



**PURE, GENDER AND SOCIAL INEQUALITIES IN SUICIDE
MORTALITY IN IRAN, 2006-2010: A TIME TREND
PROVINCE-LEVEL STUDY**

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Abstract

Objectives: Suicide is a major global health problem imposing a considerable burden on population in terms of disability-adjusted life years. There has been an increasing trend in fatal and attempted suicide in Iran over the past few decades. The aim of the current study was to assess pure, gender and social inequalities across Iran's provinces during 2006-2010.

Design: Ecological study.

Setting: The data on distribution of population at the provinces were obtained from the Statistical Centre of Iran. The data on the annual number of death caused by suicide in each province were gathered from the Iranian Forensic Medicine Organization.

Methods: Suicide mortality rate per 100,000 population was calculated. Human Development Index was used as the provinces' social rank. Gini coefficient, rate ratio and Kunst and Mackenbach relative index of inequality (RII_{KM}) were used to assess pure, gender and social inequalities, respectively. Annual percentage change was calculated using Joinpoint regression.

Results: Suicide mortality has slightly increased in Iran during 2006-2010. There was a substantial and constant pure inequality across the country over the study period. Male to female rate ratio was 2.34 (95% CI 1.45-3.79) over the same period. There were social inequalities in suicide mortality in favor of people in better-off provinces. In addition, there was an increasing trend in these social disparities over time, although it was not statistically significant.

Conclusion: We found substantial pure, gender and social disparities in the distribution of suicide mortality across the provinces in Iran. The findings showed that men in the provinces with low socio-economic status are at higher risk of suicide mortality. Further analyses are needed to explain these disparities.

Article Summary

Strength and limitations of this study

- This is the first national study to evaluate regional social inequalities in suicide mortality over five-year period.
- Social inequality in suicide mortality was evaluated using Cuzick's test for trend and two common inequality measures: rate ratio (RR) and Kunst and Mackenbach relative index of inequality (RII_{KM})
- Age and gender differences between the provinces were naïvely adjusted which might have not fully captured differences in age distribution across provinces.

Introduction

Suicide is considered as one of the three leading causes of death among 15 to 44 years age group and the second cause of death in 15-19 years age group ¹. It imposes a considerable burden on population in terms of disability-adjusted life year (DALY) and it has been projected that suicide will compose about 2.4% of global burden of diseases by 2020 ².

Similar to other developing countries, Iran has been experienced a rapid increase in suicide rate during recent years. A recent study showed that suicide and attempted suicide in Iran have increased from 8.3 per 100,000 population in 2001 to 16.3 in 2007 ³. Moreover, suicide account for 4% of the injury cases admitted to the general hospitals in the country ⁴.

The risk factors of suicide are consisted of some demographical characteristics ⁵, socio-economic situations ⁶ and medical conditions ⁷. However, there are factors related to the area of residence that influence the suicide rate ⁸. Evidence demonstrates persistent geographical disparities in distribution of suicide between and within countries which support area-level correlates of suicide ⁹.

Iran is a Middle Eastern country with 1,628,550 square kilometer land area ¹⁰ and is consisted of 31 provinces ¹¹ that are in different levels of development. Ethnic groups tend to reside in neighboring provinces. Therefore, there are variations in socioeconomic level and ethnicity across provinces as well as geographical and ecological differences that could cause a disparity among suicide mortality rate.

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3 While information on the individual risk factors and outcomes of suicide attempts have been
4 well documented in previous studies in Iran^{3, 4, 12-15}, there is little information on the role of
5 socio-economic factors and suicide incidence. In particular, there is no known study
6 evaluating regional socio-economic disparities and their impact on suicide rate in Iran.
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10 To fill the gap, this study aimed to describe pure and social inequality in suicide mortality
11 rates across all the provinces in Iran from 2006 to 2010. Though this is an ecological study, it
12 will provide a useful starting point for examining the social disparity of suicide and provide
13 valuable information for policy makers in order to prioritize prevention strategies.
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23 **METHODS**

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25 The data on distribution of population at the provinces were obtained from the Statistical
26 Centre of Iran. It should be noted that at the time of conducting the current study, Iran
27 constituted of 30 provinces and it was later when Tehran province was split into two
28 provinces. The data on the annual number of death caused by suicide in each province were
29 gathered from the published reports¹⁶ of Iranian Forensic Medicine Organization which is
30 affiliated to the Judicial Authority in Iran. According to the Iranian law, all deaths due to
31 external causes should be reported to this organization for examination and recording and to
32 issue the death certificate. It is considered as the most reliable source of mortality data in Iran
33¹⁷. Then, annual suicide mortality rates per 100,000 population were calculated for each
34 province. Human Development Index (HDI) was used as the provinces' social rank and
35 related data were obtained from the President Deputy of Strategic Planning and Control. The
36 HDI is a composite index of three basic dimensions of human development, including life
37 expectancy at birth, educational attainment (based on a combination of adult literacy rate and
38 primary education to tertiary education enrolment rates), and income (based on GDP per head
39 adjusted for purchasing-power parity [US\$])¹⁸. As a composite index, it is expected that HD
40 might capture socioeconomic development more comprehensively than single indicators such
41 as average income or expenditures.
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54 Pure inequality was examined using Lorenz curve and Gini coefficient. These two measures
55 are commonly used in assessing pure inequality in distribution of health care resources and
56 outcomes¹⁹⁻²¹. Lorenz curve is used to compare distribution of health measure with perfect
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3 equality (diagonal line). In the current study, Lorenz curve was plotted as the cumulative
4 share of population ranked by suicide mortality rate, in an increasing order, against the
5 cumulative share of suicide mortality. The further the distance from diagonal line implies the
6 greater degree of inequality. The Gini coefficient is equal to twice the area between the
7 Lorenz curve and diagonal and its value ranges from 0 (perfect equality) to one (maximum
8 possible inequality). This measure takes into account the distribution of health variable across
9 the entire population. In the current study, we used *fastgini* command in STATA to calculate
10 Gini coefficient and its jackknife 95% confidence interval. To examine gender inequality, we
11 calculated the male to female rate ratio and its 95% confidence interval using negative
12 binomial regression with a robust variance. As we had only data stratified by sex groups for
13 the whole study period and not for every specific year, an overall rate ratio was calculated.
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22 Social inequality was evaluated using Cuzick's test for trend and two common inequality
23 measures: rate ratio (RR) and Kunst and Mackenbach relative index of inequality (RII_{KM})²².
24 Cuzick's test for trend is an extension of the Wilcoxon rank-sum test and is used as a non-
25 parametric test for trend across ordered groups²³. To calculate RR, the provinces were ranked
26 and divided in five quintiles by HDI (weighted by their population). Then, negative binomial
27 regression with a robust variance was used to calculate RR and its 95% confidence interval to
28 compare the highest versus the lowest quintile. One problem with RR is that it only considers
29 the population in two extreme socioeconomic groups. To take into account the whole
30 population distribution across socioeconomic groups and also to remove differences in the
31 size of socioeconomic groups, as a source of variation in the magnitude of health inequalities,
32 RII_{KM} was calculated²². RII is widely used to measure social inequality and is recommended
33 when making comparisons over time or across populations²⁴. To calculate RII , after
34 determine the relative position of the population in the provinces ranked by HDI, the number
35 of deaths in the provinces was regressed on these relative ranks using negative binomial
36 regression with a robust variance and population as offset variable. With the lowest social
37 rank as reference, an RII_{KM} value greater (lesser) than 1 show that suicide mortality rate was
38 higher among the provinces with higher (lower) social rank (more distance from 1 implies
39 more inequality)²⁰. To account for sex and age differences between the provinces, we also
40 estimated adjusted RII_{KM} by including proportion of male in population, mean age of females
41 and mean age of males in our negative binomial regression.
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56 To examine temporal changes of suicide mortality rate across the provinces and also across
57 the quintiles of HDI, we calculated annual percentage change (APC) and its 95% confidence
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3 interval for each province and quintile using the Joinpoint Regression Program 3.5.4.
4 Moreover, this program was used to calculate APC of pure and socioeconomic inequality
5 measures over study period. APC is estimated using following regression:
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$$\text{Ln}(I_t) = b_0 + b_1(t)$$

$$APC = (e^{b_1} - 1) \times 100$$

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14 Where I_t shows the suicide mortality rate and estimated inequality indices for year t .

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16 In a sensitivity analysis, Tehran was excluded from the analysis to examine the pure, gender
17 and social inequalities across the remaining provinces. The reason for this was that Tehran
18 has special situation as the capital of the country and being the centre of economic, social and
19 political activities. Excel office and STATA version 11 (StataCorp LP, College Station, TX,
20 USA) were used for statistical analysis.
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28 Results

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30 Table 1 shows mean population, HDI, suicide mortality rate and APC (%) across the
31 provinces for years 2006-2010. Ilam and Hormozgan provinces had the highest and the
32 lowest suicide mortality rate during the study period, respectively (8.8-fold difference). Most
33 provinces (56.6%) had a suicide mortality rate of 3 to 6 per 100,000 population. In addition,
34 suicide mortality rate was more prevalent among the western provinces of Iran.
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40 The estimated APC values show that only five provinces experienced significant changes in
41 suicide mortality rate over the study period (significant increases in Ilam, Isfahan, North
42 Khorasan and Tehran provinces and significant decrease in Markazi province).
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46 Figure 1a shows temporal changes of suicide mortality rate for the country. While the graph
47 shows a slight increase in suicide mortality rate over the study period (from 4.25 in 2006 to
48 4.88 in 2010), this was not statistically significant (APC=3.05%, P=0.23). Figure 1b presents
49 suicide mortality rates for five quintiles of HDI and examining the trends showed that APC
50 was significant only in the highest quintile (APC=17.98, P=0.01). Figure 2 shows scatter
51 graphs of HDI and suicide mortality rates. It is evident that the higher HDI was associated
52 with the lower suicide mortality rate and Cuzick's test confirmed this (Z=-4.61, P<0.011).
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3 Male to female rate ratio was 2.34 (95% CI 1.45-3.79) implying a significant higher suicide
4 mortality rate among males than females over the study period. Examining this ratio in the
5 provinces showed that in all provinces but Kordestan men had a higher suicide mortality rate
6 than women. Excluding Tehran from the sample did not change this finding (2.33; 95% CI
7 1.43-3.79).
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11 Table 2 presents the pure and social inequality measures in distribution of suicide mortality
12 rate across the country through 2006-2010. The Gini coefficient ranged from 0.248 to 0.302
13 implying substantial pure inequality across the provinces. The Lorenz curves corresponded to
14 this Gini coefficient is been shown in Figure 3. There was a 14.5% decrease in Gini
15 coefficient between the first year and the last year of study implying decreasing pure
16 inequality between these two points of time. Over the study period, the APC of Gini
17 coefficient was -4.28 and statistically non-significant. Excluding Tehran resulted in a 6.9%
18 increase in Gini coefficient between the first and the last year of the study period and a
19 statistically non-significant APC of 1.42 was estimated.
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28 RR was significantly lower than 1 in overall and for all years of the study period, implying a
29 higher suicide mortality rate among people in the lowest quintile of HDI compared with the
30 highest one. Over the study period, RR was approaching 1 and the APC of RR was 12.20 and
31 statistically significant implying a decrease in the gap between the highest and the lowest
32 social ranks. Although excluding Tehran from the sample did not change the overall picture
33 of social inequality, an inverse trend (increasing social inequality) was observed.
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39 RII_{KM} was also lower than 1 in overall and for all years of the study, showing a persistent
40 inequality in favor of people living in the provinces with higher social rank. Temporal
41 analysis showed that RII_{KM} did not significantly change over the study period. Adjusting for
42 age and sex this observation. When we excluded the Tehran province, the APC value for
43 adjusted RII_{KM} was statistically significant showing an increase in social disparity across the
44 remaining provinces in Iran.
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49 Discussion

