.74, −1.61)
Mazandaran	44.86	43.56	−0.12* (−0.15, −0.1)	3.50	2.86	−0.64* (−0.7, −0.59)
North Khorasan	66.26	48.40	−1.00* (−1.02, −0.97)	6.52	4.28	−1.40* (−1.47, −1.34)
Qazvin	39.42	40.52	0.04 (−0.1, 0.12)	4.06	2.83	−1.19* (−1.28, −1.11)
Qom	38.71	37.23	−0.15* (−0.29, −0.07)	4.27	3.28	−0.91* (−1.01, −0.83)
Semnan	39.16	38.01	−0.15* (−0.27, −0.08)	3.95	2.27	−1.79* (−1.85, −1.74)
Sistan and Baluchestan	36.32	39.48	0.24* (0.15, 0.3)	3.40	3.47	0.09* (0.01, 0.15)
South Khorasan	44.36	42.09	−0.18* (−0.21, −0.16)	3.98	2.88	−1.03* (−1.11, −0.96)
Tehran	48.80	39.32	−0.78* (−0.93, −0.7)	3.11	1.97	−1.47* (−1.54, −1.39)
West Azarbayejan	67.54	54.20	−0.66* (−0.73, −0.59)	9.50	6.06	−1.46* (−1.54, −1.41)
Yazd	45.25	39.36	−0.49* (−0.58, −0.42)	3.63	2.19	−1.70* (−1.79, −1.63)
Zanjan	42.44	37.43	−0.48* (−0.59, −0.42)	4.23	2.46	−1.76* (−1.85, −1.68)

Baluchestan province was the only province where mortality rates increased (AAPC = 0.09).

Analysis of the trend of DALYs, YLDs, and YLLs due to self-harm by province in Iran during the study period (1990–2021) showed that the rates of these indicators have decreased in most provinces (Table 4). The largest decreases in DALYs, YLDs, and YLLs were in Chaharmahal and Bakhtiari (AAPC = −2.52), Kurdistan (AAPC = −2.94), and Chaharmahal and Bakhtiari (AAPC = −2.49) provinces, respectively. Sistan and Baluchestan province was the only province where DALYs (AAPC = 0.18) and YLLs (AAPC = 0.22) increased.

The results of the study show that subnational SDIs for 31 provinces of Iran in 1990, 2000, 2010, and 2021 are statistically correlated only with the rate of YLDs in 1990 and 2021. The correlation coefficient of SDI with the rate of YLDs in 1990 (r = −0.446, P = 0.012) and the correlation coefficient of SDI with the rate of YLDs in 2021 (r = −0.401, P = 0.025) indicate a significant relationship between SDI and YLDs due to self-harm (Table 5).

Figure 2 presents the spatial analysis results of incidence, mortality, DALY, YLD, and YLL due to self-harm across Iranian provinces. This analysis utilized the Getis-Ord Gi* statistic to delineate the spatial distribution of these indicators during the years 1990, 2000, 2010, and 2021.

The Getis-Ord Gi* method employs a color spectrum to visualize areas with high values (hot spots) and low values (cold spots). Hot spots represent provinces with values significantly higher than the overall mean, while

Table 4 Joinpoint trend analysis of self-harm age-standardized DALYs, YLDs and YLLs in Iran by provinces, 1990–2021

