Myocardial Infarction Iincidence at the Northwest of Iran 2014–2018: A Spatial Analysis

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Research Article

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Abstract

Background

Myocardial Infarction (MI) is a major important public health concern and has huge burden on health system across the world. This study aimed to explore the spatial variation of MI incidence and investigate if there is a spatial clusters in the MI patterns among rural areas in Zanjan province, Iran.

Materials & Methods

This was a retrospective and geospatial analysis study using MI incidence data from 2014-2018 from nine hospital information system databases. Three different spatial analysis methods (Spatial autocorrelation, hotspot analysis and cluster and outlier analysis) were used to identify potential clusters and high-risk areas of MI incidence at the study area.

Results

3,820 patients were registered at Zanjan hospitals due to MI during 2014-2018. The age-adjusted incidence rate of MI was 343 cases per 100,000 person which raised from 88 cases in 2014 to 114 cases in 2018 per 100,000 person (a 30% increase, $P<0.001$). Golabar region had the highest incidence rate of MI (515 cases per 100,000 person). Five hotspot and one high-high cluster were detected using spatial analysis methods.

Conclusion

This showed that there is a great deal of spatial variations in the pattern of MI incidence in Zanjan province. The high incidence rate of MI in the study area compared to the national average, is a warning to local health authorities to determine the possible causes of disease incidence and potential drivers of high-risk areas. The spatial cluster analysis provided new evidence for policy-makers to design tailored interventions to reduce MI incidence and allocate health resource to unmet need areas.

Introduction

It is well known that cardiovascular diseases (CVD) are one of the most important public health concerns across the world.(1) Myocardial infarction (MI) is one of the most important CVD that can lead to serious complications and even death when occurs.(2) The incidence of MI, commonly known as a heart attack, has no geographic, socioeconomic, or gender boundaries.(3) The mortality rate of MI was 265 cases in the world, 224 cases in the Eastern Mediterranean, and 221 cases per 100,000 person in Iran.(4, 5) Most of these deaths can be prevented by controlling behavioral and environmental risk factors. Individual characteristics, lifestyle, and environmental factors play an important role in MI incidence. (6–8) Most of these risk factors may interact with each other and increase the incidence rate of MI. A study by Namayande in 2016, for example, reported a significant relationship between the incidence of MI and environmental factors such as air pollution and heavy metals like lead, mercury, selenium, cobalt, nickel.(9)

Spatial analyses of MI incidence will generate new knowledge to identify high risk areas and investigate potential impact of environmental risk factors on MI incidence.(10–12) Geographic Information Systems (GIS) is a powerful tool to support geocoding MI patients' locations, conducting spatial analysis and visualizing the MI incidence patterns at finer geography level. GIS has the capacity to link spatial data with different source of MI attribute data to develop a big picture for the MI incidence pattern across communities. This would enable policy-makers to identify high risk areas of MI incidence and potential associated risk factors.(12, 13)

A number of studies examined the spatial distribution and the impact of environmental factors on MI incidence. A study by Liu used Moran's I and hotspot analysis to explore the spatial pattern of MI in Calgary, Canada from 2004 to 2013 which determined MI hotspots in older and low socioeconomics communities.(14) The results of spatial analysis of acute MI incidence in Denmark showed that people who lived in MI clusters had a significantly lower economic status compared to the people who lived outside of MI clusters.(15) Spatial hotspot analysis of MI in an urban population in Yazd province, Iran showed a significant relationship between the proximity of MI clusters and industrial facilities, especially steel factories.(9) A study by Ahmadi in 2016 reported a specific pattern in the spatial distribution of MI among different provinces of Iran (Moran's I: 0.75, $P < 0.001$) and MI was clustered in six areas of Iran included Semnan, Yazd, Kerman, North Khorasan, Mazandaran and Golestan provinces.(16)

Although spatial analysis of MI conducted in several countries across the world (10, 13–16), it has not yet been examined thoroughly at rural district levels (a finer geography level) and the majority of current spatial analyses of MI were conducted at country scales (16). Presently, there is little knowledge about the incidence rate of MI among rural areas. Zanjan province is an important industrial city with highly developed lead and zinc mines in Iran which most of them are located close to counties and rural areas. Spatial analysis of MI incidence generate new knowledge on spatial variations of MI incidence across communities at rural and urban areas and help to identify unmet areas where the MI incidence risk is greater.(16) Spatial analysis of MI at finer geography level will enable policy makers to tailor prevention strategies to areas where the MI risk is greater. The aim of this study is threefold; 1) investigate spatial pattern of age-adjusted MI incidence 2) explore the potential significant clusters (hot or cold spots) and (3) visualize the spatial pattern of MI incidence at districts levels in rural areas of Zanjan province.

Materials & Methods

This study was a retrospective and geospatial analysis of MI incidence at Zanjan province in 2021. Zanjan province is one of the 44 provinces of Iran located at the northwest which included 48 rural district and 8 counties with a population of 1,057,461 person and with an area of 291.27 square kilometer. (Fig. 1) Data were obtained from nine hospital information system (HIS) databases. Data included sex, discharge diagnosis code, residence address, admission date and discharge date of patients which were registered in HIS databases over a five-years period (between March 21, 2014 and March 21, 2019). MI was defined using the International Classification of Diseases 10th revision (ICD-10) codes I21 and I22. Latitude and longitude coordinates of each patients' residence address were obtained using google MyMap within a radius of half a kilometer. These data were exported as a KML file for analysis to ARCGIS 10.7 software (ESRI Inc., Redlands, CA, USA), and considered as a basis for all spatial and statistical analysis in the present study. The population of each area was obtained from the national population census in 2016 and for the remaining years, it was calculated based on the annual population growth rate of Zanjan province, Iran. (Fig. 2-A) The incidence rate of MI was calculated for each rural district per 100,000 person by dividing the total number of MI cases in each area by its population and then multiplying by 100,000. A direct standardization approach was used to calculate the age adjusted incidence rate of MI (AAIRMI)(17). The entire Iranian population was used as the standard population to calculate AAIRMI in Zanjan province and the entire population of Zanjan province was used as the standard population to calculate AAIRMI for each rural areas on a yearly basis during the study period.

