

Suicide Mortality Risk in Kermanshah Province, Iran: A County-level Spatial Analysis

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ABSTRACT

Background: Kermanshah province has one of the highest suicide rates in Iran. The aim of this study is to explore spatial variations in the relative risk of suicide across the counties of Kermanshah province.

Methods: This is an applied ecological study in which county-level counts of suicide deaths recorded by the forensic medicine organisation of Kermanshah province during the period March 21, 2006 to March 20, 2013 have been used. Following a Bayesian approach, Besag, York and Mollie's (BYM) model was fitted to the number of suicide deaths of males, females and all persons to make inference about the relative risk of suicide across the counties of the province.

Results: Over the study period and based on 95% credible intervals, *Kangavar, Harsin and Sonqor* counties had significantly lower relative risks of suicide for both males and females, *Salas-Babajani, Paveh, Javanrud and Ravansar* counties had significantly lower relative risks of suicide only for males and *Kermanshah* county had a significantly higher relative risk of suicide only for males. The relative risk of suicide for the other counties were not significantly different from the province's overall risk neither for males nor females.

Conclusion: The counties of Kermanshah province can be classified into four categories by the level of relative risk of suicide: low relative risk for both males and females, low relative risk only for males, high relative risk only for males and average relative risk. Findings from this study could be used to specify counties with priority for suicide prevention initiatives.

Key words: Relative Risk; Besag, York and Mollie's model; Bayesian approach; Spatial Analysis; Suicide; West of Iran

INTRODUCTION

Due to differences in ethnicity, cultures, mental health conditions and socioeconomic characteristics, suicide mortality rates vary widely by different countries and

regions [1, 2]. Identifying high-risk areas can explain the determinants of suicide from a different perspective than the individual-level risk factors and improve preventive measures [3]. For this reason, analysing the spatial heterogeneity of suicide mortality rates at national, regional and local levels has attracted the attention of many

researchers in the last few years [4-9]. Spatial statistics and disease mapping methods are used in such analyses in order to reveal areas with high suicide risk (clusters). More specifically, the Besag–York–Mollié (BYM) model is widely used in mapping of suicide risk [7, 8, 10, 11].

In Iran, the deaths by suicide showed an increasing trend in the past two decades [12, 13]. A recent national study estimated the mean national suicide mortality rate to be about 4.9 per 100000 population in 2010 and found a substantial heterogeneity across provinces and remarkably high suicide mortality rates in the western provinces of Iran [14]. In Kermanshah province, the most populated western province of Iran, the estimated suicide mortality rate is about two times more than the national average [14, 15]

Multiple factors associated with the risk of suicide at the individual level in Kermanshah province have been studied [16]. However, little has been done to identify spatial heterogeneity in risk of suicide across the counties of the province. The main aim in this study was to explore the pattern of suicide across the counties of Kermanshah province and to identify high-risk counties for men and women.

METHODS

Study Population and Data Source

Based on the 2011 National Census of Population and Housing, Kermanshah province with 1,945,227 population is the most populated province in the west of Iran. With an area of 25000 square kilometres, the

province is divided into 14 counties which contain 31 cities and towns and 2793 villages with urbanisation rate $\approx 70\%$ [17]. Figure 1 shows the counties of Kermanshah province. The western counties (*Qasr-e Shirin*, *Sarpole Zahab*, *Salas-Babajani* and *Paveh*) share a border with Iraq.

In this study, county-level counts of suicide deaths in Kermanshah province were obtained from the dataset of completed suicide cases provided by the Forensic Medicine Organization (FMO) of Kermanshah province during the period March 21, 2006 to March 20, 2013 (based on Iranian calendar time). The FMO dataset has been described and analysed in a cross-sectional study to assess factors associated with the choice of suicide method [16]. Population of the province by county and gender were extracted from the 2011 national Census of Population and Housing data reported by the Statistical Center of Iran.