Provinces	DALYs			YLDs			YLLs		
	1990	2021	AAPC (95% CI)	1990	2021	AAPC (95% CI)	1990	2021	AAPC (95% CI)
Alborz	493.12	356.58	−1.06* (−1.16, −0.97)	12.55	7.53	−1.58* (−1.62, −1.54)	480.57	349.05	−1.04* (−1.11, −0.97)
Ardebil	408.97	291.96	−1.11* (−1.2, −1.04)	16.36	7.50	−2.49* (−2.5, −2.47)	392.61	284.46	−1.08* (−1.16, −1.02)
Bushehr	341.13	171.32	−2.25* (−2.34, −2.19)	14.44	6.64	−2.49* (−2.51, −2.47)	326.68	164.68	−2.22* (−2.3, −2.15)
Chaharmahal and Bakhtiari	401.81	184.18	−2.52* (−2.59, −2.46)	15.86	6.50	−2.84* (−2.86, −2.82)	385.95	177.68	−2.49* (−2.58, −2.4)
East Azarbayejan	415.46	266.10	−1.45* (−1.51, −1.39)	14.27	7.60	−2.00* (−2.03, −1.98)	401.19	258.50	−1.43* (−1.5, −1.37)
Fars	406.88	319.17	−0.82* (−0.88, −0.77)	15.86	7.99	−2.16* (−2.2, −2.11)	391.02	311.18	−0.77* (−0.83, −0.72)
Gilan	361.58	244.75	−1.26* (−1.39, −1.17)	10.00	6.79	−1.25* (−1.29, −1.22)	351.58	237.96	−1.24* (−1.38, −1.15)
Golestan	489.57	309.10	−1.51* (−1.61, −1.42)	19.13	8.75	−2.47* (−2.51, −2.42)	470.44	300.35	−1.47* (−1.58, −1.38)
Hamadan	555.83	416.68	−0.98* (−1.07, −0.89)	16.56	8.88	−1.95* (−2.02, −1.89)	539.26	407.80	−0.95* (−1.05, −0.86)
Hormozgan	356.45	260.18	−0.98* (−1.11, −0.83)	13.95	7.12	−2.17* (−2.2, −2.15)	342.50	253.06	−0.95* (−1.09, −0.79)
Ilam	880.89	566.95	−1.45* (−1.57, −1.34)	21.61	9.91	−2.36* (−2.5, −2.23)	859.28	557.04	−1.42* (−1.54, −1.31)
Isfahan	178.11	144.55	−0.67* (−0.73, −0.63)	9.53	6.03	−1.47* (−1.53, −1.44)	168.58	138.52	−0.63* (−0.69, −0.58)
Kerman	377.80	233.57	−1.60* (−1.66, −1.55)	13.32	7.44	−1.87* (−1.88, −1.86)	364.48	226.13	−1.59* (−1.65, −1.54)
Kermanshah	785.01	477.91	−1.65* (−1.74, −1.57)	24.38	9.97	−2.76* (−2.87, −2.65)	760.63	467.94	−1.61* (−1.71, −1.54)
Khorasan-e-Razavi	355.79	198.85	−1.86* (−1.93, −1.8)	14.26	7.09	−2.24* (−2.27, −2.22)	341.53	191.76	−1.84* (−1.91, −1.78)
Khuzestan	346.58	253.28	−1.02* (−1.07, −0.96)	14.39	7.76	−1.96* (−1.98, −1.93)	332.19	245.52	−0.98* (−1.03, −0.92)
Kohgiluyeh and Boyer-Ahmad	573.56	434.18	−0.95* (−1.01, −0.88)	17.53	8.73	−2.12* (−2.23, −2)	556.04	425.45	−0.91* (−0.98, −0.84)
Kurdistan	421.82	225.02	−1.99* (−2.1, −1.89)	18.10	7.20	−2.94* (−2.96, −2.92)	403.72	217.82	−1.94* (−2.05, −1.84)
Lorestan	724.79	377.43	−2.13* (−2.23, −2.03)	20.00	8.97	−2.45* (−2.56, −2.35)	704.79	368.45	−2.11* (−2.21, −2.02)
Markazi	294.71	175.10	−1.69* (−1.76, −1.64)	12.60	6.11	−2.34* (−2.41, −2.29)	282.11	168.99	−1.66* (−1.73, −1.61)
Mazandaran	198.17	158.73	−0.70* (−0.77, −0.65)	9.38	6.06	−1.41* (−1.44, −1.38)	188.79	152.67	−0.67* (−0.74, −0.62)
North Khorasan	374.07	238.50	−1.50* (−1.57, −1.44)	18.10	8.28	−2.47* (−2.5, −2.44)	355.96	230.21	−1.45* (−1.53, −1.39)
Qazvin	223.39	149.51	−1.31* (−1.4, −1.23)	9.75	6.18	−1.53* (−1.65, −1.48)	213.64	143.32	−1.30* (−1.39, −1.22)
Qom	231.49	179.69	−0.87* (−0.98, −0.79)	9.50	5.61	−1.69* (−1.83, −1.6)	221.98	174.08	−0.84* (−0.96, −0.75)
Semnan	215.17	121.24	−1.86* (−1.92, −1.8)	9.42	5.75	−1.63* (−1.75, −1.56)	205.75	115.49	−1.87* (−1.93, −1.81)
Sistan and Baluchestan	190.00	198.58	0.18* (0.1, 0.24)	10.14	8.16	−0.73* (−0.82, −0.67)	179.86	190.42	0.22* (0.14, 0.28)
South Khorasan	223.24	158.68	−1.12* (−1.2, −1.05)	11.83	6.88	−1.75* (−1.77, −1.72)	211.40	151.79	−1.08* (−1.16, −1.01)
Tehran	170.45	106.46	−1.57* (−1.66, −1.48)	9.93	5.24	−2.09* (−2.22, −2.01)	160.52	101.22	−1.53* (−1.63, −1.44)
West Azarbayejan	539.35	334.31	−1.55* (−1.62, −1.48)	17.43	8.73	−2.13* (−2.19, −2.06)	521.92	325.58	−1.52* (−1.6, −1.45)
Yazd	200.33	120.79	−1.66* (−1.76, −1.57)	10.62	5.88	−1.93* (−2.01, −1.88)	189.71	114.91	−1.63* (−1.74, −1.55)
Zanjan	233.32	130.58	−1.85* (−1.9, −1.79)	8.70	5.68	−1.43* (−1.52, −1.35)	224.62	124.90	−1.84* (−1.9, −1.78)