Spatial analysis methods including spatial autocorrelation (Global Moran's I), hotspot analysis and cluster and outlier analysis (Anselin Local Moran's I) were used to examine potential clusters in the pattern of MI incidence in the study area. Identifying the spatial autocorrelation is essential before prejudicing and conducting any spatial clustering analysis.(18) Global Moran's I analysis was conducted to investigate if there is any spatial autocorrelation in the pattern of MI. Given a set of features (rural district locations) and an associated attribute (age-adjusted incidence rate of MI values), Global Moran's I tool determines whether MI incidence pattern was clustered, dispersed, or random in Zanjan province, Iran. After identifying the spatial autocorrelation, it is crucial to identify the clusters and high-risk areas of MI. There are several clustering analysis methods to determine the high-risk areas such as hotspot analysis, cluster and outlier analysis (Anselin Local Moran's I), K-means, geographical weighted regression (GWR).(19) Hotspot analysis and Anselin Local Moran's I statistic were common spatial techniques which was used in the present study to determine clustering patterns of MI incidence at Zanjan province.(11, 16)

Spatial autocorrelation (Global Moran's I)

Spatial autocorrelation is the natural tendency of a variable to represent similar values as a function of distance between the geographical locations at which it is being measured. (20) Strong autocorrelation occurs when there was a relationship between the values of a variable that are geographically close to each other.(21) Spatial autocorrelation analysis presents two graphically and numerically outputs. The Graphical output indicates the distribution pattern of data (scattered, clustered or a random pattern). The numerical output returns five values; Moran's I Index, Expected Index, P-value, Z-score, and Variance. The Spatial autocorrelation tool is an inferential statistic, which means that the results of the analysis are always explained within the context of its null hypothesis.(22) The null hypothesis for the Global Moran's I statistic in this study stated that the incidence of MI was distributed randomly among rural district of Zanjan province during 2014–2018. When the P-value returned by Global Moran's I statistic is statistically significant, the null hypothesis will be reject. If the value of Moran's I index was close to + 1, MI distributed spatially clustered and if it was close to -1, it was spatially scattered. Zero value of Moran's I index show that MI distributed randomly. (Appendix 1)

Local indicators of spatial autocorrelation – Hotspot (cluster) and outlier analysis

Global methods are more sensitive to departures from the null hypothesis.(23) Although they could recognize spatial structures, they are not able to identify the situation of clusters and where the clusters of high or low MI incidence rate might occur. Hotspot analysis is one of the local indicators of spatial autocorrelation (LISA) methods that identifies statistically significant hotspots (high values) and coldspots (low values) using the Getis-Ord Gi statistic.(24–26) Hotspot analysis was used to determine the clusters of rural district with high or low values of adjusted MI incidence rate. An area considered as a hotspot when the area with high MI incidence rate surrounded by a cluster of high MI incidence rate and an area considered as a coldspot when the area with low MI incidence rate surrounded by a cluster of low MI incidence rate. Hotspot analysis returns an output feature class with a P-value, Z-score, and confidence interval (CI) bin field (Gi-Bin) for each feature in the input feature class. Features in the ± 3 bins reflect statistical significance with a 99% CI; features in the ± 2 bins reflect a 95% CI; features in the ± 1 bins reflect a 90% CI; and the clustering for features in bin 0 is not statistically significant. (Appendix 1)

Additionally, Anselin local Moran's I is a type of local cluster detection method which used to examine the spatial outlier of AAIRMI in this study. This tool determined spatial clusters of rural districts with high or low MI incidence rate as well as spatial outliers. Spatial outliers refer to areas with values of MI incidence rate that were discrepant from the neighboring regions. Anselin local Moran's I had been used to verify and complement the hotspot analysis, because it allows to detect areas where anomalies existed. The results of Anselin local Moran's I showed aspects that may had been overlooked in hotspot analysis, while were interesting highlights, especially in those areas where different types of groupings coexist. The outputs of Anselin local Moran's I classified areas to five groups included: not part of a cluster (or no significant cluster), High-high cluster (HH), High-low outlier (HL), Low-High outlier (LH) and Low-Low cluster (HH).(24) (Appendix 1)

Results

A total of 68,843 hospitalized patients due to cardiovascular diseases at ZUMS hospitals during 2014–2018, after excluded 5,238 cases because of duplicated or incomplete data, 3,820 (0.06%) cases were admitted due to MI. The overall AAIRMI was 343 cases per 100,000 person and 81 cases per 100,000 person-year over a five-year period in Zanjan, which was higher in men compared to women (504 cases vs 204 cases per 100,000 person, $P < 0.0001$). (Fig. 2-B) The highest AAIRMI was observed at Golabar, Khoramdareh and Hoomeh2 (515 cases, 506 cases and 504 cases per 100,000 person, respectively). IjroodPaein, Qoltuq and SaeedAbad had the highest AAIRMI among men (1075, 823 and 774 cases per 100,000 man, respectively), while Karasf, Golabar and Mojezat had the highest AAIRMI among women (451, 398 and 383 cases per 100,000 woman, respectively). (Fig. 2-C)

Although Global Moran's I statistic results was not significant at a significance level of 0.05 and the spatial distribution of AAIRMI was random in Zanjan (Moran’s Index: -0.020779), hotspot analysis detected five hotspot in the study area included AqBolagh with a 99% CI, Sojas with a 95% CI and Karasf, SaeedAbad and IjroodPaein with a 90% CI. It also determined two coldspot at Hoomeh1 and Darasjin with a 95% CI. The spatial pattern of hotspots and coldspots was different among men compared to women. Among men, SaeedAbad, Golabar, IjroodPaein, Qoltuq and Aqbolag were determined as hotspots and Darasjin and Hoomeh1 were identified as coldspots, while among women, SaeedAbad, IjroodPaein, AqBolaq, Sohravard, Karasf and ZarinehRood were recognized as hotspots and ZanjanRoudPaein and Darasjin were determined as coldspots. (Fig. 2-D)

The results of Anselin Local Moran’s I analysis showed that there was one HH cluster at center of the study area (Sojas) and two LL cluster also detected at Hoomeh1 and Darasjin which consistent with the results of hotspot analysis. SaeedAbad and Aqbulaq were determined as a LH outlier. Figure 2 also shows clusters and outliers of AAIRMI among men and women. SaeedAbad and Golabar were detected as HH cluster among men, while SaaedAbad, IjroodePaein, Aqbolaq and ZarineRood were determined as HH cluster among women. Khoramdareh was determined as a HL outlier among men in Anselin Local Moran’s I analysis, which was detect previously as the second high risk area of MI incidence with 506 cases per 100,000 person. ZanjanroadPaein and ChaiparePaein were identified as a HL outlier among women, which means these areas had a high AAIRMI and surrounded with low AAIRMI neighbors. Sohravard and Qeshlaqat were determined a LH outlier among both men and women which mean this area had a low AAIRMI and surrounded with high AAIRMI neighbors. (Fig. 2-E)

According to the graphical and numerical outputs of Global Moran' I statistic and given the z-score of 0.005468, the spatial distribution of AAIRMI did not appear to be significantly different than random at district levels in rural areas in Zanjan (Moran’s Index: -0.020779). (Fig. 3) The spatial pattern of AAIRMI also can be regarded to be normal among men and women in the study area (Moran’s Index: 00.100771, 0.026231, respectively). (Fig. 3)