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52 In this study, for the first time, we assessed pure and social disparities in the distribution of
53 suicide mortality across the provinces of Iran over a period of five years (2006-2010). The
54 findings showed that suicide mortality has slightly increased over the study period. The
55 findings also indicated that there were substantial pure, gender and social disparities in the
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3 distribution of suicide mortality across the country, and it was higher in the provinces with
4 lower social rank. These disparities were generally stable and persistent over the study
5 period.
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9 The findings from the current study showed an inverse association between the provinces'
10 social rank and suicide mortality in Iran. Although the studies on association between area
11 social rank and suicide mortality reported mixed results^{9, 25}, the results of this study is in line
12 with previous ecological studies investigating the relationship between socioeconomic
13 characteristics and suicide rate, in particular the studies focused on high income settings^{9, 26-}
14³². Rehkopf and Buka⁹ in their systematic review of suicide and socioeconomic
15 characteristics of geographical areas found that, among studies with statistically significant
16 results, 50% and 73% of studies reported an inverse relation between area income and
17 education characteristics and completed suicide, respectively. They also found that the
18 probability of reporting an inverse relationship between area social rank and suicide mortality
19 was higher among the studies conducted in Asia (94% of studies with statistically significant
20 results)⁹. Similar finding was reported by another study³³ focusing on the countries in
21 Eastern Mediterranean region (where Iran is located), indicating that high income countries
22 had lower suicide mortality rate than their low and middle income counterparts. It is argued
23 that people in the provinces with lower social rank generally have more adverse experiences,
24 poorer mental health, lower access to psychiatric services, and lower access to health
25 facilities. These factors might partly explain higher suicide mortality rate in the provinces
26 with lower social rank in Iran.
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40 The four Western provinces of Iran (i.e., Ilam, Kermanshah, Lorestan and Hamedan) had the
41 highest suicide mortality rate in the country. One potential explanation for this observation
42 can be low socioeconomic status of these provinces. These provinces are among the
43 provinces with the highest unemployment rate and the lowest HDI in the country. High
44 divorce rates in these provinces (except for Ilam) can be another potential explanation. A
45 recent study has reported divorce as one of the risk factors for completed suicides in Iran³. In
46 addition, cultural issues such as the tribal structure of communities and the extreme
47 fanaticism prevailing in these provinces have been considered as another potential
48 explanation for this finding³⁴.
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56 The high gender gap in suicide mortality rate observed in the current study is in line with the
57 previous epidemiological studies in Iran^{3, 4, 14} and is comparable to the studies conducted in
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3 other settings, in particular high income countries^{6, 9, 35, 36}. Although many studies, including
4 the previous studies in Iran^{3, 4, 14}, have shown higher suicide attempt rate among females,
5 completed (fatal) suicides are higher among males. One potential explanation can be the
6 difference in methods of attempting suicide among males and females. For example, the most
7 common methods of attempting suicide used by males in Iran are hanging and firearms which
8 have higher fatality rate compared with self-burning method commonly used by females^{3, 14,}
9 ^{36, 37}. Greater psychosocial impact of problems, such as unemployment or retirement, on
10 males compared to female^{36, 38, 39} and adopting coping strategies such as emotional
11 inexpressiveness, lack of help-seeking, risk-taking behaviour, violence, alcohol and drug
12 abuse by males (which are triggered by norms of traditional masculinity)^{40, 41} are other
13 potential factors which have been discussed in the literature.
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22 Temporal analysis of suicide mortality showed interesting results indicating that among five
23 quintiles of HDI, it was only the highest quintile that experienced a significant change in
24 suicide mortality over the study period. This finding potentially can be explained by
25 increasing prevalence of mental disorders, raising unemployment rate^{13, 42} and increasing
26 trend in divorce rate¹³ in the provinces with higher HDI, such as Tehran, the capital city of
27 Iran.
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33 The current study has several limitations that should be considered when interpreting its
34 findings. Firstly, age and gender differences between the provinces were naïvely adjusted
35 which might have not fully captured differences in age distribution across provinces.
36 Secondly, there is the issue of availability and quality of data on suicide which is common in
37 developing countries settings^{25, 43} and leads to underestimation and misclassification of
38 suicide. This might be an issue in this study because of the social stigma of suicide and
39 religious sanctions and some legal issues in the Iranian context^{33, 4}. Moreover, the
40 underestimation and misclassification of suicide mortality might be more common in the
41 provinces with lower social rank; therefore, we expect that the social disparity to be more
42 profound than what has been reported here. Thirdly, the current study is an ecological study
43 using province as unit of analysis which embraces substantial heterogeneity within provinces.
44 This implies that the observed disparities in suicide mortality are between-provinces and it is
45 not necessarily applicable to smaller geographic units or individuals. Furthermore, no causal
46 inference can be drawn due to ecological nature of the study and that there was no control for
47 confounders in this study.
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Conclusion

The present study indicated that there were substantial pure, gender and social disparities in the distribution of suicide mortalities across the provinces in Iran. Moreover, the study showed an inverse association between the provinces' social rank and suicide mortality. The findings imply that prevention resources should be targeted high risk groups, in particular men in the provinces with low socio-economic status. Further investigations are needed to explain these disparities in suicide mortality across the provinces. Moreover, more studies needed to explore the association of socio-economic factors and suicide (attempt and fatal) focusing on the smaller geographical units and at the individual level in order to design better prevention strategies.

List of Abbreviations

DALY: Disability-adjusted Life Years, HDI: Human Development Index, RR: rate ratio, RII_{KM} : Kunst and Mackenbach relative index of inequality, APC: annual percentage change

Authors' contributions

AAK was involved in the study conception and design, data collection and analysis, interpretation of the data, and writing the manuscript. HHB and SS were involved in the study design, results interpretation, and writing the manuscript. HS was involved in the study design, data collection and finalization of the manuscript. All authors read and approved the final manuscript

Competing interests

The authors declare that they have no competing interests. No funding has been received for the conduct of this study and/or preparation of this manuscript.

Data sharing statement

No additional data

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Table 1. Mean population, human development index (HDI), suicide mortality rate and annual percentage change across the provinces in Iran, 2006-2010 (Ranked by Suicide mortality rate).

	Population	HDI	Suicide mortality rate per 100,000 population	APC (%)*
Ilam	555,929	0.729	19.53	10.11
Kermanshah	1,892,100	0.748	13.74	0.46
Lorestan	1,736,946	0.761	10.64	1.18
Hamedan	1,700,960	0.740	9.59	-1.52
Gilan	2,428,553	0.769	6.52	9.98
Ardebil	1,235,234	0.735	6.22	-2.32
East Azerbaijan	3,646,459	0.763	5.58	1.31
Zanjan	973,739	0.752	5.53	12.14
Kohgiluyeh & Boyerahmad	651,577	0.718	5.25	-4.20
Khuzestan	4,372,242	0.762	5.11	-7.13
West Azerbaijan	2,944,224	0.713	4.72	-2.74
Kordestan	1,453,503	0.713	4.69	5.25
Golestan	1,651,708	0.737	4.49	5.67
Overall (Iran)	72,599,045	0.758	4.46	3.05
Qazvin	1,177,582	0.783	4.25	-1.13
North Khorasan	824,979	0.759	4.24	10.64
Fars	4,431,684	0.783	4.16	1.56
Chaharmahal Bakhtiari	875,207	0.749	4.00	-7.72
Qom	1,087,011	0.773	3.75	7.89
Mazandaran	2,979,189	0.745	3.66	-5.71
Isfahan	4,680,831	0.810	3.64	4.62
Kerman	2,799,417	0.750	3.10	-5.03
Bushehr	914,710	0.786	3.02	15.55
South Khorasan	656,469	0.723	3.02	-2.28
Tehran	14,106,297	0.843	2.92	17.98
Yazd	1,028,152	0.809	2.68	-4.48
Razavi Khorasan	5,765,706	0.777	2.66	-2.64
Semnan	606,982	0.814	2.60	4.27
Markazi	1,371,514	0.785	2.38	-10.73
Sistan & Baluchestan	2,569,107	0.643	2.23	6.11
Hormozgan	1,481,031	0.766	2.21	-5.59

*Bold figures show statistically significant results (p<0.05)

Table 2. Pure and social inequality measures of suicide mortality in Iran, 2006-2010.