Table 5 Correlation between Socio-demographic Index (SDI) and age-standardized incidence, death, DALYs, YLDs and YLLs in Iran across key years 1990, 2000, 2010, and 2021

Year	Incidence	Death	DALYs	YLDs	YLLs
1990	−0.259 (0.159)*	−0.254 (0.168)	−0.275 (0.134)	-.446 **(0.012)**	−0.270 (0.141)
2000	−0.080 (0.667)	−0.076 (0.683)	−0.100 (0.594)	−0.264 (0.151)	−0.095 (0.611)
2010	0.015 (0.937)	0.006 (0.973)	−0.013 (0.945)	−0.206 (0.266)	−0.009 (0.963)
2021	−0.012 (0.950)	−0.089 (0.636)	−0.101 (0.589)	−0.401 (0.025)	−0.097 (0.602)

* Pearson Correlation (*P*-value)

cold spots denote regions with values significantly lower than the mean. Areas lacking statistical significance are displayed in intermediate colors. The results revealed that certain provinces remained consistent as hot spots or cold spots across all years, while others exhibited shifts in their spatial patterns. Kermanshah and Ilam provinces were identified as hot spots, with high Gi* values and statistical significance levels in all indicators, in all years studied. Also, Khuzestan province exhibited a similar pattern, except for YLD and YLL indices. In contrast, Qom, South Khorasan, and Semnan provinces were identified as cold spots for mortality, DALY, and YLL, exhibiting negative Gi* values with statistical significance ($P < 0.05$) throughout all years. For other provinces, Gi* values were not statistically significant ($P > 0.05$), indicating no distinct spatial clustering patterns in these regions (Supplementary Tables S2–S6).

Discussion

National data on self-harm in Iran from 1990 to 2021 reveals a declining trend overall. While women exhibited a sharper reduction in non-fatal self-harm incidents, they continued to report higher incidence rates compared to men, who experienced disproportionately higher mortality rates. Notably, adolescents aged 10–19 emerged as the age group with the most significant increase in cases. Geographically, Kurdistan province demonstrated the most substantial reductions in incidence rates and YLDs, whereas Chaharmahal and Bakhtiari province exhibited the sharpest declines in mortality rates, DALYs, and YLLs. In contrast, Sistan and Baluchestan province demonstrated the most pronounced upward trends in mortality rates, DALYs, and YLLs during the analyzed period. Meanwhile, Kermanshah and Ilam provinces consistently demonstrated the highest rates of self-harm throughout this period.