Table 1
Numerical outputs of Global Moran's I for AAIRMI in Zanjan province from 2014–2018

	Year	Moran's index	Expected index	Variance	Z-score	P-value	Pattern
Total	2014	0.132095	-0.021277	0.008322	1.681216	0.092721	Clustered
	2015	-0.036007	-0.021277	0.008293	-0.161750	0.871502	Random
	2016	-0.010825	-0.021277	0.008271	0.114916	0.908511	Random
	2017	-0.082883	-0.021277	0.008082	-0.685277	0.493169	Random
	2018	0.295579	-0.021277	0.008038	3.534136	0.000409	Clustered
Men	2014	0.171553	-0.021277	0.008041	2.150404	0.031523	Clustered
	2015	-0.045255	-0.021277	0.007131	-0.283957	0.776443	Random
	2016	-0.001827	-0.021277	0.008252	0.214108	0.830463	Random
	2017	-0.117834	-0.021277	0.008144	-1.069968	0.284634	Random
	2018	0.174963	-0.021277	0.008124	2.177200	0.029466	Clustered
Women	2014	0.189901	-0.021277	0.008187	2.333896	0.019601	Clustered
	2015	0.006763	-0.021277	0.007901	0.315442	0.752426	Random
	2016	-0.062129	-0.021277	0.008261	-0.449474	0.653090	Random
	2017	0.040164	-0.021277	0.007677	0.701237	0.483155	Random
	2018	0.239113	-0.021277	0.007787	2.950813	0.003169	Clustered

MI incidence rate was different between various years and an ascending trend was observed in Zanjan during 2014–2018 ($P < 0001$). (Fig. 4-A) It was increased from 88 cases in 2014 to 114 cases in 2018 per 100,000 person (a 30% increase). While AAIRMI was decreased at Bonab from 71 cases in 2014 to 69 cases in 2018 per 100,000 person as the first populated region, the highest increase of AAIRMI was occurred at Karasf which increased from 35 cases in 2014 to 253 cases in 2018 per 100,000 person, a 620% increase. A significant increase of AAIRMI also observed at DolatAbad (from 0 to 167 cases), Sohravard (from 35 to 253 cases), Khararood (from 29 to 194 cases) and Hoomeh2 (from 24 to 189 cases). (Fig. 4-B)

Spatial autocorrelation analysis of overall AAIRMI showed that the Moran's I statistic was significant only in 2014 and 2018, (Moran's Index: 0.132095 and 0.295579, respectively) and the spatial pattern was clustered only in these years (Table 1). As Fig. 4 reveals, the spatial distribution of hotspots and coldspots was changed over a five years in Zanjan and shifted south from center. 10 hotspot and two coldspot were detected in 2018, which most of them were different from those observed previously. (Fig. 4-C) Anselin local Moran's I analysis showed that the spatial clusters of AAIRMI were different among various years during 2014–2018. The number of HH clusters was increased from three clusters in 2014 to five clusters in 2018, while the number of LL clusters was decreased from six to one during 2014–2018. One LL cluster was observed at QaraBolaq in 2018 located at the east, which was different from those observed previously. (Fig 4-D)

MI incidence rate was not consistence among men across different years and an ascending trend was observed during 2014–2018 (P < 0001). (Fig. 5-A) It was raised from 70 cases in 2014 to 128 cases in 2018 per 100,000 man, an 80% increase. Among men, the highest AAIRMI was observed at IjroodPaein with 1046 cases per 100,000 man. The highest increase of AAIRMI was detected at DolatAbad which increased from 0 case in 2014 to 289 cases in 2018 per 100,000 man, while the highest decrease was observed at Gozaldareh which decreased from 205 cases in 2014 to 0 case in 2018. A significant increase of AAIRMI also observed among men at Sohravard (form 35 to 310 cases), Hoomeh2 (from 42 to 305 cases) and Karasf (from 32 to 257 cases) during 2014–2018. (Fig. 5-B)

Spatial autocorrelation analysis showed that the Moran's I statistic was significant among men only in 2014 and 2018 (Moran's Index: 0.171553, 0.174963, respectively), and the spatial pattern of AAIRMI was clustered only in these years. (Table 1) As Fig. 5 reveals, the spatial distribution of hotspots and coldspots was changed among men over a five years in Zanjan, which shifted south from center. Among men, eight hotspot and one coldspot were recognized in the study area in 2018, which were different from those observed previously. The number of hotspots and coldspots was decreased from 11 hotspot and seven coldspot in 2014 to seven hotspot and one coldspot in 2018. (Fig. 5-C) Anselin local Moran’s I analysis showed that the spatial clusters of AAIRMI was different among men across various years which consistent with the results of hotspots analysis. Five HH cluster and one LL cluster was observed among men in 2018 which were different from those observed previously. As Fig. 5 shows, the spatial distribution of clusters was changed over a five years and the spatial distribution of HH clusters was shifted the south from center during 2014–2018. (Fig. 5-D)

MI incidence rate was not homogenous also among women across different years and an ascending trend was observed from 2014–2018 (P < 0001). (Fig. 6-A) AAIRMI was increased from 27 cases in 2014 to 59 cases in 2018 per 100,000 woman, a 120% increase. Among women, Karasf had the highest AAIRMI with 451 cases per 100,000 woman and also had the highest increase of AAIRMI compared to other regions, which increased from 37 cases in 2014 to 258 cases in 2018 per 100,000 woman, a 600% increase. A significant ascending trend also observed at BezinehRood region which increased from 0 case in 2014 to 182 cases in 2018 per 100,000 woman. (Fig. 6-B)

Although, Moran's I statistic was significant among women only in 2014 and in 2018 (Moran's Index: 0.189901, 0.239113, respectively), the spatial pattern of AAIRMI was random across other years from 2014–2018. (Table 1) As Fig. 6 shows, the spatial distribution of hotspots and coldspots was changed among women over a five years period which shifted the south and southwest from the northeast. Among women, nine hotspot and two coldspot were detected in 2018 which were different from those observed previously. The number of hotspots was increased from seven hotspot in 2014 to nine hotspot in 2018, while the number of coldspots was decreased from three coldspot in 2014 to two coldspot in 2018. (Fig. 6-C) Anselin local Moran's I analysis showed that the spatial clusters of AAIRMI were different among women across various years during 2014–2018, which consistent with the results of hotspots analysis. Six HH clusters located at the south, were observed among women in 2018 which were different from those observed in previous years. One LL cluster was detected at Gilvan located at the northeast in 2018, while this region was determined as a HH cluster in 2014 (Fig. 6-D)

Discussion

Spatial analysis of MI had been investigated rarely compared to other diseases such as cancers in the world. In addition, most studies examined the spatial analysis of MI at country scales not at finer geographical levels. From authors' point of view, this was the first study conducted to investigate the spatial analysis of AAIRMI at district levels in rural areas to determine the geographical distribution and high-risk areas of MI incidence in Zanjan province, Iran.