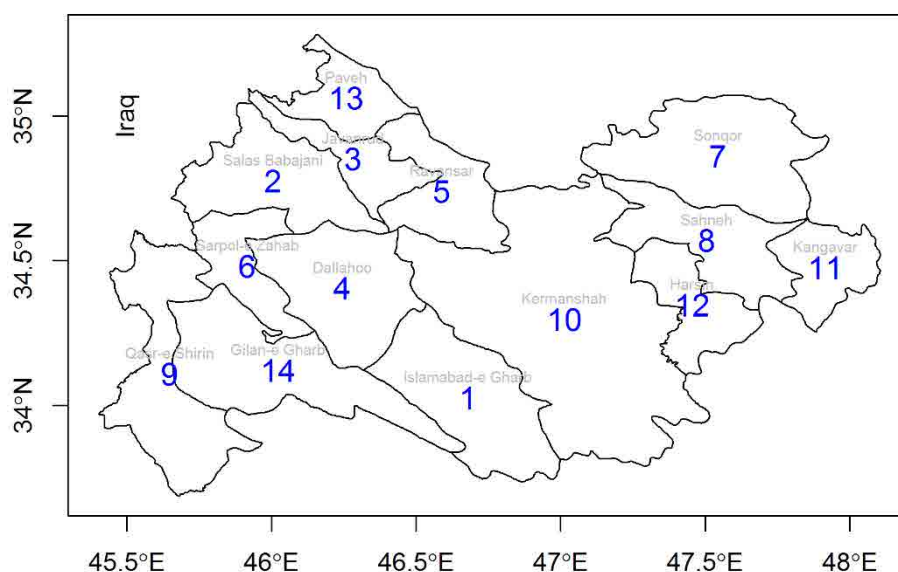
Ethics Considerations

Before receiving data, burial permit number, name and surname of the deceased were omitted due to respect to the principle of medical secrecy. No private information of the deceased who committed suicide were used in conducted analysis and obtained results and hence no informed consent was required for this study.

Statistical Analysis

Let Y_i and n_i denote, respectively, the observed number of completed suicide cases and population of

FIGURE 1. The counties of Kermanshah province, west of Iran: 1) Islamabad-e Gharb, 2) Salas-Babajani, 3) Javanrud, 4) Dallahoo, 5) Ravansar, 6) Sarpol-e Zahab, 7) Sonqor, 8) Sahneh, 9) Qasr-e Shirin, 10) Kermanshah, 11) Kangavar, 12) Harsin, 13) Paveh, 14) Gilan-e Gharb.



the i^{th} county, $i=1,K,14$, of the province. Following the disease mapping literature [18] Y_i was assumed to be distributed according to a Poisson distribution with mean $\lambda_i=E_i\theta_i$, where E_i and θ_i are, respectively, the expected number of completed suicide cases and the relative risk of suicide mortality in the i^{th} county under a null model. Considering the null model of homogenous suicide rate for the whole province, $\theta_i > 1$ ($\theta_i < 1$) indicates higher (lower) relative risk of suicide mortality for the i^{th} county than the overall province risk. Under this null model, the expected number of completed suicide cases in each county can be estimated by

$$\hat{E}_i = n_i \frac{\sum_{i=1}^{14} Y_i}{\sum_{i=1}^{14} n_i}$$

Then, the relative risk was modelled using the log-linear model

$$\theta_i = \exp(\alpha + u_i + v_i),$$

where α is the intercept term representing the mean relative risk (in logarithmic scale) of suicide across the province, v_i is the county-specific random effect representing the heterogeneity in the relative risk of suicide among the counties of the province and u_i is the structured spatial random effect representing the correlation between the neighbouring counties. For the random effects, $v_i, K, v_{1,4}$ were assumed to be independent and identically distributed according to a Gaussian distribution with mean zero and precision (inverse of variance) τ_v and given $\{u_i; j \neq i\}$. u_i was assumed to follow a Gaussian distribution with mean