	Total sample (n=30)						APC (Pvalue)
	2006	2007	2008	2009	2010	Overall	
Gini index	0.290 (0.193-0.386)	0.302 (0.212-0.392)	0.271 (0.182-0.361)	0.268 (0.165-0.371)	0.248 (0.151-0.345)	0.281 (0.240-0.322)	-4.28 (0.050)
Rate ratio*	0.359 (0.256-0.503)	0.325 (0.225-0.469)	0.428 (0.284-0.646)	0.496 (0.296-0.830)	0.535 (0.316-0.906)	0.426 (0.275-0.659)	12.20 (0.049)
RII _{KM}	0.345 (0.174-0.686)	0.257 (0.127-0.521)	0.289 (0.142-0.588)	0.337 (0.147-0.776)	0.341 (0.148-0.784)	0.339 (0.166-0.671)	1.75 (0.745)
Adjusted RII _{KM} **	0.279 (0.129-0.600)	0.205 (0.098-0.431)	0.224 (0.102-0.489)	0.133 (0.039-0.455)	0.160 (0.051-0.507)	0.171 (0.054-0.548)	-13.75 (0.073)
Sample excluding Tehran (n=29)							
Gini index	0.259 (0.168-0.350)	0.285 (0.187-0.382)	0.282 (0.187-0.378)	0.292 (0.192-0.392)	0.277 (0.191-0.363)	0.282 (0.243-0.322)	1.42 (0.38)
Rate ratio*	0.646 (0.444-0.938)	0.397 (0.226-0.695)	0.415 (0.247-0.696)	0.520 (0.277-0.974)	0.492 (0.262-0.924)	0.584 (0.380-0.896)	-6.59 (0.403)
RII _{KM}	0.460 (0.257-0.823)	0.339 (0.179-0.644)	0.352 (0.185-0.672)	0.397 (0.187-0.839)	0.389 (0.185-0.819)	0.411 (0.215-0.785)	-2.76 (0.575)
Adjusted RII _{KM} **	0.402 (0.224-0.722)	0.301 (0.168-0.541)	0.310 (0.165-0.580)	0.211 (0.077-0.577)	0.241 (0.093-0.623)	0.241 (0.090-0.649)	-12.95 (0.045)

*The highest vs. the lowest quintile of HDI

**Adjusted for proportion of males and mean age of males and females in the provinces.

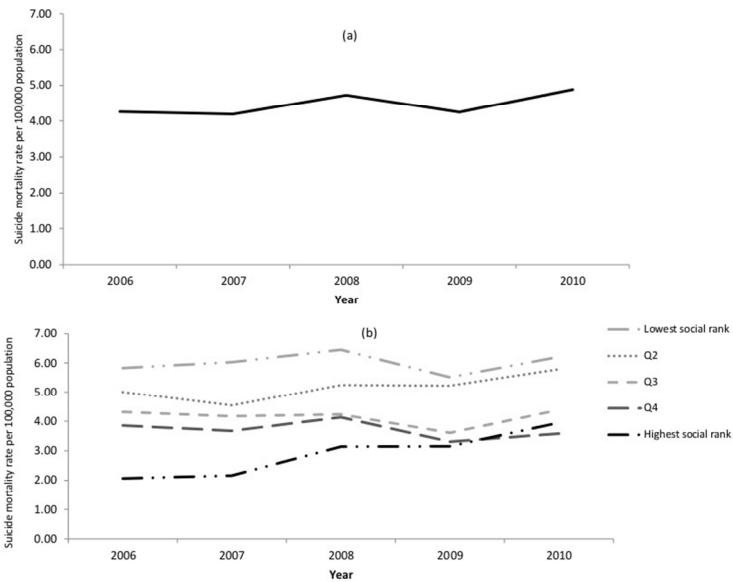
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3 **Figure 1.** Suicide mortality rates per 100,000 populations in a) total sample; b) quintiles of
4 HDI, 2006-2010.
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7 **Figure 2.** Scatter plots of HDI and suicide mortality rates, stratified by year of study.
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10 **Figure 3.** Lorenz curves of the distribution of suicide mortality in Iran, 2006-2010.
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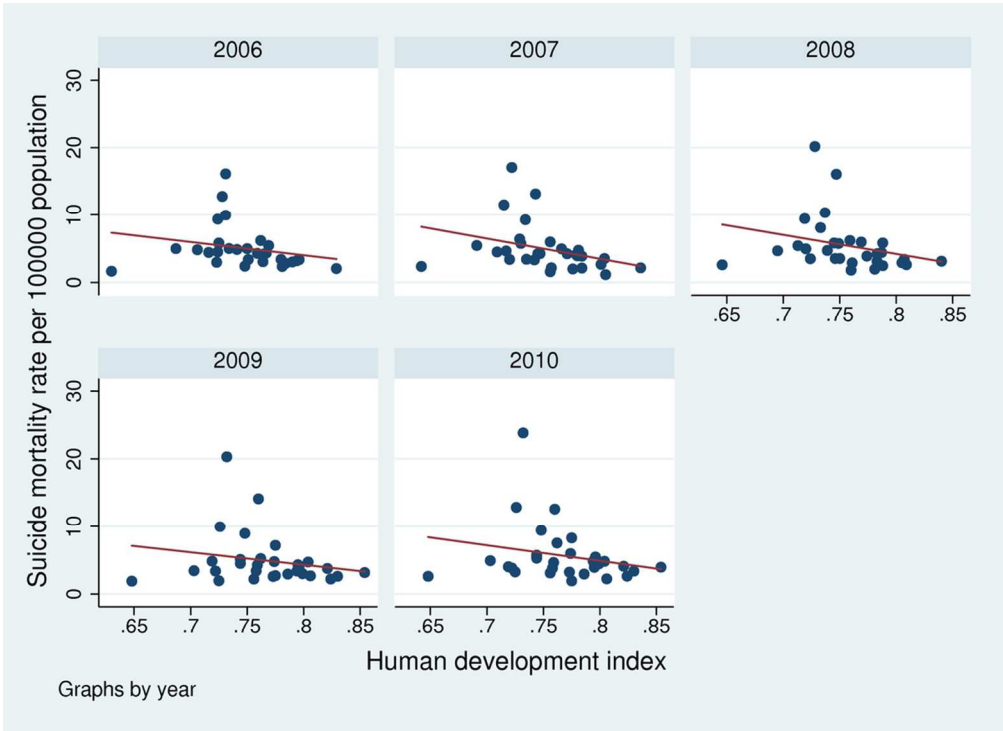
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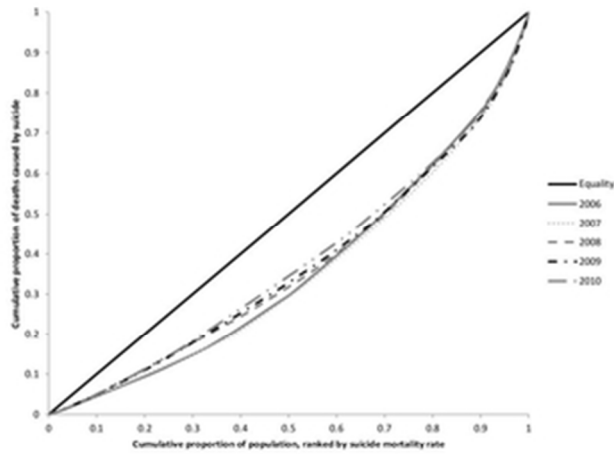
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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

Continued on next page

Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

OVERALL, GENDER AND SOCIAL INEQUALITIES IN SUICIDE MORTALITY IN IRAN, 2006-2010: A TIME TREND PROVINCE-LEVEL STUDY

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Primary Subject Heading:	Sociology
Secondary Subject Heading:	Epidemiology, Health economics, Health policy, Mental health, Public health
Keywords:	Suicide mortality, Social inequality, Pure inequality, Temporal analysis, Iran

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4 **OVERALL, GENDER AND SOCIAL INEQUALITIES IN**
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10 **PROVINCE-LEVEL STUDY**
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38 **Running Title:** Inequalities in suicide mortality in Iran

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41 *Key words:* Suicide mortality, Social inequality, Overall inequality, Temporal analysis, Iran.
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43 Word Count: 3125
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Abstract

Objectives: Suicide is a major global health problem imposing a considerable burden on population in terms of disability-adjusted life years. There has been an increasing trend in fatal and attempted suicide in Iran over the past few decades. The aim of the current study was to assess overall, gender and social inequalities across Iran's provinces during 2006-2010.

Design: Ecological study.

Setting: The data on distribution of population at the provinces were obtained from the Statistical Centre of Iran. The data on the annual number of death caused by suicide in each province were gathered from the Iranian Forensic Medicine Organization.

Methods: Suicide mortality rate per 100,000 population was calculated. Human Development Index was used as the provinces' social rank. Gini coefficient, rate ratio and Kunst and Mackenbach relative index of inequality (RII_{KM}) were used to assess overall, gender and social inequalities, respectively. Annual percentage change was calculated using Joinpoint regression.

Results: Suicide mortality has slightly increased in Iran during 2006-2010. There was a substantial and constant overall inequality across the country over the study period. Male to female rate ratio was 2.34 (95% CI 1.45-3.79) over the same period. There were social inequalities in suicide mortality in favor of people in better-off provinces. In addition, there was an increasing trend in these social disparities over time, although it was not statistically significant.

Conclusion: We found substantial overall, gender and social disparities in the distribution of suicide mortality across the provinces in Iran. The findings showed that men in the provinces with low socio-economic status are at higher risk of suicide mortality. Further analyses are needed to explain these disparities.

Article Summary

Strength and limitations of this study

- This is the first national study to evaluate regional social inequalities in suicide mortality over five-year period.
- Social inequality in suicide mortality was evaluated using Cuzick's test for trend and two common inequality measures: rate ratio (RR) and Kunst and Mackenbach relative index of inequality (RII_{KM})
- Age and gender differences between the provinces were naïvely adjusted which might have not fully captured differences in age distribution across provinces.

Introduction

Suicide is considered as one of the three leading causes of death among 15 to 44 years age group and the second cause of death in 15-19 years age group ¹. It imposes a considerable burden on population in terms of disability-adjusted life year (DALY) and it has been projected that suicide will compose about 2.4% of global burden of diseases by 2020 ².

Similar to other developing countries, Iran has been experienced a rapid increase in suicide rate during recent years. A recent study showed that suicide and attempted suicide in Iran have increased from 8.3 per 100,000 population in 2001 to 16.3 in 2007 ³. Moreover, suicide account for 4% of the injury cases admitted to the general hospitals in the country ⁴.

The risk factors of suicide are consisted of some demographical characteristics ⁵, socio-economic situations ⁶ and medical conditions ⁷. However, there are factors related to the area of residence that influence the suicide rate ⁸. Evidence demonstrates persistent geographical disparities in distribution of suicide between and within countries which support area-level correlates of suicide ⁹.