The overall AAIRMI was 343 cases per 100,000 person, and 81 cases per 100,000 person-year in the present study which was higher in men (68%) compared to women (28%). AAIRMI was higher in Zanjan compared to the national average (74 cases per 100,000 person-year) and it was lower than AAIRMI in other provinces of Iran such as Kerman (149 cases), North Khorasan (152 cases) and Semnan (132 cases per 100,000 person)(2). The crude incidence rate of MI was 783 per 100,000 person-year in Yazd province, Iran as one of the important industrial city, which was significantly higher than the results of present study.(9) The incidence rate of MI was different among the neighbors of Zanjan province, Iran. It was 108 cases in Ardabil province (the north) (27), 39 cases in East Azerbaijan province (the west) (28), 97 cases in Qazvin province (the east) (29), 96 cases in Gilan province (the northeast) and 58 cases in Hamedan province (the south) (28).

According to the report of Statistical Center of Iran, Bonab, Hoomeh2 and Khoramdareh had the highest population density in Zanjan in 2016. (445018, 105330 and 67260 persons, respectively) Bonab, the first metropolis and populated region which located at the center, classified as the 12th high-risk area of MI in this study with 370 cases per 100,000 person. In comparison to populated areas, while the population density of Golabar was lower (16588 person), the highest AAIRMI was observed in this region which ranked it as the first high-risk area of MI incidence with 515 cases per 100,000 person. IjroodPaein and Qoltuq were defined as the high risk areas of MI incidence among men (1075 cases and 823 cases per 100,000 man, respectively), while Karasf and Golabar were detected as the high-risk areas of MI incidence among women. (451 cases and 398 cases per 100,000 woman, respectively).

Although the highest AAIRMI was in Golabar region, it didn't have the highest population density compared to other regions in Zanjan. Therefore, besides population density, there should be other factors influenced MI incidence. According to Rathore's study, the main risk factors of MI included individual characteristics (family history, age and sex), lifestyle factors (physical activity, smoking and diet), underlying factors (socioeconomic factors and access to health care) and environmental factors (climate, temperature, humidity).(8)

According to Ahmadi’s study in 2014 (28) and the results of present study, AAIRMI was almost tripled in Zanjan during six years, which increased from 40 cases in 2012 to 114 cases in 2018 per 100,000 person-year, an 185% increase, while the population density increased only 4%. The highest AAIRMI was observed at Karasf region which increased from 35 cases in 2014 to 253 cases in 2018 per 100,000 person-year, a 600% increase. An ascending trend of MI incidence was reported in Iran during 1992 to 2004, which was similar to the trend of MI incidence in developing countries and consistent with the results of present study.(2) The trend of MI incidence was different in developed countries compared to developing countries. Developed countries such as Japan(30), Korea(31), European countries(5) and the United States(32) experienced a descending trend of MI incidence in recent years which was in contrast with the results of this study. Several reasons explain this decline such as controlling CVD risk factors, smoking cessation programs, lifestyle changes, quick use of percutaneous coronary angioplasty, use of drug eluting stents and evidence-based medications in the prevention of major adverse of MI events.(2, 30-32)

Spatial analysis plays an important role to visualize the spatial distribution of disease and identify the potential high-risk areas of MI incidence (2). Hotspot analysis and Anselin Local Moran's I are advanced statistical techniques, which were used in the number of health studies to explore the potential significant clusters of disease events. (21, 24, 33, 34) When mapping the spatial distribution of MI incidence using color coding techniques to classify the severity of incidence among areas, different results can be obtained by changing the classification range of incidence severity. Therefore, this approach cannot be useful to detect the real and potential high or low risk areas of MI incidence alone and might misdirect the results.(18) The spatial autocorrelation (Global Moran's I) can identify the spatial pattern of MI incidence and determine whether has a random, clustered or scattered distribution pattern, but it cannot specify where clusters are located.(21) Hotspot and Anselin Local Moran analysis be able to recognize the location of clusters and identify the spatial variation of MI incidence.(24) Therefore, global Moran' I used to determine if a spatial autocorrelation exist in the pattern of MI incidence. Testing spatial autocorrelation is necessary before conducting any hotspot and cluster analyses.

AAIRMI was not distributed homogeneously among various regions of Zanjan provinceduring 2014-2018(P <0.0001). The results of studies conducted in Ardabil (27) and Yazd (9) provinces as well as the studies conducted in Denmark (15), Sweden (13), Canada,(14) and United State (32) also showed a different spatial distribution of MI incidence among various areas which consistent with the results of this study. Spatial autocorrelation showed that the spatial distribution of overall AAIRMI was random and there were different hotspots and clusters of AAIRMI in the study area. Various studies also showed that MI incidence was clustered among different geographical areas which consistent with the results of this study.(3, 9, 10, 16)

One hotspot with a 99% CI, one hotspot with a 95% CI and three hotspot with a 90% CI were detected in the neighboring region of Golabar. This study was consistent with the results of a study conducted in Ardabil province, Iran which identified hotpots of MI incidence using hotspot analysis.(27) Different clusters and outliers of AAIRMI were detected in Zanjan province, Iran which most of them were located in rural areas. Anselin Local Moran analyses was performed in different studies to determine the cluster of phenomena among various areas. For example, Khalkhal County was recognized as a LH outlier in the first three years of the study, while no clusters was defined among the counties of Ardabil province. (27) The results of studies conducted in Iran (16), Canada (14), Denmark (15), USA (11), Sub-Saharan Africa (22), Korea (31) and Sweden (13) support the efficiency of Anselin Local Moran I analyses to define the potential high-risk areas of diseases, which was consistent with the results of this study.

The results of this study showed that the highest AAIRMI was observed in rural areas compared to urban areas. Majority of people living in rural areas are farmer and related to agriculture work and have a poor socio-economic status. Lifestyle, socioeconomic differences such as education and income, low access to preventive health care services such as cholesterol screening and cardiac rehabilitation and a routine physical checkup are the common risk factors of high incidence of MI in rural areas (2, 35). The distribution of common MI risk factors (obesity, smoking) and mortality rate were considerably high at rural areas compared to urban areas in USA. The smoking and obesity rates in US rural are 29.6% and 39.6% compared to 24.2% and 33.4% in the urban USA population respectively(36, 37). A higher incidence rate of MI in rural areas may be attributed to the difference in quality of life and lifestyle factors between rural and urban communities or it may arise from systematic differences between rural and urban cultures.(38) However, more data and further research are required to identify main reasons that are contributing to the difference in MI incidence in rural and urban areas of Zanjan province.

