

Spatial analysis of myocardial infarction in Iran: National report from the Iranian myocardial infarction registry

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Background: Myocardial infarction (MI) is a leading cause of mortality and morbidity in Iran. No spatial analysis of MI has been conducted to date. The present study was conducted to determine the pattern of MI incidence and to identify the associated factors in Iran by province. **Materials and Methods:** This study has two parts. One part is prospective and hospital-based, and the other part is an ecological study. In this study, the data of 20,750 new MI cases registered in Iranian Myocardial Infarction Registry in 2012 were used. For spatial analysis in global and local, spatial autocorrelation, Moran's I, Getis-Ord, and logistic regression models were used. Data were analyzed by Stata software and ArcGIS 9.3. **Results:** Based on autocorrelation coefficient, a specific pattern was observed in the distribution of MI incidence in different provinces (Moran's I: 0.75, $P < 0.001$). Spatial pattern of incidence was approximately the same in men and women. MI incidence was clustering in six provinces (North Khorasan, Yazd, Kerman, Semnan, Golestan, and Mazandaran). Out of the associated factors with clustered MI in six provinces, temperature, humidity, hypertension, smoking, and body mass index (BMI) could be mentioned. Hypertension, smoking, and BMI contributed to clustering with, respectively, 2.36, 1.31, and 1.31 odds ratio. **Conclusion:** Addressing the place-based pattern of incidence and clarifying their epidemiologic dimension, including spatial analysis, has not yet been implemented in Iran. Report on MI incidence rate by place and formal borders is useful and is used in the planning and prioritization in different levels of health system.

Key words: Myocardial infarction, spatial epidemiology, spatial analysis

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INTRODUCTION

High prevalence and incidence of myocardial infarction (MI) as the most important cardiovascular disease and the reason for death has no geographical, spatial, gender, and social limit.^[1,2] Mortality rate, per 100,000 population, due to these diseases is 265 worldwide, 224 in Eastern Mediterranean, and 171 in Iran.^[2,3] By 2020, cardiovascular disease-associated mortalities will increase by 15% in developed countries, 77% in China, and 106% in other Asian countries.^[2,4] In epidemiologic studies, MI incidence rate in a population could be used as an index or alternative for estimation of coronary heart diseases and their burden.^[5,6] Identifying and determining the pattern of geographical distribution and spatial analysis of MIs contributes significantly to implementing the plans and focusing on creative, novel initiatives in health system and mitigating disparity in cardiovascular diseases. Person, time, and place comprise three basic components in epidemiologic

studies and health planning. Place is a subdiscipline of health geography.^[7-9] This discipline addresses the spatial distribution of health outcome and geographical variations in diseases and their risk factors in the human population.^[10,11] Epidemiologic studies have mainly placed greater emphasis on two elements of person and time rather than place. With developments in the geographic information system as a powerful, speedy tool, spatial patterns could be investigated in epidemiologic studies and health management.^[10-12] Identifying the patterns of MI incidence, the patterns of random, dispersed and cluster are important for management of MI.^[12,13] Spatial analysis is frequently used for infectious diseases and cancer incidence.^[13-15] This approach has been rarely used for cardiovascular diseases.^[15] In Iran, no spatial analysis of MIs has been conducted to date. The present study was conducted to analyze MI spatially and determine the pattern of MI geographical distribution in Iran by province.