$\frac{1}{m_i} \sum_{j \neq i} w_{ij} u_j$ and precision $m_i \tau_u$, where $m_i = \sum_{j \neq i} w_{ij}$, $w_{ij} = 1$ if the i^{th} and j^{th} counties are neighbours and $w_{ij} = 0$ otherwise. The considered model is called the Besag–York–Mollié (BYM) model, which is the most widely used parametric model in disease mapping [19]. According to this model, the relative risk θ_i is factorised into the province overall relative risk $\exp(\alpha)$ and the county-specific relative risk

$$\xi_i = \frac{\theta_i}{\exp(\alpha)} = \exp(u_i + v_i)$$

To conduct a Bayesian inference, the non-informative prior (improper uniform distribution on the real line) for α and standard Gaussian priors for both $\log \tau_v$ and $\log \tau_u$ were considered. Instead of a Monte Carlo Markov Chain (MCMC) algorithm, characteristics of the posterior distributions of parameters and random effects were obtained by the integrated nested Laplace approximation (INLA) method [20] using the R [21] package R-INLA

[22, 23]. More specifically, posterior means, standard deviations, and 95% credible intervals for α , τ_v and τ_u were obtained. In addition, posterior means and 95% credible intervals for the relative risks $\theta_i, K, \theta_{1,4}$ were also calculated and the map of posterior mean of the county-specific relative risk ξ_i was produced to assess the heterogeneity of suicide mortality relative risk across the counties of Kermanshah province. The probability of excess risk

$$P(\xi_i > 1 | Y_1, K, Y_{14})$$

was also calculated to take into account the uncertainty of ξ_i [22]. The results were obtained for males, females and all persons.

RESULTS

The observed and estimated expected number of completed suicide cases in each county of Kermanshah province for males, females and all persons are given in Table 1. Table 2 summarises the posterior means, standard deviations, and 95% credible intervals for parameters of the fitted BYM models to the number of suicide deaths of males, females and all persons. The posterior mean of proportion of variance explained by the structured spatial random effect u_i , i.e. $\tau_u / (\tau_u + \tau_v)$, is 52.9% for males, 54.5% for females and 53.8% for all persons. This means that the county-specific random effect v_i and the structured spatial random effect u_i have nearly the same contribution to the total spatial heterogeneity of suicide risk across the province.

Figure 2 shows the map of posterior mean and probability of excess risk of the county-specific relative risk ξ_i . The posterior means of the county-specific relative risk are categorised into very low (0.3-0.75), low (0.75-0.95), medium (0.95-1.05), high (1.05-1.25) and very high (1.25-1.8) relative risk groups and the excess risk probabilities are categorised into low (0-0.25), medium (0.25-0.75) and high (0.75-1) probability groups. The maps reveal heterogeneity in the suicide mortality relative risk across the counties of Kermanshah province. It can be seen that for males, the northwestern counties (*Salas-Babajani, Javanrud, Ravansar and Paveh*) fall into the very low relative risk category. Thus, the risk of suicide mortality for males in these counties is, in average, half of the overall province risk. This fact is also reflected in the probability of excess risk for males, which is low for these counties. On the other hand, *Qasr-e Shirin, Sarpole Zahab, Islamabade Gharb, Kermanshah and Sahneh* are counties with very high relative risks and high probabilities of excess risk. The risk of suicide mortality for males in these counties is, in average, 1.5 times more than the overall province risk.

TABLE 1. The observed (Y_i) and estimated expected (\hat{E}_i) number of cases in each county of Kermanshah province, from 3/21/2006 to 3/20/2013, for men, women and both sexes combined. The corresponding populations (n_i) of counties are obtained from the 2011 national census of population and housing.