Spatial analyses in this study revealed that AAIRMI patterns changes. For example, the spatial distribution of hotspots was shifted south from center and the spatial distribution of coldspots was shifted northeast from southeast during 2014-2018. Identifying the spatial and temporal patterns of AAIRMI is very important for policy planning at local level. The allocation of limited health resources should be focused on high-priority areas with the greatest risk of MI incidence. The results of this study provide ground work for future studies to explore risk factors of MI among high-risk areas in Zanjan province, Iran.

Conclusion

This study provides an overview and the spatial distribution of MI incidence in Zanjan province, Iran during 2014-2018. There are various causes of MI incidence including genetic, lifestyle, socioeconomic and environmental factors, which makes it difficult to identify the main reasons of this public health concern. A high AAIRMI was observed in this study compared to the national average, which was higher in men compared to women. It is a warning to health authorities and policymakers to clarify the possible causes of this disease incidence at high-risk areas and develop prevention program to reduce it. These findings also confirm the link between MI incidence and geographical factors, which generate new knowledge for authorities to reduce the burden of disease in high risk areas by allocating health care resources. Clusters, meanwhile, represent the center of high-incidence areas, and preventive measures should not be limited to just one hotspot, but also should be limited to neighboring areas. Recent use of GIS to analysis or estimate spatial inequalities, highlighted many health problems which were found to be related to spatial differences or spatial inequalities. At conclusion, according to the 25 by 25 World Health Organization's target (39), achieving a 25% global reduction in cardiovascular mortality by 2025, and whereas MI is a leading cause of death, the results of present study can help public health authorities to develop more effective prevention campaigns against MI incidence at high risk areas, and all hotspots and clusters should be prioritized for policy-makers to allocate health resources and reduce the burden for health system.

Limitation

This study had two limitations. First, we collected patients' data who were admitted due to MI at ZUMS hospitals during 2014-2018. Patients of three private hospitals did not included in this study. Therefore, it may not represent the overall MI patients in Zanjan province, Iran. In addition, the second limitation is the use of population census data as the dominant method for calculating the incidence rate of MI and age-adjusted incidence rate of MI. The population census is conducted every five years in Iran, so because there is no annual population census, we used national population census data in 2016 and estimated the population of other years by population annual growing rate, which reported annually by Statistical center of Iran.

Declarations

Ethics approval and consent to participate

The study was approved by the ethics committee of Zanjan University of Medical Sciences protocol Number: IR.ZUMS.REC.1398.056. All methods were performed in accordance with the principles of the Declaration of Helsinki and all protocols were carried out in accordance with relevant guidelines and regulations. Data gathered from hospital information system databases and data collection for this research was approved by the Health Systems Research (HSR) committee of Zanjan University of Medical Sciences protocol Number: A-12-1171-3. Informed consent was not obtained due to the nature of the study and the gathered data did not include any identification items and the ethical committee of Zanjan University of Medical Sciences approved that with protocol number: IR.ZUMS.REC.1398.056.

Consent for Publication

Not applicable, because this study used the data of hospital information system databases which did not include any identification items.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

M.S designed the study, drafted the manuscript, acquired the data from Hospitals, and conducted the statistical analysis. **N.B** revised the manuscript critically and adding relevant suggestions to improve the manuscript quality. All authors agreement for all aspects of the work and approval of the final version to be published.

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Availability of Data and Material

The datasets are available from the corresponding author on reasonable request.

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Figures

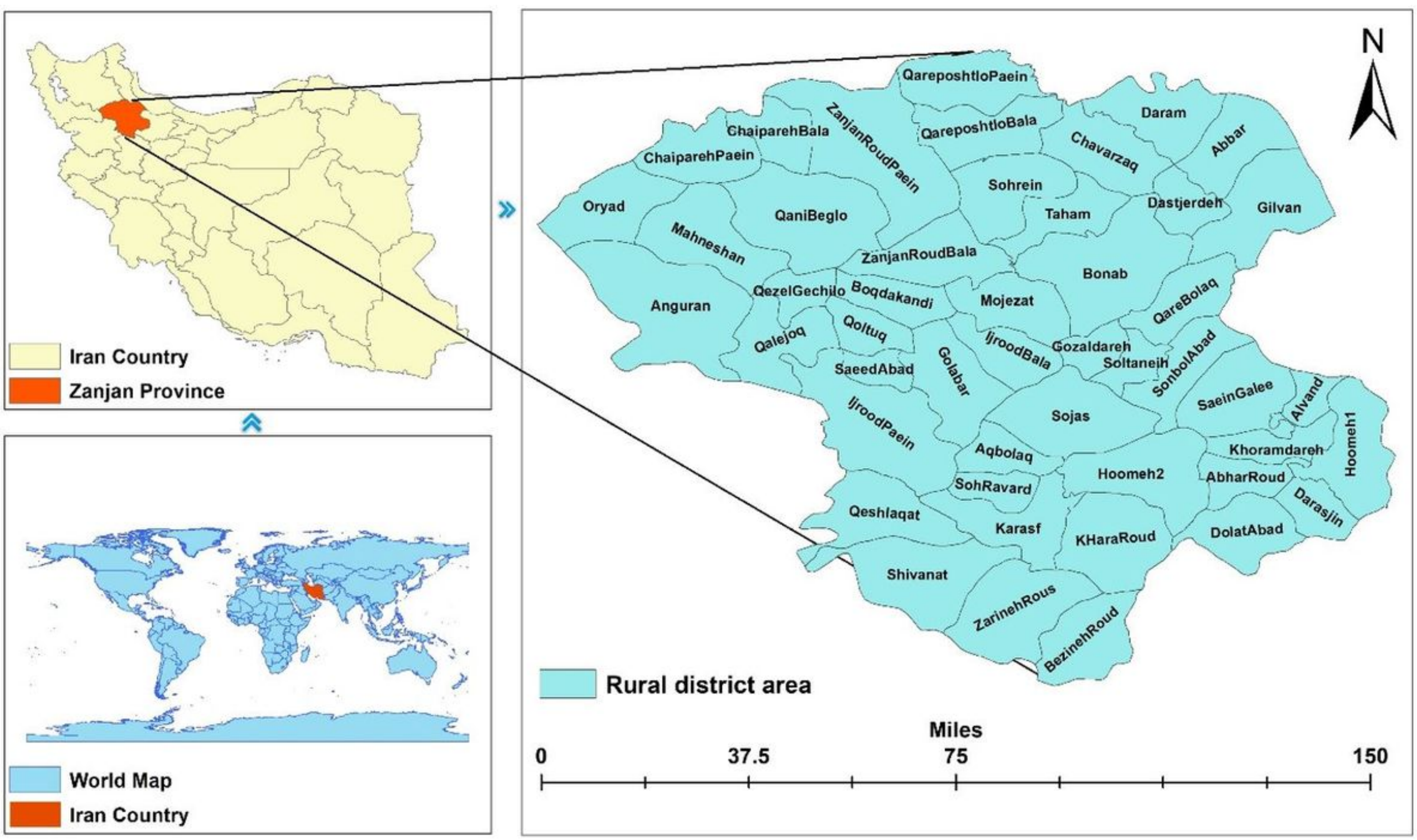

Figure 1

Geographical Location of Zanjan province at rural district levels in Iran country. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