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MATERIALS AND METHODS

This study has two parts. One part is prospective and population-based, and the other part is an ecological study. In this study, the data of Iranian Myocardial Infarction Registry in all hospitals equipped with a Cardiac Care Unit in 31 provinces of Iran were used. Iran is one of the South-Western Asian (Middle East) countries. It is bordered by Afghanistan and Pakistan from east, Turkmenistan from north-east, Caspian Sea from the middle north, Azerbaijan and Armenia from north-west, Turkey and Iraq from west, and Persian Gulf and Oman sea from south.^[16] Inclusion criteria were based on World Health Organization (WHO) and World Heart Federation definition of MI diagnosis by International Classification of Diseases (the codes I22, I21).^[6] The patients with MI history or nondefinite diagnosis made by the specialist were excluded from the study. The data on age, gender, and the province of residence were collected. Crude incidence rates were calculated for each province and whole country per 100,000 individuals based on sex. For the calculation of actual incidence rate in denominator, the data of population census by Statistical Center of Iran in 2011 were used. To adjust for age and gender effects on geographical scales, direct standardization method and WHO standard population were used. For spatial analysis, global and local indicators of spatial autocorrelation, Moran's I, and Getis-Ord were used. Moran's I generally lies between +1 and -1. A Moran's I of zero indicates the null hypothesis of no clustering, a positive Moran's I indicates positive spatial autocorrelation (i.e., clustering of areas of similar attribute values), while a negative coefficient indicates negative spatial autocorrelation (i.e., neighboring areas tend to have dissimilar attribute values). The Getis-Ord is an indicator of local clustering that measures the concentration of a spatially distributed attribute variables. By comparing local estimates of spatial autocorrelation with global averages, the Getis-Ord identifies hot spot in spatial data. The local Moran's I detects local spatial autocorrelation in aggregated data by decomposing Moran's I statistic into contributions for each area within a study region. These indicators detect clusters of either similar or dissimilar MI frequency values around a given observation.^[17-19] To identify the factors associated with the spatial distribution of MI in ecological study (a binary response indicating the presence or absence of MI clustering at a given location), multiple logistic regression was used to model and simultaneously examine the variables' effect and to control confounding variables. The unit of analysis in the regression is a group of people, typically defined by geography. In ecological analysis of the study, MI risk factors (hypertension, diabetes, body mass index [BMI], smoking, diet, obesity, and blood lipid disorder) were used as group (prevalence rate) across the provinces. These factors were obtained from the national study of noncommunicable diseases (NCDs) risk factors

in Iran and meteorological data (temperature, relative humidity, altitude, and precipitation) of the provinces from Iran Meteorological Organization. The methodology of the survey was based on WHO's STEPwise approach to NCD surveillance. The methodology has been already described in other sources.^[4,20,21] Data were analyzed by Stata Software (Stata Corp. 2011. Stata Statistical Software: Release 12. College Station, TX: Stata Corp LP) and ArcGIS (ESRI 2011. ArcGIS Desktop: Release 9.3).

RESULTS

Of 20,750 new cases of MI, 15,033 (72.4%) were male and the rest female. The mean age at MI development was by place significantly different among the provinces. Mean \pm standard deviation of age was 59.6 ± 13.3 years in men, 65.4 ± 12.6 in women, and 61.2 ± 13.4 in the whole population. The mean age at MI incidence was significantly different among the provinces.

Based on the coefficient of global autocorrelation (spatial autocorrelation), a specific pattern was observed in the distribution of MI incidence in different provinces (Moran's Index: 0.751, variance: 0.017, Z-Score: 5.86 and $P < 0.001$).

Coefficient of global autocorrelation per sex is shown in Table 1. Figure 1 depicts spatial pattern of MI incidence by gender. MI incidence was clustering in six provinces (North Khorasan, Yazd, Kerman, Semnan, Golestan, and Mazandaran) Map A [Figure 1]. Spatial pattern of incidence was observed as clustering for men in six provinces (North Khorasan, Yazd, Kerman, Semnan, Quazvin, and Mazandaran) and for women in six provinces (North Khorasan, Yazd, Kerman, Semnan, Golestan, and Mazandaran) Maps B and C [Figure 1].

Table 2 indicates the results of spatial analysis and clusters. Figure 2 shows MI incidence hot spot in Golestan, Mazandaran, Quazvin, Zanjan, Yazd, North Khorasan, South Khorasan, Razavi Khorasan, Isfahan, Hamadan, and Semnan provinces Maps D, E, and F [Figure 2] show hot spot analysis for all, male, and female patients, respectively.