The present study provides the first comprehensive subnational analysis of self-harm trends in Iran from 1990 to 2021, utilizing GBD 2021 data. The results of the present study indicate a decreasing trend in self-harm indicators over the past few decades in Iran. Some of the important reasons for this decreasing trend in the Iranian population are as follows:

Considering that the Iran-Iraq War ended in 1988 and the study began in 1990, the decreasing trend in these rates can be considered due to the higher suicide rate due to the effects of war and post-traumatic stress disorder in military and civilians in the early years after the war [29, 30].

Despite challenges such as being multi-ethnic, multicultural, and multilingual, Iran has been able to develop a National Suicide Prevention Program (NSPP), which can reduce suicide rates [31].

However, a study evaluating the NSPP stated that this program in Iran faces challenges such as underreporting due to the Islamic nature of the country, a top-down approach to implementation, and lack of early detection [32].

The incidence rate increased by 8% in men but decreased by 34.6% in women. Despite this, the rate remained higher in women than in men by the end of the study period. The mortality rate also decreased by 57.6% in women compared to an 18.6% decrease in men but remained higher in men than in women at the end of the study period. In general, higher suicide attempt rates in women than in men and higher suicide death rates in men than in women have been found in other previous studies [33–35]. Among the reasons for the higher fatal suicide rates in men than in women and the lower incidence of suicide in men could be that suicide in men is due to the use of more lethal methods, as well as social factors and women being more likely to consult about their problems [36, 37]. The slight increase in suicide rates in men could also be due to quarantine and social distancing, and economic problems related to the COVID-19 pandemic; Given that men were more affected as the economic breadwinners of the family [38]. Higher suicide rates during quarantine among men and the 35–49 age group were also found in a study in Hungary [39].

The largest annual decrease in all indicators was observed in the age group 10–19 years. In a review study examining the trend of suicide in countries around the world, it was observed that in some countries, suicide rates among adolescents have increased and in others, this trend has decreased; the decrease in