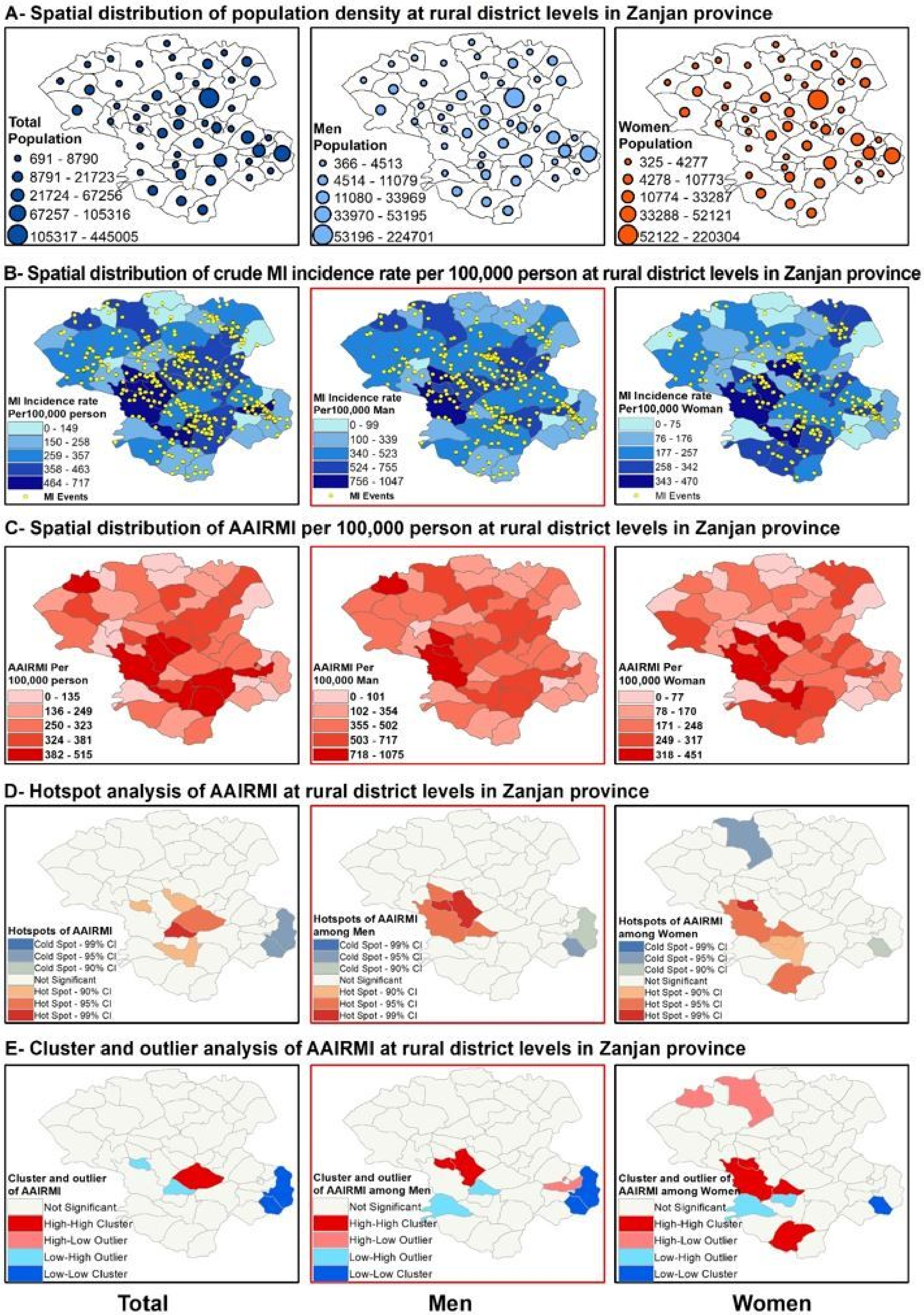

Figure 2

Spatial analysis of overall MI by gender at rural district level in Zanjan province. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