After entering different risk factors and meteorological factors in different logistic regression models, five variables were

Table 1: Coefficient of global autocorrelation for patterns of MI incidence in Iran in 2012

Statistic	Total	Male	Female
Moran's Index	0.751	0.748	0.74
Variance	0.017	0.017	0.017
Z	5.86	5.83	5.77
P	0.0001	0.0001	0.0001

MI = Myocardial infarction

found as associated with clustered MI. Out of the associated factors with clustered MI in six provinces, temperature, humidity, hypertension, smoking, and BMI could be mentioned. Odds ratios (OR) of the associated factors with clustering are shown in Table 3. Hypertension, smoking,

and BMI contributed to clustering with, respectively, 2.36, 1.31, and 1.31 OR. The highest OR was obtained for hypertension, followed by BMI and smoking. Calculated ORs for the temperature and humidity were inversely correlated with mortality, MI: (0.97: 0.096-0.98) and (0.95: 0.93-0.97), respectively, OR = 95% confidence interval.

Table 2: Local autocorrelation for cluster detection and hot spot analysis (Getis-Ord) in six provinces in Iran

Cluster	Province	Local autocorrelation			Getis-Ord	
		LMi Index	Moran's I score	P	LGi score	P
1	Golestan	3.47	2.11	0.035	2.78	0.005
2	North Khorasan	4.9	3.1	0.002	2.33	0.019
3	Kerman	4.64	2.23	0.025	1.88	0.059
4	Semnan	6.33	2.49	0.012	2.02	0.043
5	Yazd	4.9	2.59	0.009	2.13	0.032
6	Mazandaran	4.77	2.12	0.033	2.49	0.012

DISCUSSION

The present work is the first report on spatial analysis of MIs in Iran. Cardiovascular diseases are the first reason for death in Iran and impose a large burden on community. Addressing the place-based pattern of incidence and clarifying the epidemiologic dimension, including spatial analysis, has not yet been implemented in Iran. Therefore, the necessity of conducting this research is highly obvious to help decision makers and planners in the health system. Through these findings, the plans concerning prevention and control of cardiovascular