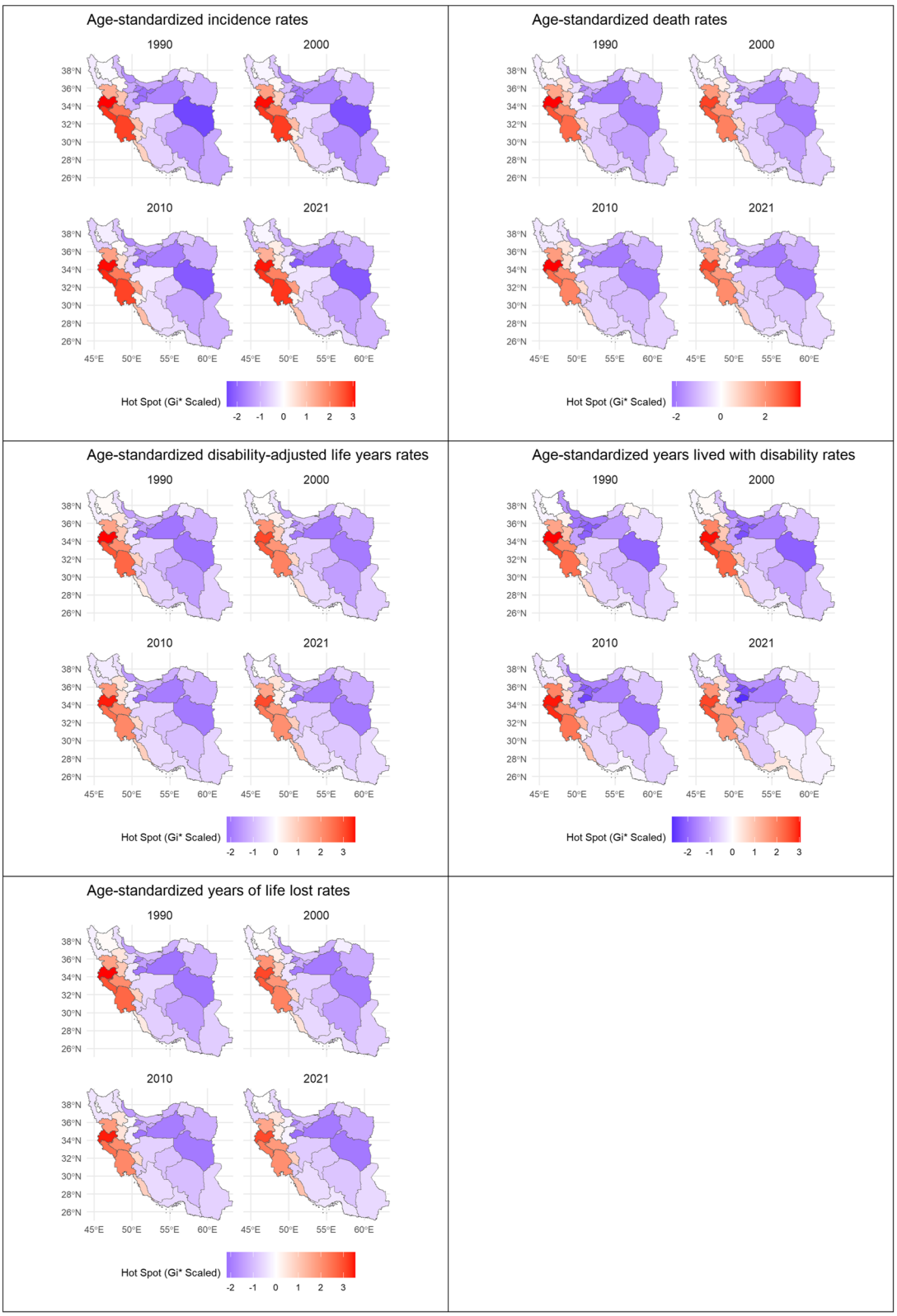

Fig. 2 Hot spot Analysis of age-standardized incidence, death, DALYs, YLDs and YLLs rates of self-harm across provinces in Iran across key years 1990, 2000, 2010, and 2021

this trend could be related to the increase in mental health services and programs [40]. Overall, this result requires further research.

According to the results of this study, most provinces showed a decreasing trend in incidence and mortality. The largest decreases in incidence and mortality were in Kurdistan and Chaharmahal and Bakhtiari provinces, respectively, and the only province where the mortality rate increased was Sistan and Baluchestan. A review study from 2010 to 2021 regarding suicide in Iran found an increasing trend in suicide attempts and a decreasing trend in suicides leading to death [18]. The greater decrease in incidence and mortality rates in Kurdistan and Chaharmahal and Bakhtiari provinces may be due to the higher rates at the beginning of the trend. However, a study in 2002 showed that the highest rate of mental disorders in Iran was in Chaharmahal and Bakhtiari province [41].

The increasing death rate in Sistan and Baluchestan province could be due to the choice of more lethal suicide methods in this province. According to a study conducted in this province, the most common method of suicide is self-burning, and the province is also considered as one of the low- and middle-income provinces, which could be associated with higher suicide rate [42]. The province also has the highest drug consumption in the country [43]. As a result, this province requires more attention in terms of suicide prevention planning.

The highest reductions in DALYs, YLDs, and YLLs were observed in Chaharmahal and Bakhtiari, Kurdistan, and Chaharmahal and Bakhtiari provinces, respectively. The reduction in these rates could be due to a decrease in the incidence of self-harm, which would also reduce these rates. Also, when examining age groups, it could be due to the increasing average age of people who self-harm [44]. The only province where the DALYs and YLLs also increased is Sistan and Baluchestan province. This increase could also be due to the increase in the death rate in this province and the decrease in the average age of people who self-harm [44].