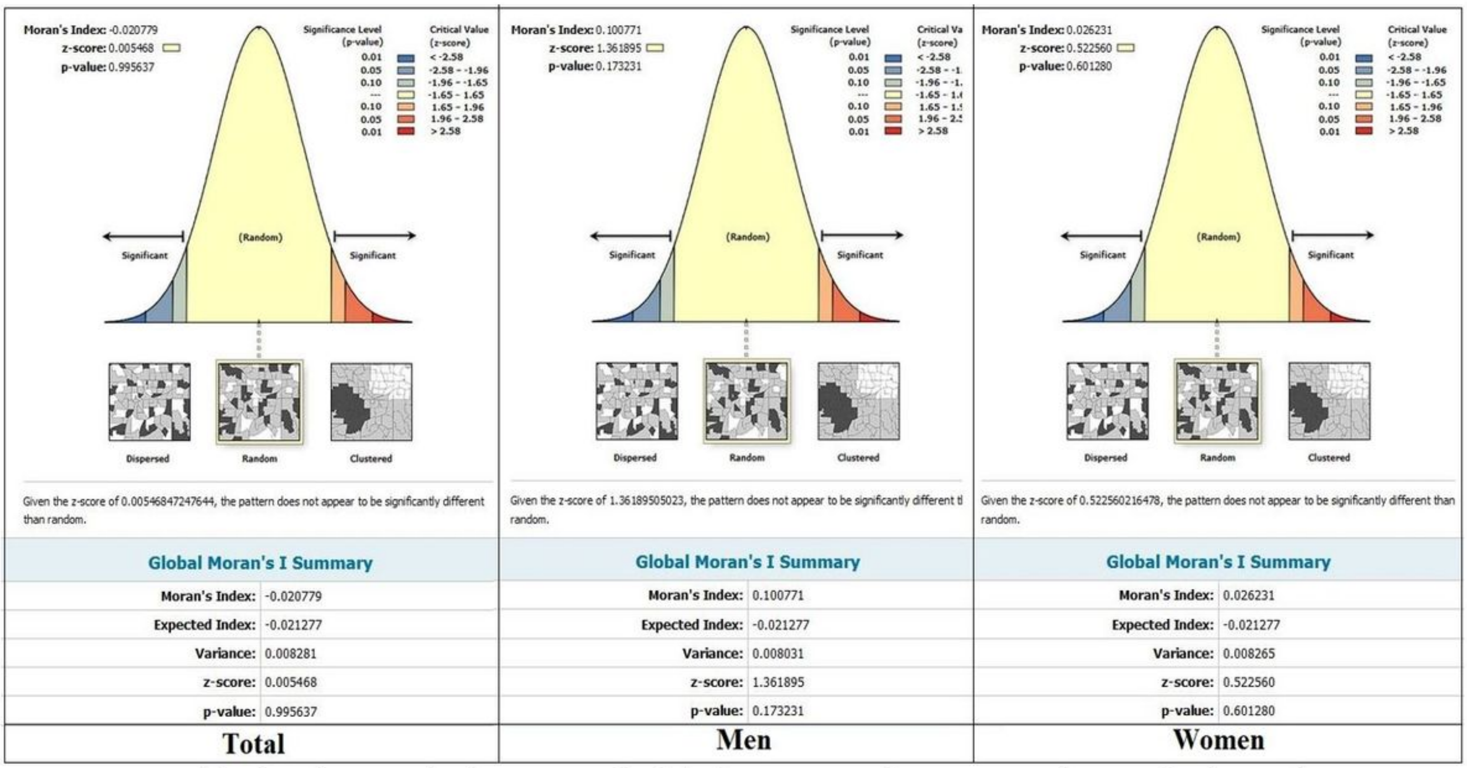

Figure 3

Graphical and Numerical outputs of Global Moran's I for AAIRMI by gender in Zanjan

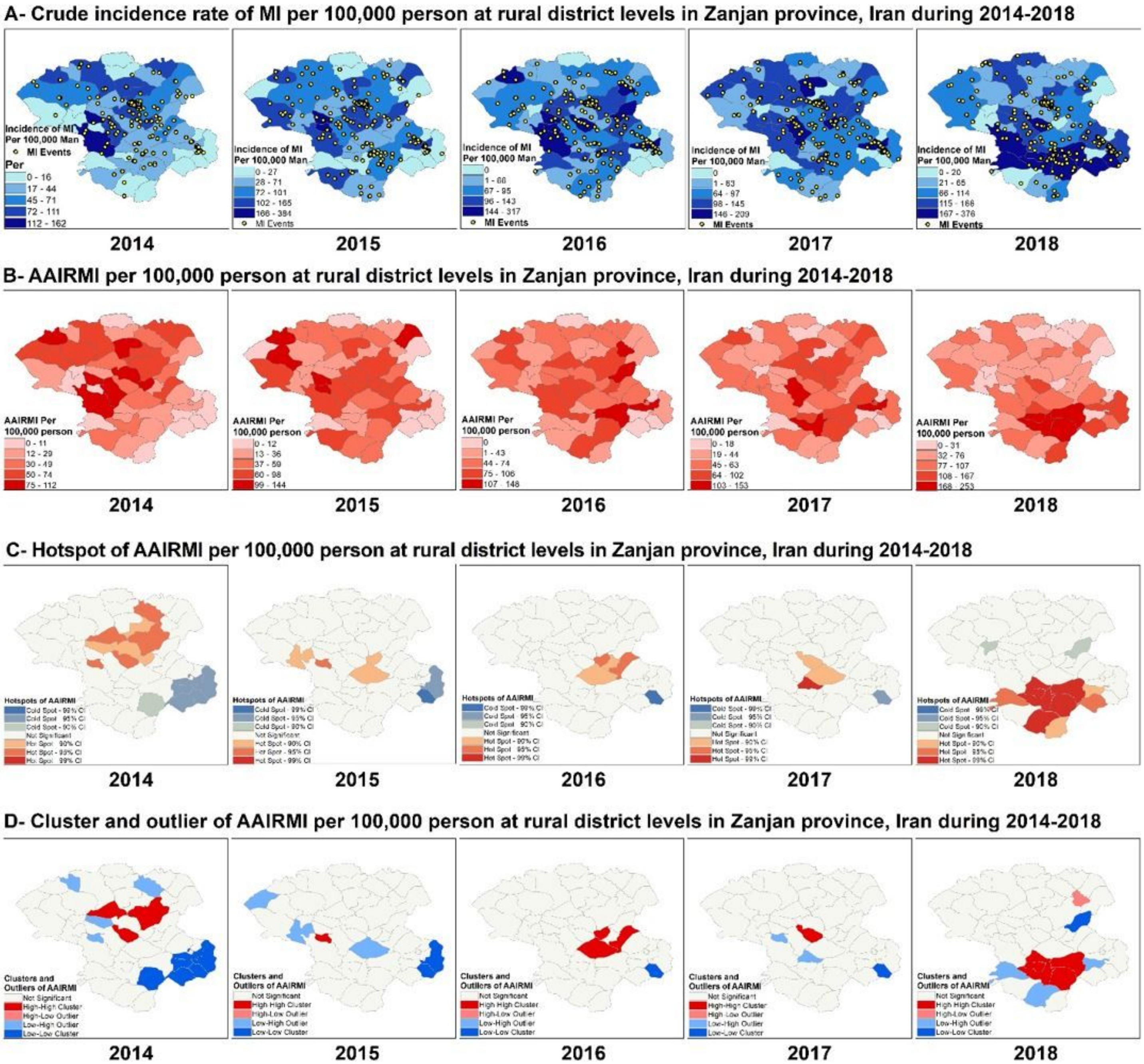

Figure 4

Spatial analysis of overall MI over time in Zanjan province from 2014-2018. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