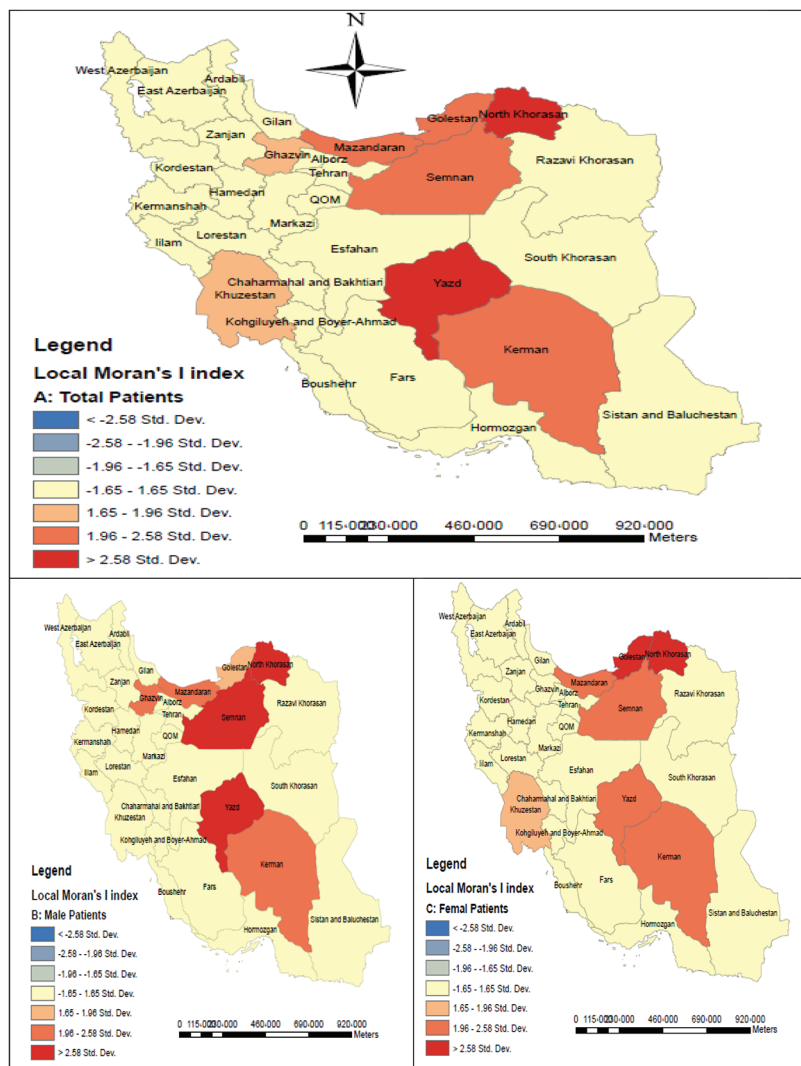


Figure 1: Cluster analysis: Z Score of Moran's I for male, female and total patients with myocardial infarction in Iran; 2012

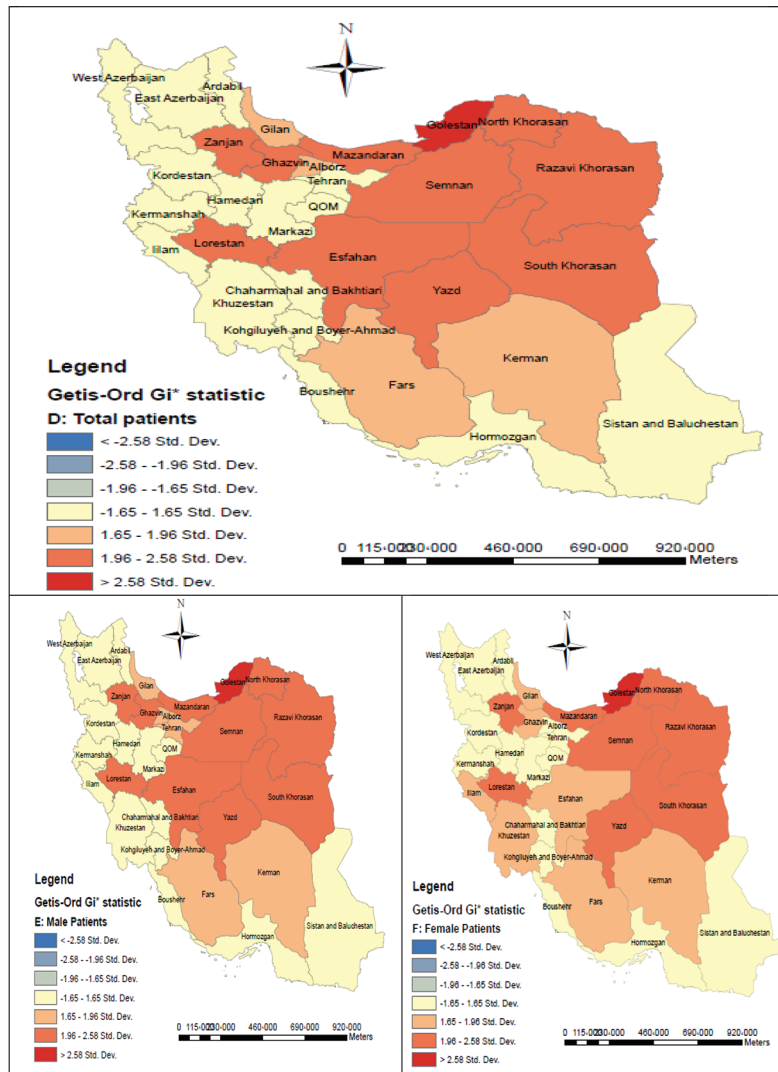


Figure 2: Hot spot analysis: Z Score of Getis-OrdGi* statistic (spatial statistics) for male, female and total patients with myocardial infarction in Iran; 2012