Iran is a Middle Eastern country with 1,628,550 square kilometer land area ¹⁰ and is consisted of 31 provinces ¹¹ that are in different levels of development. Ethnic groups tend to reside in neighboring provinces. Therefore, there are variations in socioeconomic level and ethnicity across provinces as well as geographical and ecological differences that could cause a disparity among suicide mortality rate.

While information on the individual risk factors and outcomes of suicide attempts have been well documented in previous studies in Iran ^{3, 4, 12-15}, there is little information on the role of socio-economic factors and suicide incidence. In particular, there is no known study evaluating regional socio-economic disparities and their impact on suicide rate in Iran.

To fill the gap, this study aimed to describe overall and social inequality in suicide mortality rates across all the provinces in Iran from 2006 to 2010. Though this is an ecological study, it will provide a useful starting point for examining the social disparity of suicide and provide valuable information for policy makers in order to prioritize prevention strategies.

METHODS

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3 The data on distribution of population at the provinces were obtained from the Statistical
4 Centre of Iran. It should be noted that at the time of conducting the current study, Iran
5 constituted of 30 provinces and it was later when Tehran province was split into two
6 provinces. The data on the annual number of death caused by suicide in each province were
7 gathered from the published reports ¹⁶ of Iranian Forensic Medicine Organization which is
8 affiliated to the Judicial Authority in Iran. According to the Iranian law, all deaths due to
9 external causes should be reported to this organization for examination and recording and to
10 issue the death certificate. It is considered as the most reliable source of mortality data in Iran
11 ¹⁷. Then, annual suicide mortality rates per 100,000 population were calculated for each
12 province. Human Development Index (HDI) was used as the provinces' social rank and
13 related data were obtained from the President Deputy of Strategic Planning and Control. The
14 HDI is a composite index of three basic dimensions of human development, including life
15 expectancy at birth, educational attainment (based on a combination of adult literacy rate and
16 primary education to tertiary education enrolment rates), and income (based on GDP per head
17 adjusted for purchasing-power parity [US\$]) ¹⁸. As a composite index, it is expected that HDI
18 might capture socioeconomic development more comprehensively than single indicators such
19 as average income or expenditures.
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32 Overall inequality measures inequalities in health irrespective of the other characteristics of
33 the individuals ¹⁹. To measure overall inequality we followed the same approach as
34 measuring income inequality and used Lorenz curve and Gini coefficient. These two
35 measures are commonly used in assessing overall inequality in distribution of health care
36 resources and outcomes ²⁰⁻²². Lorenz curve is used to compare distribution of health measure
37 with perfect equality (diagonal line). In the current study, Lorenz curve was plotted as the
38 cumulative share of population ranked by suicide mortality rate, in an increasing order,
39 against the cumulative share of suicide mortality. The further the distance from diagonal line
40 implies the greater degree of inequality. The Gini coefficient is equal to twice the area
41 between the Lorenz curve and diagonal and its value ranges from 0 (perfect equality) to one
42 (maximum possible inequality). This measure takes into account the distribution of health
43 variable across the entire population. In the current study, we used *fastgini* command in
44 STATA to calculate Gini coefficient and its jackknife 95% confidence interval. In order to
45 examine gendered nature of suicide mortalities (i.e. gender inequality) in Iran, we calculated
46 the male to female rate ratio and its 95% confidence interval using negative binomial
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3 regression with a robust variance. As we had only data stratified by sex groups for the whole
4 study period and not for every specific year, an overall rate ratio was calculated.
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7 Social inequality was evaluated using Cuzick's test for trend and two common inequality
8 measures: rate ratio (RR) and Kunst and Mackenbach relative index of inequality (RII_{KM})²³.
9 Cuzick's test for trend is an extension of the Wilcoxon rank-sum test and is used as a non-
10 parametric test for trend across ordered groups²⁴. To calculate RR, the provinces were ranked
11 and divided in five quintiles by HDI (weighted by their population). Then, negative binomial
12 regression with a robust variance was used to calculate RR and its 95% confidence interval to
13 compare the highest versus the lowest quintile. One problem with RR is that it only considers
14 the population in two extreme socioeconomic groups. To take into account the whole
15 population distribution across socioeconomic groups and also to remove differences in the
16 size of socioeconomic groups, as a source of variation in the magnitude of health inequalities,
17 RII_{KM} was calculated²³. RII is widely used to measure social inequality and is recommended
18 when making comparisons over time or across populations²⁵. To calculate RII, after
19 determine the relative position of the population in the provinces ranked by HDI, the number
20 of deaths in the provinces was regressed on these relative ranks using negative binomial
21 regression with a robust variance and population as offset variable. With the lowest social
22 rank as reference, an RII_{KM} value greater (lesser) than 1 show that suicide mortality rate was
23 higher among the provinces with higher (lower) social rank (more distance from 1 implies
24 more inequality)²¹. To account for sex and age differences between the provinces, we also
25 estimated adjusted RII_{KM} by including proportion of male in population, mean age of females
26 and mean age of males in our negative binomial regression.
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41 To examine temporal changes of suicide mortality rate across the provinces and also across
42 the quintiles of HDI, we calculated annual percentage change (APC) and its 95% confidence
43 interval for each province and quintile using the Joinpoint Regression Program 3.5.4.
44 Moreover, this program was used to calculate APC of overall and socioeconomic inequality
45 measures over study period. APC is estimated using following regression:
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$$\text{Ln}(I_t) = b_0 + b_1(t)$$

$$APC = (e^{b_1} - 1) \times 100$$

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55 Where I_t shows the suicide mortality rate and estimated inequality indices for year t .
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3 In a sensitivity analysis, Tehran was excluded from the analysis to examine the overall,
4 gender and social inequalities across the remaining provinces. The reason for this was that
5 Tehran has special situation as the capital of the country and being the centre of economic,
6 social and political activities. Excel office and STATA version 11 (StataCorp LP, College
7 Station, TX, USA) were used for statistical analysis.
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11 12 13 14 15 **Results**

16
17 Table 1 shows mean population, HDI, suicide mortality rate and APC (%) across the
18 provinces for years 2006-2010. Ilam and Hormozgan provinces had the highest and the
19 lowest suicide mortality rate during the study period, respectively (8.8-fold difference). Most
20 provinces (56.6%) had a suicide mortality rate of 3 to 6 per 100,000 population. In addition,
21 suicide mortality rate was more prevalent among the western provinces of Iran (Figure 1).
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26 The estimated APC values show that only five provinces experienced significant changes in
27 suicide mortality rate over the study period (significant increases in Ilam, Isfahan, North
28 Khorasan and Tehran provinces and significant decrease in Markazi province).
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32 Figure 2a shows temporal changes of suicide mortality rate for the country. While the graph
33 shows a slight increase in suicide mortality rate over the study period (from 4.25 in 2006 to
34 4.88 in 2010), this was not statistically significant (APC=3.05%, P=0.23). Figure 2b presents
35 suicide mortality rates for five quintiles of HDI and examining the trends showed that APC
36 was significant only in the highest quintile (APC=17.98, P=0.01). Figure 3 shows scatter
37 graphs of HDI and suicide mortality rates. It is evident that the higher HDI was associated
38 with the lower suicide mortality rate and Cuzick's test confirmed this (Z=-4.61, P<0.011).
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44 Male to female rate ratio was 2.34 (95% CI 1.45-3.79) implying a significant higher suicide
45 mortality rate among males than females over the study period. Examining this ratio in the
46 provinces showed that in all provinces but Kordestan men had a higher suicide mortality rate
47 than women. Excluding Tehran from the sample did not change this finding (2.33; 95% CI
48 1.43-3.79).
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53 Table 2 presents the overall and social inequality measures in distribution of suicide mortality
54 rate across the country through 2006-2010. The Gini coefficient ranged from 0.248 to 0.302
55 implying substantial overall inequality across the provinces. The Lorenz curves corresponded
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3 to this Gini coefficient is been shown in Figure 4. There was a 14.5% decrease in Gini
4 coefficient between the first year and the last year of study implying decreasing overall
5 inequality between these two points of time. Over the study period, the APC of Gini
6 coefficient was -4.28 and statistically non-significant. Excluding Tehran resulted in a 6.9%
7 increase in Gini coefficient between the first and the last year of the study period and a
8 statistically non-significant APC of 1.42 was estimated.
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13 RR was significantly lower than 1 in overall and for all years of the study period, implying a
14 higher suicide mortality rate among people in the lowest quintile of HDI compared with the
15 highest one. Over the study period, RR was approaching 1 and the APC of RR was 12.20 and
16 statistically significant implying a decrease in the gap between the highest and the lowest
17 social ranks. Although excluding Tehran from the sample did not change the overall picture
18 of social inequality, an inverse trend (increasing social inequality) was observed.
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24 RII_{KM} was also lower than 1 in overall and for all years of the study, showing a persistent
25 inequality in favor of people living in the provinces with higher social rank. Temporal
26 analysis showed that RII_{KM} did not significantly change over the study period. Adjusting for
27 age and sex this observation. When we excluded the Tehran province, the APC value for
28 adjusted RII_{KM} was statistically significant showing an increase in social disparity across the
29 remaining provinces in Iran.
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35 Discussion