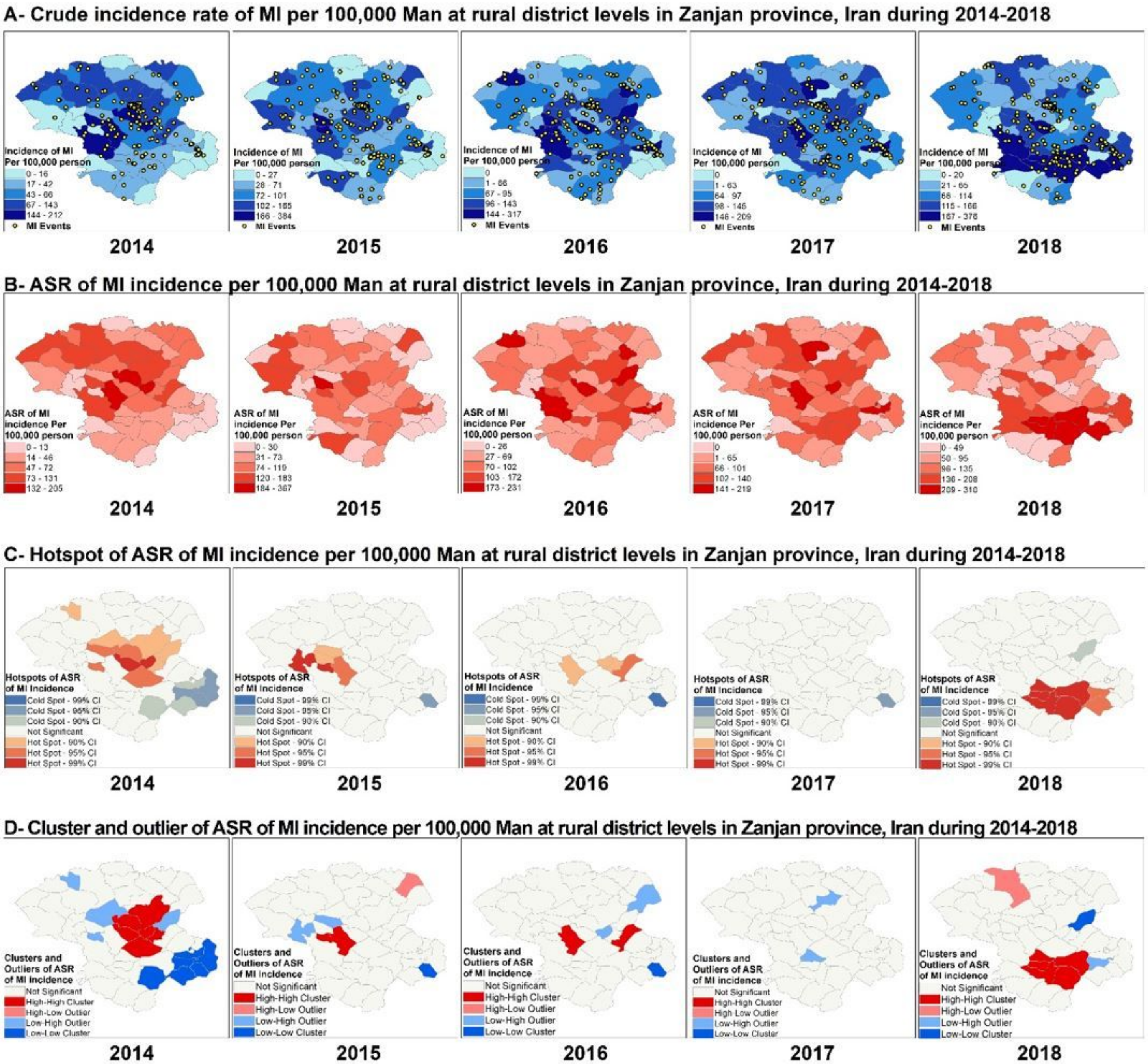

Figure 5

Spatial analysis of MI among Men in Zanjan province from 2014-2018. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

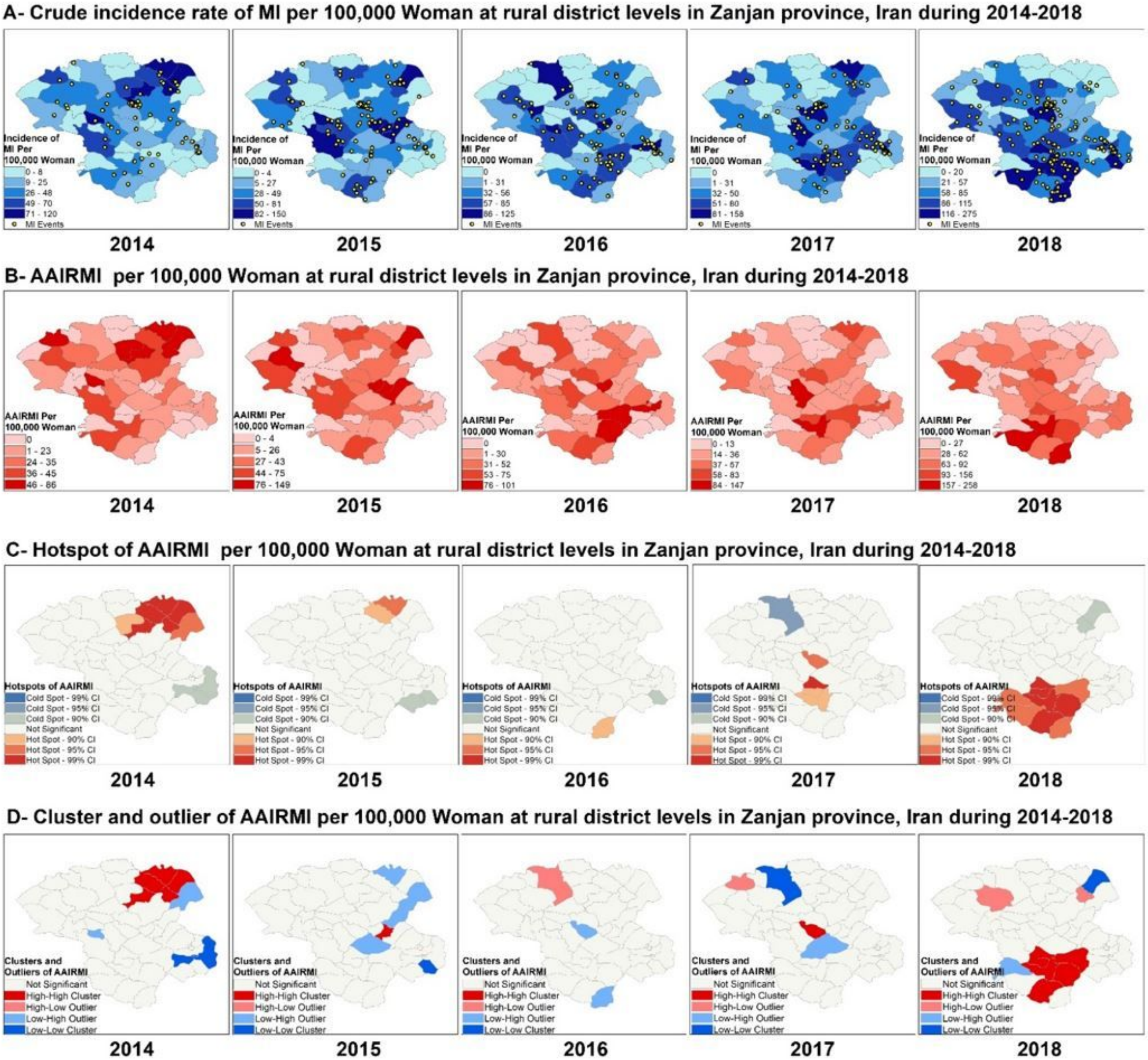

Figure 6

Spatial analysis of MI among Women in Zanjan province from 2014-2018. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

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- Appendix1.docx