The results of the present ecological study showed that subnational SDIs for 31 Iranian provinces were statistically correlated with YLDs only in 1990 and 2021. Other studies have also shown that reducing indicators related to illness and death can improve Gross Domestic Product (GDP) per capita, which is one of the factors affecting the size of the SDI [45]. A study in China from 1990 to 2015 showed that improving socio-economic factors can have a strong impact on decreasing suicide rates [46]. Therefore, improving economic and social infrastructure may have a significant impact on reducing the burden of self-harm.

According to the findings of this study, the provinces of Ilam and Kermanshah consistently exhibited the highest rates across all self-harm indicators throughout the study period. In contrast, Qom, South Khorasan, and Semnan provinces consistently showed the lowest rates in mortality, DALY, and YLL indicators. In general, based on previous studies, the western provinces of the country, including Ilam and Kermanshah, have the highest incidence of self-harm in Iran, which is similar to the results obtained in other studies [17, 47]. Among the reasons for the higher suicide rates in these provinces is the use of more lethal suicide methods, including self-burning in women and hanging in men [48].

One of the reasons for the lower indicators in Qom province is that this province is more religious than other provinces in Iran [49]. In general, the lower rates of mortality, DALY, and YLL indicators in Qom, South Khorasan, and Semnan provinces may be attributed to factors such as greater accessibility to healthcare services, socioeconomic stability, and healthier lifestyles in these provinces. Further research, such as comparative studies between low and high-burden provinces, could help to pinpoint the exact causes behind these trends and to identify replicable best practices to improve health outcomes in high-burden provines.

The main limitation of this study is its ecological nature and the lack of accurate local information on risk factors of suicide. Moreover, data used from the GBD database may be underreported due to poor recording and/or estimation of self-harm cases. This is particularly significant in areas with poor infrastructure or cultural sensitivity towards suicide. However, given that Iran's official suicide statistics have not been reported to the WHO in recent years, estimated GBD data can be considered as the only reliable source. Despite these limitations, this study is one of the first comprehensive studies using GBD data that provides valuable findings for health policy and suicide prevention activities across provinces of Iran.

Conclusion

The results of this study indicate that the incidence, mortality, DALYs, YLDs, and YLLs due to self-harm in Iran decreased over the 32 years (1990 to 2021). However, the increasing trend of some indicators in men and some regions, such as Sistan and Baluchestan province, requires special attention and implementation of targeted intervention programs. The significant decrease in indicators in the 10–19 age group and provinces such as Kurdistan and Chaharmahal and Bakhtiari could indicates the positive impact of intervention programs in these regions. Given the significant correlation between YLDs and SDI in 2021, it seems that improving economic and social infrastructure may have a significant impact on reducing the burden

of self-harm. Spatial pattern analysis of provinces can also help policymakers to prioritize intervention activities.

Abbreviations

SDI	Socio-Demographic index
DALYs	Disability-adjusted life years
YLDs	Years lived with disability
YLLs	Years of life lost
GBD	Global burden of disease
AAPC	Average annual percent change
GDP	Gross domestic product
NSPP	National Suicide prevention program

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
M.S. contributed to the design of the study, writing, and drafting of the manuscript. M.B.H. contributed to the acquisition, analysis, and interpretation of the data. M.R. proposed the study, supervised the research, and reviewed and revised the manuscript. All authors read and approved the final version of the manuscript.

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Data availability
The Self-harm burden data is freely accessible in the GBD compare website (available at http://ghdx.healthdata.org/gbd-results-tool). Requests for additional information should be addressed to the corresponding author.

Declarations

Ethics approval and consent to participate
The Ethics Committee of Rafsanjan University of Medical Sciences approved the study (IR.RUMS.REC.1402.193). Not applicable.

Consent for publication
Not applicable. This study does not contain any individual person's data in any form.

Competing interests
The authors declare no competing interests.

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