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38 In this study, for the first time, we assessed overall and social disparities in the distribution of
39 suicide mortality across the provinces of Iran over a period of five years (2006-2010). The
40 findings showed that suicide mortality has slightly increased over the study period. The
41 findings also indicated that there were substantial overall, gender and social disparities in the
42 distribution of suicide mortality across the country, and it was higher in the provinces with
43 lower social rank. These disparities were generally stable and persistent over the study
44 period.
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50 The findings from the current study showed an inverse association between the provinces'
51 social rank and suicide mortality in Iran. Although the studies on association between area
52 social rank and suicide mortality reported mixed results^{9, 26}, the results of this study is in line
53 with previous ecological studies investigating the relationship between socioeconomic
54 characteristics and suicide rate, in particular the studies focused on high income settings^{9, 27-}
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3 33. Rehkopf and Buka⁹ in their systematic review of suicide and socioeconomic
4 characteristics of geographical areas found that, among studies with statistically significant
5 results, 50% and 73% of studies reported an inverse relation between area income and
6 education characteristics and completed suicide, respectively. They also found that the
7 probability of reporting an inverse relationship between area social rank and suicide mortality
8 was higher among the studies conducted in Asia (94% of studies with statistically significant
9 results)⁹. Similar finding was reported by another study³⁴ focusing on the countries in
10 Eastern Mediterranean region (where Iran is located), indicating that high income countries
11 had lower suicide mortality rate than their low and middle income counterparts. It is argued
12 that people in the provinces with lower social rank generally have more adverse experiences,
13 poorer mental health, lower access to psychiatric services, and lower access to health
14 facilities. These factors might partly explain higher suicide mortality rate in the provinces
15 with lower social rank in Iran.
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25 The four Western provinces of Iran (i.e., Ilam, Kermanshah, Lorestan and Hamedan) had the
26 highest suicide mortality rate in the country. One potential explanation for this observation
27 can be low socioeconomic status of these provinces. These provinces are among the
28 provinces with the highest unemployment rate and the lowest HDI in the country. High
29 divorce rates in these provinces (except for Ilam) can be another potential explanation as
30 divorce is considered as a risk factor for suicide mortality^{35, 36}. In addition, cultural issues
31 such as the tribal structure of communities and the extreme fanaticism prevailing in these
32 provinces have been considered as another potential explanation for this finding³⁷.
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40 The high gender gap in suicide mortality rate observed in the current study is in line with the
41 previous epidemiological studies in Iran^{3, 4, 14} and is comparable to the studies conducted in
42 other settings, in particular high income countries^{6, 9, 38, 39}. Although many studies, including
43 the previous studies in Iran^{3, 4, 14}, have shown higher suicide attempt rate among females,
44 completed (fatal) suicides are higher among males. One potential explanation can be the
45 difference in methods of attempting suicide among males and females. For example, the most
46 common methods of attempting suicide used by males in Iran are hanging and firearms which
47 have higher fatality rate compared with self-burning method commonly used by females^{3, 14,}
48 ^{39, 40}. Greater psychosocial impact of problems, such as unemployment or retirement, on
49 males compared to female^{39, 41, 42} and adopting coping strategies such as emotional
50 inexpressiveness, lack of help-seeking, risk-taking behaviour, violence, alcohol and drug
51 abuse by males (which are triggered by norms of traditional masculinity)^{43, 44} are other
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3 potential factors which have been discussed in the literature. The findings of the gender
4 analysis are important for designing and implementing suicide prevention strategies as the
5 factors, patterns, and behaviours associated with suicide are affected by gender.
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11 Temporal analysis of suicide mortality showed interesting results indicating that among five
12 quintiles of HDI, it was only the highest quintile that experienced a significant change in
13 suicide mortality over the study period. This finding potentially can be explained by
14 increasing prevalence of mental disorders, raising unemployment rate^{13, 45} and increasing
15 trend in divorce rate¹³ in the provinces with higher HDI, such as Tehran, the capital city of
16 Iran.
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21 To our knowledge, this is the first national study evaluating social inequalities across
22 different regions over time. Although this study conducted in the context of Iran, however,
23 the findings may also be applicable to other middle-income countries, in particular countries
24 in the Middle East region, which share similar culture. Moreover, we believe that, in terms of
25 methodology, our analysis present a good example for employing a triangulation of different
26 methods for evaluating inequalities in suicide mortalities. However, the current study has
27 several limitations that should be considered when interpreting its findings. Firstly, age and
28 gender differences between the provinces were naïvely adjusted which might have not fully
29 captured differences in age distribution across provinces. Secondly, there is the issue of
30 availability and quality of data on suicide which is common in developing countries settings
31^{26, 46} and leads to underestimation and misclassification of suicide. This might be an issue in
32 this study because of the social stigma of suicide and religious sanctions and some legal
33 issues in the Iranian context^{34, 4}. Moreover, the underestimation and misclassification of
34 suicide mortality might be more common in the provinces with lower social rank; therefore,
35 we expect that the social disparity to be more profound than what has been reported here.
36 Thirdly, the current study is an ecological study using province as unit of analysis which
37 embraces substantial heterogeneity within provinces. This implies that the observed
38 disparities in suicide mortality are between-provinces and it is not necessarily applicable to
39 smaller geographic units or individuals. Furthermore, no causal inference can be drawn due
40 to ecological nature of the study and that there was no control for confounders in this study.
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55 **Conclusion**

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3 The present study indicated that there were substantial overall, gender and social disparities
4 in the distribution of suicide mortalities across the provinces in Iran. Moreover, the study
5 showed an inverse association between the provinces' social rank and suicide mortality. The
6 findings imply that prevention resources should be targeted high risk groups, in particular
7 men in the provinces with low socio-economic status. Further investigations are needed to
8 explain these disparities in suicide mortality across the provinces. Moreover, more studies
9 needed to explore the association of socio-economic factors and suicide (attempt and fatal)
10 focusing on the smaller geographical units and at the individual level in order to design better
11 prevention strategies.
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19 **List of Abbreviations**

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21 DALY: Disability-adjusted Life Years, HDI: Human Development Index, RR: rate ratio,
22 RII_{KM}: Kunst and Mackenbach relative index of inequality, APC: annual percentage change
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Authors' contributions

AAK was involved in the study conception and design, data collection and analysis, interpretation of the data, and writing the manuscript. HHB and SS were involved in the study design, results interpretation, and writing the manuscript. HS was involved in the study design, data collection and finalization of the manuscript. All authors read and approved the final manuscript.

Competing interests

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Data Sharing Statement

No additional data available

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Table 1. Mean population, human development index (HDI), suicide mortality rate and annual percentage change across the provinces in Iran, 2006-2010 (Ranked by Suicide mortality rate).

	Population	HDI	Suicide mortality rate per 100,000 population	APC (%)*
Ilam	555,929	0.729	19.53	10.11
Kermanshah	1,892,100	0.748	13.74	0.46
Lorestan	1,736,946	0.761	10.64	1.18
Hamedan	1,700,960	0.740	9.59	-1.52
Gilan	2,428,553	0.769	6.52	9.98
Ardebil	1,235,234	0.735	6.22	-2.32
East Azerbaijan	3,646,459	0.763	5.58	1.31
Zanjan	973,739	0.752	5.53	12.14
Kohgiluyeh & Boyer-Ahmad	651,577	0.718	5.25	-4.20
Khuzestan	4,372,242	0.762	5.11	-7.13
West Azerbaijan	2,944,224	0.713	4.72	-2.74
Kordestan	1,453,503	0.713	4.69	5.25
Golestan	1,651,708	0.737	4.49	5.67
Overall (Iran)	72,599,045	0.758	4.46	3.05
Qazvin	1,177,582	0.783	4.25	-1.13
North Khorasan	824,979	0.759	4.24	10.64
Fars	4,431,684	0.783	4.16	1.56
Chaharmahal Bakhtiari	875,207	0.749	4.00	-7.72
Qom	1,087,011	0.773	3.75	7.89
Mazandaran	2,979,189	0.745	3.66	-5.71
Isfahan	4,680,831	0.810	3.64	4.62
Kerman	2,799,417	0.750	3.10	-5.03
Bushehr	914,710	0.786	3.02	15.55
South Khorasan	656,469	0.723	3.02	-2.28
Tehran	14,106,297	0.843	2.92	17.98
Yazd	1,028,152	0.809	2.68	-4.48
Razavi Khorasan	5,765,706	0.777	2.66	-2.64
Semnan	606,982	0.814	2.60	4.27
Markazi	1,371,514	0.785	2.38	-10.73
Sistan & Baluchestan	2,569,107	0.643	2.23	6.11
Hormozgan	1,481,031	0.766	2.21	-5.59

*Bold figures show statistically significant results (p<0.05)

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Table 2. Overall and social inequality measures of suicide mortality in Iran, 2006-2010.

	Total sample (n=30)					Overall	APC (Pvalue)
	2006	2007	2008	2009	2010		
Gini index	0.290 (0.193-0.386)	0.302 (0.212-0.392)	0.271 (0.182-0.361)	0.268 (0.165-0.371)	0.248 (0.151-0.345)	0.281 (0.240-0.322)	-4.28 (0.050)
Rate ratio*	0.359 (0.256-0.503)	0.325 (0.225-0.469)	0.428 (0.284-0.646)	0.496 (0.296-0.830)	0.535 (0.316-0.906)	0.426 (0.275-0.659)	12.20 (0.049)
RII _{KM}	0.345 (0.174-0.686)	0.257 (0.127-0.521)	0.289 (0.142-0.588)	0.337 (0.147-0.776)	0.341 (0.148-0.784)	0.339 (0.166-0.671)	1.75 (0.745)
Adjusted RII _{KM} **	0.279 (0.129-0.600)	0.205 (0.098-0.431)	0.224 (0.102-0.489)	0.133 (0.039-0.455)	0.160 (0.051-0.507)	0.171 (0.054-0.548)	-13.75 (0.073)
Sample excluding Tehran (n=29)							
Gini index	0.259 (0.168-0.350)	0.285 (0.187-0.382)	0.282 (0.187-0.378)	0.292 (0.192-0.392)	0.277 (0.191-0.363)	0.282 (0.243-0.322)	1.42 (0.38)
Rate ratio*	0.646 (0.444-0.938)	0.397 (0.226-0.695)	0.415 (0.247-0.696)	0.520 (0.277-0.974)	0.492 (0.262-0.924)	0.584 (0.380-0.896)	-6.59 (0.403)
RII _{KM}	0.460 (0.257-0.823)	0.339 (0.179-0.644)	0.352 (0.185-0.672)	0.397 (0.187-0.839)	0.389 (0.185-0.819)	0.411 (0.215-0.785)	-2.76 (0.575)
Adjusted RII _{KM} **	0.402 (0.224-0.722)	0.301 (0.168-0.541)	0.310 (0.165-0.580)	0.211 (0.077-0.577)	0.241 (0.093-0.623)	0.241 (0.090-0.649)	-12.95 (0.045)

*The highest vs. the lowest quintile of HDI
 **Adjusted for proportion of males and mean age of males and females in the provinces.