County	ALL			MEN			WOMEN		
	Y_i	n_i	\hat{E}_i	Y_i	n_i	\hat{E}_i	Y_i	n_i	\hat{E}_i
Islamabade Gharb	150	151473	138.06	99	76025	82.78	51	75448	55.131
Salas-Babajani	15	38475	35.07	2	19679	21.43	13	18796	13.734
Javanrud	46	71235	64.93	16	35971	39.17	30	35264	25.768
Dallahoo	38	39837	36.31	17	19703	21.45	21	20134	14.712
Ravansar	33	46411	42.30	11	23695	25.8	22	22716	16.599
Sarpol-e Zahab	94	85616	78.04	52	43012	46.83	42	42604	31.131
Sonqor	49	91935	83.79	35	46194	50.3	14	45741	33.423
Sahneh	81	76678	69.89	49	38266	41.66	32	38412	28.068
Qasr-e Shirin	29	25517	23.26	18	14561	15.85	11	10956	8.006
Kermanshah	1062	1030978	939.69	673	520382	566.6	389	510596	373.097
Kangavar	42	81051	73.87	30	40707	44.32	12	40344	29.480
Harsin	48	86342	78.70	31	43192	47.03	17	43150	31.530
Paveh	28	56837	51.80	10	28630	31.17	18	28207	20.611
Gilan-e Gharb	58	62858	57.29	26	31779	34.6	32	31079	22.710

TABLE 2. Posterior means (M), standard deviations (SD) and 95% credible intervals of parameters of the BYM models fitted to the number of suicide cases in Kermanshah province, for males, females and all persons.

	PARAMETER	M	SD	95% CI	
	All	exp (α)	0.822	0.0736	0.644
τ_u		8.575	5.99	1.979	24.255
τ_v		7.26	5.205	1.581	20.839
Males	exp (α)	0.675	0.0800	0.484	0.903
	τ_u	5.141	3.782	1.091	15.065
	τ_v	4.419	3.274	0.993	13.002
Females	exp (α)	0.948	0.0920	0.729	1.207
	τ_u	8.224	5.904	1.804	23.683
	τ_v	6.6	4.676	1.505	18.862