Table 3: OR in logistic regression model for influencing the presence clustering of MI in Iran; 2012

Explanatory variable	OR	95% CI: OR	P
Mean temperature	0.97	0.96-0.98	0.001
Relative humidity	0.95	0.93-0.97	0.001
Hypertension*	2.36	2.26-2.46	0.001
Smoking*	1.31	1.28-1.34	0.001
BMI	1.31	1.23-1.40	0.001

*Prevalence; CI = Confidence interval; OR = Odds ratio; BMI = Body mass index; MI = Myocardial infarction

diseases and MI, as the most important cause of death, could be desirably implemented.^[22] Considering the limited resources and detecting the population at risk by place at provincial scale, prioritization in resource allocation and plans implementation in line with different levels of prevention (primary, secondary, tertiary) could be conducted more efficiently. In this study, the hypothesis of random incidence of MI at national scale was examined by spatial analysis and global Moran's I.

This hypothesis was not confirmed. Therefore, at global scale, MI incidence in Iran was observed as clustering. Then, this analysis was done at provincial scale, and MI incidence was found as clustering in six provinces. Spatial pattern of incidence was approximately the same in men and women. The results of our study are consistent with those of a study in Australia, reporting clustering incidence of MI.^[15] By comparison, it is fully obvious that incidence rate of MI in Iran is higher than that in Japan.^[23] This rate is higher in Spain and Finland compared to Iran. In Finland, incidence rate is the same in men and women, but spatial pattern is various. Our study results are consistent with spatial difference in incidence observed in the study of Finland.^[24,25] In a study in the USA, the standardized incidence rate of MI in 20 states was reported 22.2-39.7/100,000 population of 35 years old and over in 2008. That study reported large geographical variations among the states. The comparison between our work with the study of US states indicates that the

incidence rate in Iran's provinces is variable similar to that in the US states, but incidence rate in Iran is higher compared to the USA.^[26] Our findings are in agreement with a study in Brazil in which out of 35 studied regions, 31.4% of the regions had an MI incidence above national mean incidence and also MI incidence was unequal among different regions.^[27]

Our findings are consistent with those of the studies conducted in Canada, Australia, and Finland, reporting temperature, relative humidity, and hypertension as MI risk factors.^[15,24,27,28] The difference in MI incidence rate could be explained by various genetic, environmental factors or disparity of the disease risk factors in different provinces and socioeconomic classes. This issue requires further investigation in subsequent works. Although the quality of hospital registry of MI in Iran has been reported as acceptable,^[29] failure to register MI cases who die outside hospital and no link between the MI and mortalities registry were of the limitations of this work and should be addressed in future research alongside periodical assessment of MIs registry to examine the precision of the registered cases until registry of data of MIs will become stable across Iran. Being population-based, including all provinces of the country, and estimating the incidence based on formal, provincial borders and the population reported by Statistical Center of Iran per WHO standards, and definite diagnosis by the cardiologist could be considered as strengths of our work. In addition, this was the first report on MI incidence in Iran. Ecological fallacy bias due to ecological analysis of the study and including grouped variables into analysis model are of limitations of this study, needing special interpretation. Ecological inferences will, therefore, continue to be made. Aggregate data are often easier to obtain than data on individuals, and may offer valuable clues to individual behavior.^[30,31] The problems of confounding and aggregation bias, however, are unlikely to be resolved in near future. Deeper and more extensive studies should be conducted in six provinces of the country, where MI clustering was noted, to determine the reasons for clustering.

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AUTHOR'S CONTRIBUTIONS

AA contributed in the conception of the work, conducting the study, revising the draft, approval of the final version of the manuscript, and agreed for all aspects of the work. HS, KE and YM contributed in the conception of the work, drafting and revising the draft, approval of the final version of the manuscript, and agreed for all aspects of the work. All of the authors reviewed drafts of the article and contributed to the conceptual framework.

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