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3 **Figure 1.** Distribution of suicide mortality rate across the provinces in Iran.
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5 **Figure 2.** Suicide mortality rates per 100,000 populations in a) total sample; b) quintiles of
6 HDI, 2006-2010.
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9 **Figure 3.** Scatter plots of HDI and suicide mortality rates, stratified by year of study.
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11 **Figure 4.** Lorenz curves of the distribution of suicide mortality in Iran, 2006-2010.
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4 **OVERALL, GENDER AND SOCIAL INEQUALITIES IN**
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7 **SUICIDE MORTALITY IN IRAN, 2006-2010: A TIME TREND**
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10 **PROVINCE-LEVEL STUDY**

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38 **Running Title:** Inequalities in suicide mortality in Iran

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41 *Key words:* Suicide mortality, Social inequality, Overall inequality, Temporal analysis, Iran.
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43 Word Count: 3125
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Abstract

Objectives: Suicide is a major global health problem imposing a considerable burden on population in terms of disability-adjusted life years. There has been an increasing trend in fatal and attempted suicide in Iran over the past few decades. The aim of the current study was to assess overall, gender and social inequalities across Iran's provinces during 2006-2010.

Design: Ecological study.

Setting: The data on distribution of population at the provinces were obtained from the Statistical Centre of Iran. The data on the annual number of death caused by suicide in each province were gathered from the Iranian Forensic Medicine Organization.

Methods: Suicide mortality rate per 100,000 population was calculated. Human Development Index was used as the provinces' social rank. Gini coefficient, rate ratio and Kunst and Mackenbach relative index of inequality (RII_{KM}) were used to assess overall, gender and social inequalities, respectively. Annual percentage change was calculated using Joinpoint regression.

Results: Suicide mortality has slightly increased in Iran during 2006-2010. There was a substantial and constant overall inequality across the country over the study period. Male to female rate ratio was 2.34 (95% CI 1.45-3.79) over the same period. There were social inequalities in suicide mortality in favor of people in better-off provinces. In addition, there was an increasing trend in these social disparities over time, although it was not statistically significant.

Conclusion: We found substantial overall, gender and social disparities in the distribution of suicide mortality across the provinces in Iran. The findings showed that men in the provinces with low socio-economic status are at higher risk of suicide mortality. Further analyses are needed to explain these disparities.

Article Summary

Strength and limitations of this study

- This is the first national study to evaluate regional social inequalities in suicide mortality over five-year period.
- Social inequality in suicide mortality was evaluated using Cuzick's test for trend and two common inequality measures: rate ratio (RR) and Kunst and Mackenbach relative index of inequality (RII_{KM})
- Age and gender differences between the provinces were naïvely adjusted which might have not fully captured differences in age distribution across provinces.

Introduction

Suicide is considered as one of the three leading causes of death among 15 to 44 years age group and the second cause of death in 15-19 years age group ¹. It imposes a considerable burden on population in terms of disability-adjusted life year (DALY) and it has been projected that suicide will compose about 2.4% of global burden of diseases by 2020 ².

Similar to other developing countries, Iran has been experienced a rapid increase in suicide rate during recent years. A recent study showed that suicide and attempted suicide in Iran have increased from 8.3 per 100,000 population in 2001 to 16.3 in 2007 ³. Moreover, suicide account for 4% of the injury cases admitted to the general hospitals in the country ⁴.

The risk factors of suicide are consisted of some demographical characteristics ⁵, socio-economic situations ⁶ and medical conditions ⁷. However, there are factors related to the area of residence that influence the suicide rate ⁸. Evidence demonstrates persistent geographical disparities in distribution of suicide between and within countries which support area-level correlates of suicide ⁹.

Iran is a Middle Eastern country with 1,628,550 square kilometer land area ¹⁰ and is consisted of 31 provinces ¹¹ that are in different levels of development. Ethnic groups tend to reside in neighboring provinces. Therefore, there are variations in socioeconomic level and ethnicity across provinces as well as geographical and ecological differences that could cause a disparity among suicide mortality rate.

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3 While information on the individual risk factors and outcomes of suicide attempts have been
4 well documented in previous studies in Iran^{3, 4, 12-15}, there is little information on the role of
5 socio-economic factors and suicide incidence. In particular, there is no known study
6 evaluating regional socio-economic disparities and their impact on suicide rate in Iran.
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10 To fill the gap, this study aimed to describe overall and social inequality in suicide mortality
11 rates across all the provinces in Iran from 2006 to 2010. Though this is an ecological study, it
12 will provide a useful starting point for examining the social disparity of suicide and provide
13 valuable information for policy makers in order to prioritize prevention strategies.
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20 METHODS

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22 The data on distribution of population at the provinces were obtained from the Statistical
23 Centre of Iran. It should be noted that at the time of conducting the current study, Iran
24 constituted of 30 provinces and it was later when Tehran province was split into two
25 provinces. The data on the annual number of death caused by suicide in each province were
26 gathered from the published reports¹⁶ of Iranian Forensic Medicine Organization which is
27 affiliated to the Judicial Authority in Iran. According to the Iranian law, all deaths due to
28 external causes should be reported to this organization for examination and recording and to
29 issue the death certificate. It is considered as the most reliable source of mortality data in Iran
30¹⁷. Then, annual suicide mortality rates per 100,000 population were calculated for each
31 province. Human Development Index (HDI) was used as the provinces' social rank and
32 related data were obtained from the President Deputy of Strategic Planning and Control. The
33 HDI is a composite index of three basic dimensions of human development, including life
34 expectancy at birth, educational attainment (based on a combination of adult literacy rate and
35 primary education to tertiary education enrolment rates), and income (based on GDP per head
36 adjusted for purchasing-power parity [US\$])¹⁸. As a composite index, it is expected that HDI
37 might capture socioeconomic development more comprehensively than single indicators such
38 as average income or expenditures.
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52 Overall inequality measures inequalities in health irrespective of the other characteristics of
53 the individuals¹⁹. To measure overall inequality we followed the same approach as
54 measuring income inequality and used Lorenz curve and Gini coefficient. These two
55 measures are commonly used in assessing overall inequality in distribution of health care
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resources and outcomes²⁰⁻²². Lorenz curve is used to compare distribution of health measure with perfect equality (diagonal line). In the current study, Lorenz curve was plotted as the cumulative share of population ranked by suicide mortality rate, in an increasing order, against the cumulative share of suicide mortality. The further the distance from diagonal line implies the greater degree of inequality. The Gini coefficient is equal to twice the area between the Lorenz curve and diagonal and its value ranges from 0 (perfect equality) to one (maximum possible inequality). This measure takes into account the distribution of health variable across the entire population. In the current study, we used *fastgini* command in STATA to calculate Gini coefficient and its jackknife 95% confidence interval. **In order to examine gendered nature of suicide mortalities (i.e. gender inequality) in Iran,** we calculated the male to female rate ratio and its 95% confidence interval using negative binomial regression with a robust variance. As we had only data stratified by sex groups for the whole study period and not for every specific year, an overall rate ratio was calculated.

Social inequality was evaluated using Cuzick's test for trend and two common inequality measures: rate ratio (RR) and Kunst and Mackenbach relative index of inequality (RII_{KM})²³. Cuzick's test for trend is an extension of the Wilcoxon rank-sum test and is used as a non-parametric test for trend across ordered groups²⁴. To calculate RR, the provinces were ranked and divided in five quintiles by HDI (weighted by their population). Then, negative binomial regression with a robust variance was used to calculate RR and its 95% confidence interval to compare the highest versus the lowest quintile. One problem with RR is that it only considers the population in two extreme socioeconomic groups. To take into account the whole population distribution across socioeconomic groups and also to remove differences in the size of socioeconomic groups, as a source of variation in the magnitude of health inequalities, RII_{KM} was calculated²³. RII is widely used to measure social inequality and is recommended when making comparisons over time or across populations²⁵. To calculate RII, after determine the relative position of the population in the provinces ranked by HDI, the number of deaths in the provinces was regressed on these relative ranks using negative binomial regression with a robust variance and population as offset variable. With the lowest social rank as reference, an RII_{KM} value greater (lesser) than 1 show that suicide mortality rate was higher among the provinces with higher (lower) social rank (more distance from 1 implies more inequality)²¹. To account for sex and age differences between the provinces, we also estimated adjusted RII_{KM} by including proportion of male in population, mean age of females and mean age of males in our negative binomial regression.

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3 To examine temporal changes of suicide mortality rate across the provinces and also across
4 the quintiles of HDI, we calculated annual percentage change (APC) and its 95% confidence
5 interval for each province and quintile using the Joinpoint Regression Program 3.5.4.
6 Moreover, this program was used to calculate APC of overall and socioeconomic inequality
7 measures over study period. APC is estimated using following regression:
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$$\text{Ln}(I_t) = b_0 + b_1(t)$$

$$\text{APC} = (e^{b_1} - 1) \times 100$$

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12 Where I_t shows the suicide mortality rate and estimated inequality indices for year t .
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20 In a sensitivity analysis, Tehran was excluded from the analysis to examine **the overall**,
21 gender and social inequalities across the remaining provinces. The reason for this was that
22 Tehran has special situation as the capital of the country and being the centre of economic,
23 social and political activities. Excel office and STATA version 11 (StataCorp LP, College
24 Station, TX, USA) were used for statistical analysis.
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32 **Results**

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34 Table 1 shows mean population, HDI, suicide mortality rate and APC (%) across the
35 provinces for years 2006-2010. Ilam and Hormozgan provinces had the highest and the
36 lowest suicide mortality rate during the study period, respectively (8.8-fold difference). Most
37 provinces (56.6%) had a suicide mortality rate of 3 to 6 per 100,000 population. In addition,
38 suicide mortality rate was more prevalent among the western provinces of Iran (**Figure 1**).
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43 The estimated APC values show that only five provinces experienced significant changes in
44 suicide mortality rate over the study period (significant increases in Ilam, Isfahan, North
45 Khorasan and Tehran provinces and significant decrease in Markazi province).
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49 Figure **2a** shows temporal changes of suicide mortality rate for the country. While the graph
50 shows a slight increase in suicide mortality rate over the study period (from 4.25 in 2006 to
51 4.88 in 2010), this was not statistically significant (APC=3.05%, P=0.23). Figure **2b** presents
52 suicide mortality rates for five quintiles of HDI and examining the trends showed that APC
53 was significant only in the highest quintile (APC=17.98, P=0.01). Figure **3** shows scatter
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graphs of HDI and suicide mortality rates. It is evident that the higher HDI was associated with the lower suicide mortality rate and Cuzick's test confirmed this ($Z=-4.61$, $P<0.011$).

Male to female rate ratio was 2.34 (95% CI 1.45-3.79) implying a significant higher suicide mortality rate among males than females over the study period. Examining this ratio in the provinces showed that in all provinces but Kordestan men had a higher suicide mortality rate than women. Excluding Tehran from the sample did not change this finding (2.33; 95% CI 1.43-3.79).