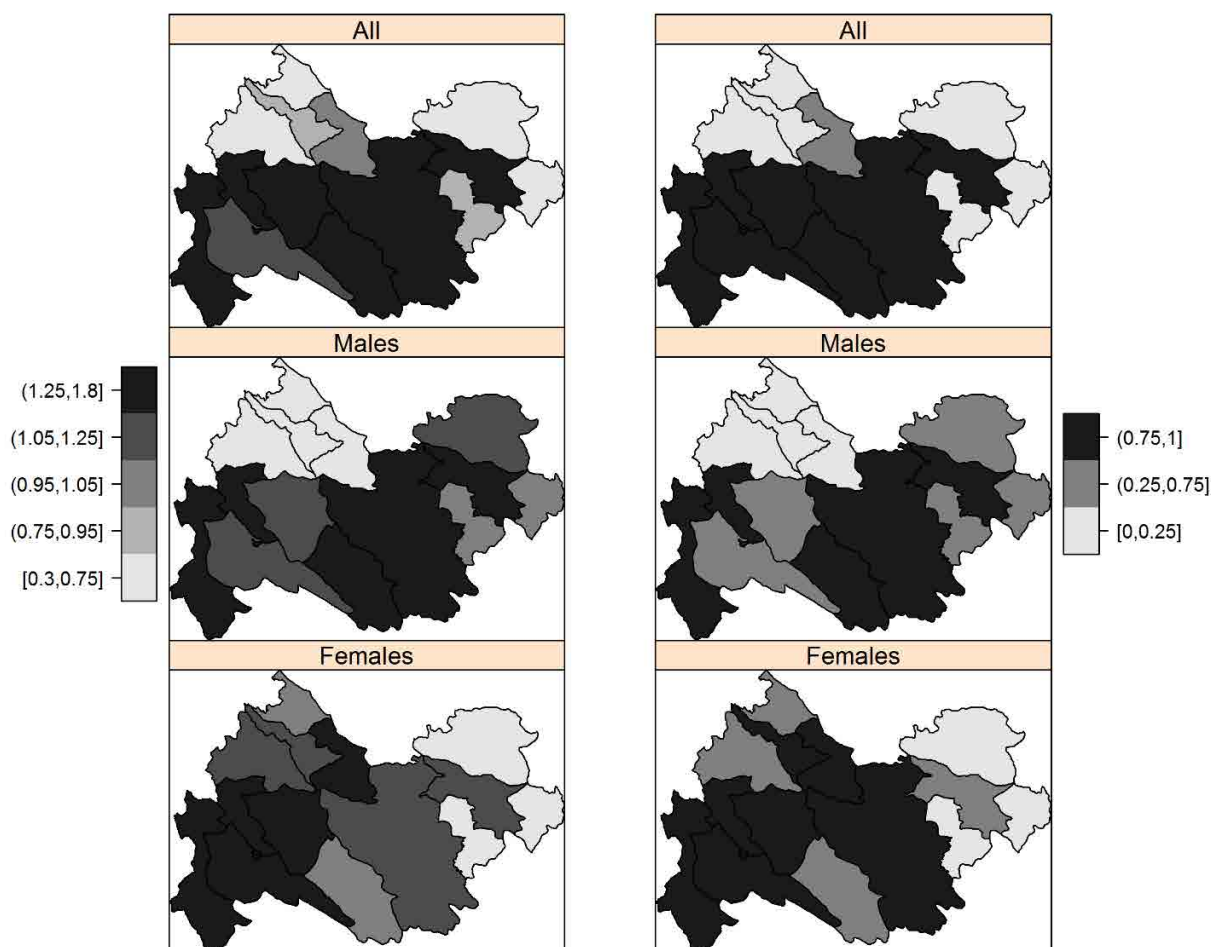
For females, *Sonqor*, *Harsin* and *Kangavar* are counties with very low suicide mortality relative risks and low excess risk probabilities while *Qasr-e Shirin*, *Sarpol-e Zahab*, *Dallahoo*, *Ravansar* and *Gilan-e Gharb* have very high suicide mortality relative risks. Moreover, the probability of excess risk for *Javanrud* is high.

For all persons, *Sonqor*, *Harsin*, *Kangavar*, *Paveh*, *Salas-*

Babajani and *Javanrud* are counties with low probabilities of excess risk and very low or low suicide mortality relative risks, *Ravansar* has medium relative risk and probability of excess risk and the rest of counties have high probabilities of excess risk and very high or high relative risks.

Instead of county-specific relative risk ξ_i , posterior mean and 95% credible interval for the total relative

FIGURE 2. Posterior mean (left) and excess probability (right) of the county-specific relative risk of the counties of Kermanshah province, compared to the whole province risk.



risk θ_i of each county are presented in Table 3. If its corresponding 95% credible interval contains one, it can be inferred that the relative risk θ_i is not significantly (at the 0.05 level) different from one. Based on this argument, *Salas Babajani* (0.226), *Paveh* (0.351), *Javanrud* (0.420), *Ravansar* (0.458), *Harsin* (0.680), *Kangavar* (0.695) and *Sonqor* (0.713) for males, *Kangavar* (0.463), *Sonqor* (0.480) and *Harsin* (0.590) for females and *Salas-Babajani* (0.505), *Paveh* (0.566), *Kangavar* (0.588), *Sonqor* (0.604), *Harsin* (0.630) and *Javanrud* (0.714) for all persons have significantly less than one relative risks. On the other hand, *Kermanshah* county has significantly greater than one relative risk for males (1.186) and all persons (1.129).