Table 2 presents the overall and social inequality measures in distribution of suicide mortality rate across the country through 2006-2010. The Gini coefficient ranged from 0.248 to 0.302 implying substantial overall inequality across the provinces. The Lorenz curves corresponded to this Gini coefficient is been shown in Figure 4. There was a 14.5% decrease in Gini coefficient between the first year and the last year of study implying decreasing overall inequality between these two points of time. Over the study period, the APC of Gini coefficient was -4.28 and statistically non-significant. Excluding Tehran resulted in a 6.9% increase in Gini coefficient between the first and the last year of the study period and a statistically non-significant APC of 1.42 was estimated.

RR was significantly lower than 1 in overall and for all years of the study period, implying a higher suicide mortality rate among people in the lowest quintile of HDI compared with the highest one. Over the study period, RR was approaching 1 and the APC of RR was 12.20 and statistically significant implying a decrease in the gap between the highest and the lowest social ranks. Although excluding Tehran from the sample did not change the overall picture of social inequality, an inverse trend (increasing social inequality) was observed.

RII_{KM} was also lower than 1 in overall and for all years of the study, showing a persistent inequality in favor of people living in the provinces with higher social rank. Temporal analysis showed that RII_{KM} did not significantly change over the study period. Adjusting for age and sex this observation. When we excluded the Tehran province, the APC value for adjusted RII_{KM} was statistically significant showing an increase in social disparity across the remaining provinces in Iran.

Discussion

In this study, for the first time, we assessed overall and social disparities in the distribution of suicide mortality across the provinces of Iran over a period of five years (2006-2010). The

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3 findings showed that suicide mortality has slightly increased over the study period. The
4 findings also indicated that there were substantial overall, gender and social disparities in the
5 distribution of suicide mortality across the country, and it was higher in the provinces with
6 lower social rank. These disparities were generally stable and persistent over the study
7 period.
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12 The findings from the current study showed an inverse association between the provinces'
13 social rank and suicide mortality in Iran. Although the studies on association between area
14 social rank and suicide mortality reported mixed results^{9,26}, the results of this study is in line
15 with previous ecological studies investigating the relationship between socioeconomic
16 characteristics and suicide rate, in particular the studies focused on high income settings^{9,27-}
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33. Rehkopf and Buka⁹ in their systematic review of suicide and socioeconomic characteristics of geographical areas found that, among studies with statistically significant results, 50% and 73% of studies reported an inverse relation between area income and education characteristics and completed suicide, respectively. They also found that the probability of reporting an inverse relationship between area social rank and suicide mortality was higher among the studies conducted in Asia (94% of studies with statistically significant results)⁹. Similar finding was reported by another study³⁴ focusing on the countries in Eastern Mediterranean region (where Iran is located), indicating that high income countries had lower suicide mortality rate than their low and middle income counterparts. It is argued that people in the provinces with lower social rank generally have more adverse experiences, poorer mental health, lower access to psychiatric services, and lower access to health facilities. These factors might partly explain higher suicide mortality rate in the provinces with lower social rank in Iran.

43 The four Western provinces of Iran (i.e., Ilam, Kermanshah, Lorestan and Hamedan) had the
44 highest suicide mortality rate in the country. One potential explanation for this observation
45 can be low socioeconomic status of these provinces. These provinces are among the
46 provinces with the highest unemployment rate and the lowest HDI in the country. High
47 divorce rates in these provinces (except for Ilam) can be another potential explanation **as**
48 **divorce is considered as a risk factor for suicide mortality**^{35,36}. In addition, cultural issues
49 such as the tribal structure of communities and the extreme fanaticism prevailing in these
50 provinces have been considered as another potential explanation for this finding³⁷.
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3 The high gender gap in suicide mortality rate observed in the current study is in line with the
4 previous epidemiological studies in Iran^{3, 4, 14} and is comparable to the studies conducted in
5 other settings, in particular high income countries^{6, 9, 38, 39}. Although many studies, including
6 the previous studies in Iran^{3, 4, 14}, have shown higher suicide attempt rate among females,
7 completed (fatal) suicides are higher among males. One potential explanation can be the
8 difference in methods of attempting suicide among males and females. For example, the most
9 common methods of attempting suicide used by males in Iran are hanging and firearms which
10 have higher fatality rate compared with self-burning method commonly used by females^{3, 14,}
11 ^{39, 40}. Greater psychosocial impact of problems, such as unemployment or retirement, on
12 males compared to female^{39, 41, 42} and adopting coping strategies such as emotional
13 inexpressiveness, lack of help-seeking, risk-taking behaviour, violence, alcohol and drug
14 abuse by males (which are triggered by norms of traditional masculinity)^{43, 44} are other
15 potential factors which have been discussed in the literature. The findings of the gender
16 analysis are important for designing and implementing suicide prevention strategies as the
17 factors, patterns, and behaviours associated with suicide are affected by gender.
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31 Temporal analysis of suicide mortality showed interesting results indicating that among five
32 quintiles of HDI, it was only the highest quintile that experienced a significant change in
33 suicide mortality over the study period. This finding potentially can be explained by
34 increasing prevalence of mental disorders, raising unemployment rate^{13, 45} and increasing
35 trend in divorce rate¹³ in the provinces with higher HDI, such as Tehran, the capital city of
36 Iran.
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41 To our knowledge, this is the first national study evaluating social inequalities across
42 different regions over time. Although this study conducted in the context of Iran, however,
43 the findings may also be applicable to other middle-income countries, in particular countries
44 in the Middle East region, which share similar culture. Moreover, we believe that, in terms of
45 methodology, our analysis present a good example for employing a triangulation of different
46 methods for evaluating inequalities in suicide mortalities. However, the current study has
47 several limitations that should be considered when interpreting its findings. Firstly, age and
48 gender differences between the provinces were naïvely adjusted which might have not fully
49 captured differences in age distribution across provinces. Secondly, there is the issue of
50 availability and quality of data on suicide which is common in developing countries settings
51 ^{26, 46} and leads to underestimation and misclassification of suicide. This might be an issue in
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3 this study because of the social stigma of suicide and religious sanctions and some legal
4 issues in the Iranian context ^{34, 4}. Moreover, the underestimation and misclassification of
5 suicide mortality might be more common in the provinces with lower social rank; therefore,
6 we expect that the social disparity to be more profound than what has been reported here.
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8 Thirdly, the current study is an ecological study using province as unit of analysis which
9 embraces substantial heterogeneity within provinces. This implies that the observed
10 disparities in suicide mortality are between-provinces and it is not necessarily applicable to
11 smaller geographic units or individuals. Furthermore, no causal inference can be drawn due
12 to ecological nature of the study and that there was no control for confounders in this study.
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19 **Conclusion**

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21 The present study indicated that there were substantial overall, gender and social disparities
22 in the distribution of suicide mortalities across the provinces in Iran. Moreover, the study
23 showed an inverse association between the provinces' social rank and suicide mortality. The
24 findings imply that prevention resources should be targeted high risk groups, in particular
25 men in the provinces with low socio-economic status. Further investigations are needed to
26 explain these disparities in suicide mortality across the provinces. Moreover, more studies
27 needed to explore the association of socio-economic factors and suicide (attempt and fatal)
28 focusing on the smaller geographical units and at the individual level in order to design better
29 prevention strategies.
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37 **List of Abbreviations**

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39 DALY: Disability-adjusted Life Years, HDI: Human Development Index, RR: rate ratio,
40 RII_{KM}: Kunst and Mackenbach relative index of inequality, APC: annual percentage change
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44 **Competing interests**

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46 The authors declare that they have no competing interests. No funding has been received for
47 the conduct of this study and/or preparation of this manuscript.
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51 **Authors' contributions**

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53 AAK was involved in the study conception and design, data collection and analysis,
54 interpretation of the data, and writing the manuscript. HHB and SS were involved in the
55 study design, results interpretation, and writing the manuscript. HS was involved in the study
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design, data collection and finalization of the manuscript. All authors read and approved the final manuscript.

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Table 1. Mean population, human development index (HDI), suicide mortality rate and annual percentage change across the provinces in Iran, 2006-2010 (Ranked by Suicide mortality rate).

	Population	HDI	Suicide mortality rate per 100,000 population	APC (%)*
Ilam	555,929	0.729	19.53	10.11
Kermanshah	1,892,100	0.748	13.74	0.46
Lorestan	1,736,946	0.761	10.64	1.18
Hamedan	1,700,960	0.740	9.59	-1.52
Gilan	2,428,553	0.769	6.52	9.98
Ardebil	1,235,234	0.735	6.22	-2.32
East Azerbaijan	3,646,459	0.763	5.58	1.31
Zanjan	973,739	0.752	5.53	12.14
Kohgiluyeh & Boyer-Ahmad	651,577	0.718	5.25	-4.20
Khuzestan	4,372,242	0.762	5.11	-7.13
West Azerbaijan	2,944,224	0.713	4.72	-2.74
Kordestan	1,453,503	0.713	4.69	5.25
Golestan	1,651,708	0.737	4.49	5.67
Overall (Iran)	72,599,045	0.758	4.46	3.05
Qazvin	1,177,582	0.783	4.25	-1.13
North Khorasan	824,979	0.759	4.24	10.64
Fars	4,431,684	0.783	4.16	1.56
Chaharmahal Bakhtiari	875,207	0.749	4.00	-7.72
Qom	1,087,011	0.773	3.75	7.89
Mazandaran	2,979,189	0.745	3.66	-5.71
Isfahan	4,680,831	0.810	3.64	4.62
Kerman	2,799,417	0.750	3.10	-5.03
Bushehr	914,710	0.786	3.02	15.55
South Khorasan	656,469	0.723	3.02	-2.28
Tehran	14,106,297	0.843	2.92	17.98
Yazd	1,028,152	0.809	2.68	-4.48
Razavi Khorasan	5,765,706	0.777	2.66	-2.64
Semnan	606,982	0.814	2.60	4.27
Markazi	1,371,514	0.785	2.38	-10.73
Sistan & Baluchestan	2,569,107	0.643	2.23	6.11
Hormozgan	1,481,031	0.766	2.21	-5.59

*Bold figures show statistically significant results (p<0.05)

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Table 2. Overall and social inequality measures of suicide mortality in Iran, 2006-2010.