DISCUSSION

As already noted, Kermanshah province had the second highest suicide mortality rate in the whole country

[14]. In the present study, the aim was to identify and assess variations in the risk of suicide by gender across the counties of Kermanshah province. In this study, we found substantial gender inequality in the distribution of suicide mortality across the counties in Kermanshah province. Also we found that *Kangavar*, *Harsin* and *Sonqor* counties had significantly lower relative risks of suicide for both males and females, *Salas Babajani*, *Paveh*, *Javanrud* and *Ravansar* counties had significantly lower relative risks of suicide only for males and *Kermanshah* county had a significantly higher relative risk of suicide only for males over the study period. The relative risk of suicide for the other counties were not significantly different from the province's overall risk neither for males nor for females. Thus, the counties of Kermanshah province can be classified into four categories by the level of relative risk: low relative risk for both males and females, low relative risk only for males, high relative risk only for males and average relative risk. In line with previous studies [15, 16], the results indicate gender differences in the risk of suicide

TABLE 3. Posterior means (M) and 95% credible intervals of the relative risks of the counties of Kermanshah province, obtained from the fitted BYM models, for males, females and all persons.

County	ALL			MALES			FEMALES		
	M	95% CI		M	95% CI		M	95% CI	
<i>Islamabad-e Gharb</i>	1.086	0.922	1.263	1.191	0.97	1.432	0.944	0.712	1.205
<i>Salas-Babajani</i>	0.505	0.309	0.741	0.226	0.0795	0.435	1.018	0.600	1.545
<i>Javanrud</i>	0.714	0.53	0.923	0.420	0.251	0.632	1.168	0.807	1.594
<i>Dallahoo</i>	1.038	0.751	1.371	0.794	0.4862	1.18	1.384	0.899	1.987
<i>Ravansar</i>	0.787	0.557	1.056	0.458	0.2527	0.724	1.296	0.847	1.848
<i>Sarpole Zahab</i>	1.196	0.97	1.442	1.094	0.8212	1.403	1.348	0.987	1.763
<i>Sonqor</i>	0.604	0.454	0.774	0.713	0.5042	0.954	0.48	0.286	0.718
<i>Sahneh</i>	1.139	0.908	1.395	1.163	0.8657	1.501	1.087	0.753	1.485
<i>Qasr-e Shirin</i>	1.24	0.847	1.706	1.129	0.6866	1.68	1.392	0.762	2.23
<i>Kermanshah</i>	1.129	1.063	1.197	1.186	1.0988	1.276	1.042	0.942	1.146
<i>Kangavar</i>	0.588	0.43	0.767	0.695	0.4769	0.951	0.463	0.263	0.716
<i>Harsin</i>	0.63	0.471	0.81	0.680	0.4698	0.925	0.590	0.364	0.865
<i>Paveh</i>	0.566	0.387	0.776	0.351	0.1843	0.57	0.922	0.575	1.347
<i>Gilan-e Gharb</i>	1.02	0.784	1.286	0.773	0.5183	1.076	1.398	0.978	1.893

across the counties of *Kermanshah* province. This finding is associated with an adverse experiences due to low socio-economic status of *Kermanshah* province in Iran [14].

This study provided the first evidence in *Kermanshah* province on the spatial heterogeneity of suicide mortality in the county-level. However, identifying the possible causes of this heterogeneity is beyond the scope of this paper and an issue that needs further research from different points of view. Such studies should take into account the impact of the Iran-Iraq war (1980-1988) on each county of *Kermanshah* province, as well as rapid urbanisation and socio-cultural transformation in the province [16, 24], which intensified conflicts between traditions and modernity. Nevertheless, findings from this study could be used to specify priority counties for suicide prevention initiatives.

Due to data limitations and unavailability, important county-level factors such as human development index and multidimensional poverty index were not included in the analysis. Also, lack of data prevented us from providing the relative risk of suicide by suicide method and age group. Hopefully, a more comprehensive study can be carried out when more information is available.

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Conflict of Interest

The authors declare that they have no conflicts of interest in this study.

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