	Total sample (n=30)					Overall	APC (Pvalue)
	2006	2007	2008	2009	2010		
Gini index	0.290 (0.193-0.386)	0.302 (0.212-0.392)	0.271 (0.182-0.361)	0.268 (0.165-0.371)	0.248 (0.151-0.345)	0.281 (0.240-0.322)	-4.28 (0.050)
Rate ratio*	0.359 (0.256-0.503)	0.325 (0.225-0.469)	0.428 (0.284-0.646)	0.496 (0.296-0.830)	0.535 (0.316-0.906)	0.426 (0.275-0.659)	12.20 (0.049)
RII _{KM}	0.345 (0.174-0.686)	0.257 (0.127-0.521)	0.289 (0.142-0.588)	0.337 (0.147-0.776)	0.341 (0.148-0.784)	0.339 (0.166-0.671)	1.75 (0.745)
Adjusted RII _{KM} **	0.279 (0.129-0.600)	0.205 (0.098-0.431)	0.224 (0.102-0.489)	0.133 (0.039-0.455)	0.160 (0.051-0.507)	0.171 (0.054-0.548)	-13.75 (0.073)
Sample excluding Tehran (n=29)							
Gini index	0.259 (0.168-0.350)	0.285 (0.187-0.382)	0.282 (0.187-0.378)	0.292 (0.192-0.392)	0.277 (0.191-0.363)	0.282 (0.243-0.322)	1.42 (0.38)
Rate ratio*	0.646 (0.444-0.938)	0.397 (0.226-0.695)	0.415 (0.247-0.696)	0.520 (0.277-0.974)	0.492 (0.262-0.924)	0.584 (0.380-0.896)	-6.59 (0.403)
RII _{KM}	0.460 (0.257-0.823)	0.339 (0.179-0.644)	0.352 (0.185-0.672)	0.397 (0.187-0.839)	0.389 (0.185-0.819)	0.411 (0.215-0.785)	-2.76 (0.575)
Adjusted RII _{KM} **	0.402 (0.224-0.722)	0.301 (0.168-0.541)	0.310 (0.165-0.580)	0.211 (0.077-0.577)	0.241 (0.093-0.623)	0.241 (0.090-0.649)	-12.95 (0.045)

*The highest vs. the lowest quintile of HDI
 **Adjusted for proportion of males and mean age of males and females in the provinces.

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3 **Figure 1. Distribution of suicide mortality rate across the provinces in Iran.**
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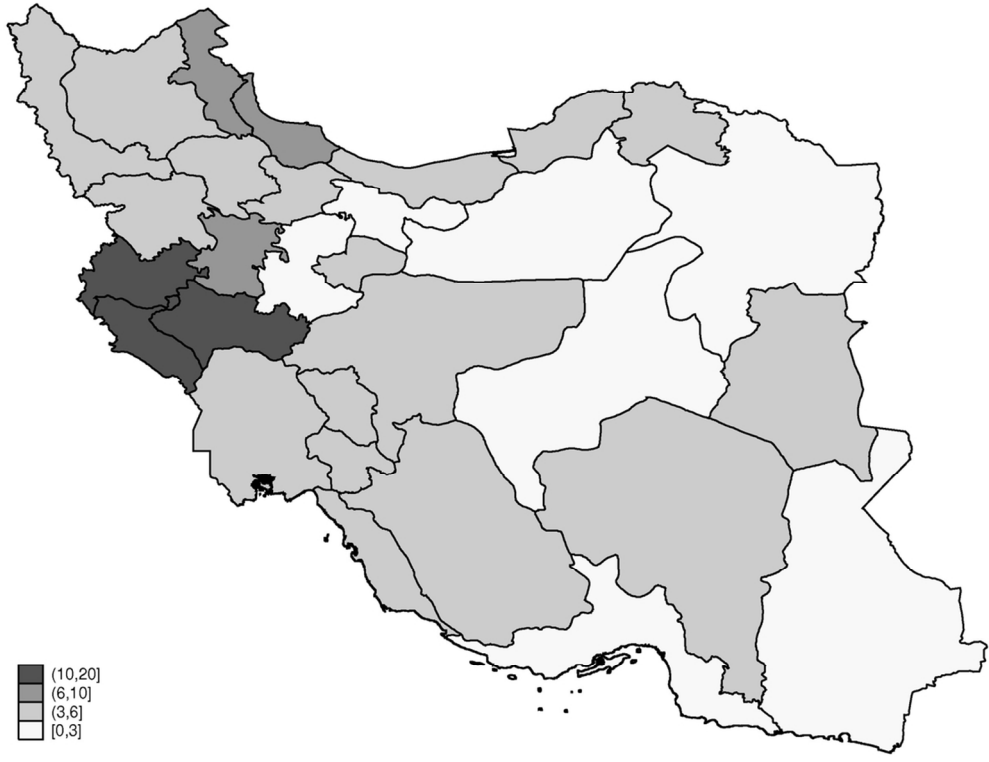
5 **Figure 1.** Suicide mortality rates per 100,000 populations in a) total sample; b) quintiles of
6 HDI, 2006-2010.
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9 **Figure 2.** Scatter plots of HDI and suicide mortality rates, stratified by year of study.
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11 **Figure 3.** Lorenz curves of the distribution of suicide mortality in Iran, 2006-2010.
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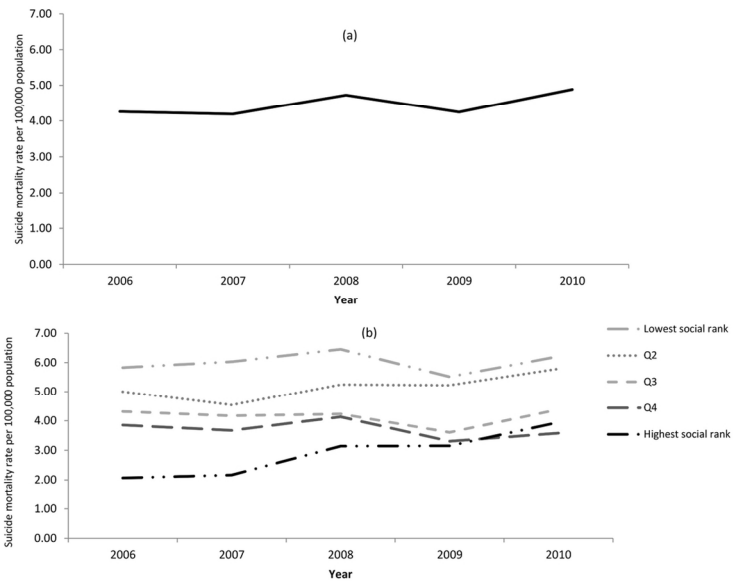
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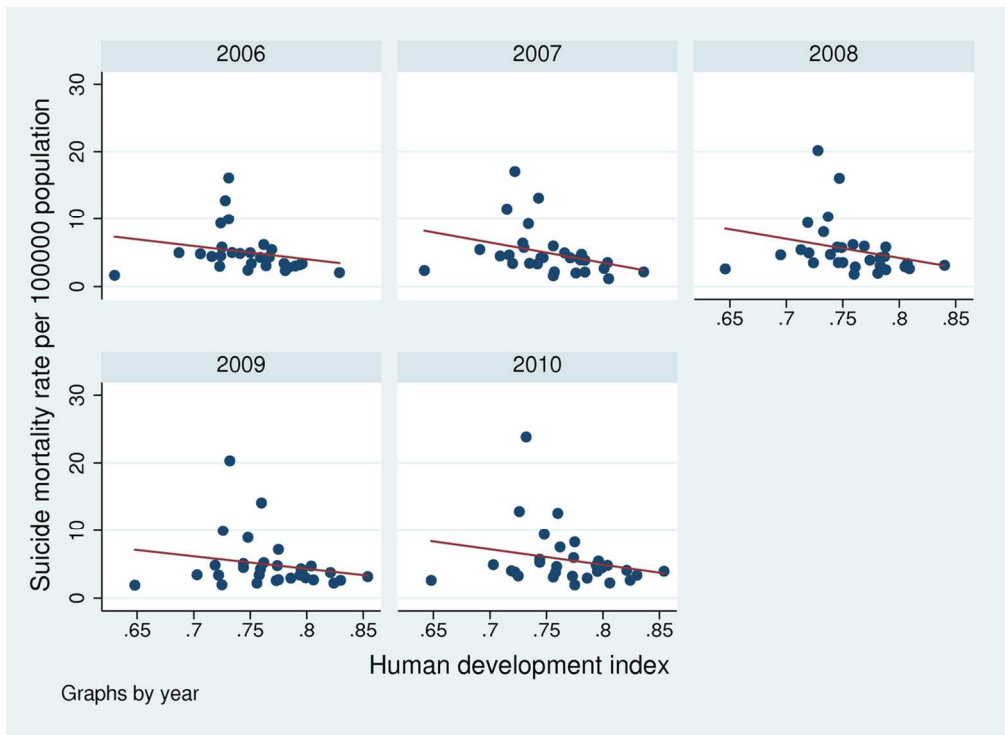
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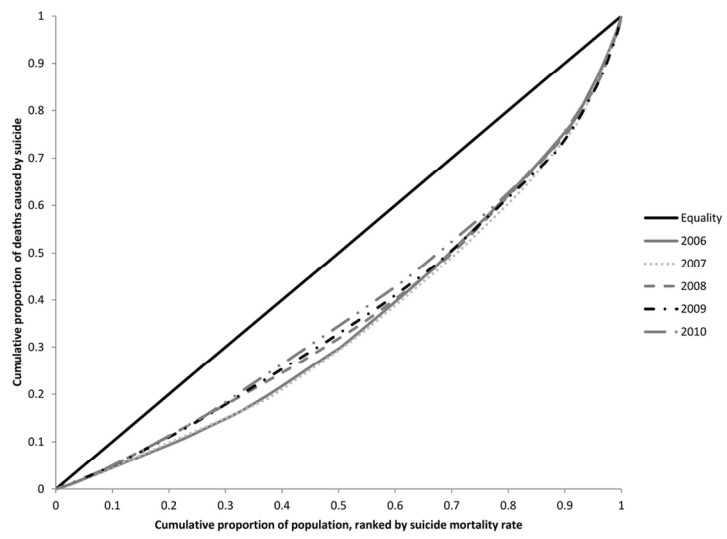
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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

Continued on next page

Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.