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Original Article

Spatial Hotspot Analysis of Acute Myocardial Infarction Events in an Urban Population: A Correlation Study of Health Problems and Industrial Installation

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Abstract

Background: The current study's objectives were to find any possible spatial patterns and hotspot of cardiovascular events and to perform a correlation study to find any possible relevance between cardiovascular disease (CVE) and location of industrial installation said above.

Methods: We used the Acute Myocardial Infarction (AMI) hospital admission record in three main hospitals in Yazd, Yazd Province, Iran during 2013, because of CVDs and searched for possible correlation between industries as point-source pollutants and non-random distribution of AMI events.

Results: MI incidence rate in Yazd was obtained 531 per 100,000 person-year among men, 458 per 100,000 person-year among women and 783/100,000 person-yr totally. We applied a GIS Hotspot analysis to determine feasible clusters and two sets of clusters were observed. Mean age of 56 AMI events occurred in the cluster cells was calculated as 62.21±14.75 yr. Age and sex as main confounders of AMI were evaluated in the cluster areas in comparison to other areas. We observed no significant difference regarding sex (59% in cluster cells versus 55% in total for men) and age (62.21±14.7 in cluster cells versus 63.28± 13.98 in total for men).

Conclusion: We found proximity of AMI events cluster to industries installations, and a steel industry, specifically. There could be an association between road-related pollutants and the observed sets of cluster due to the proximity exist between rather crowded highways nearby the events cluster.

Key words: Correlation study, Geographical Information System, Cardiac events, Industries, Hotspot

Introduction

There has been an increasing frequency of cardiovascular disease (CVD) fatal report in developing countries and CVD remained a major and the first public health thread in Iran (1-3). Several studies have shown the significant relevance of CVDs and air pollution parameters such as PM_{10} and $PM_{2.5}$ (4-7) and other air pollutants such as NO_X, SO_2, CO and O_3 (8-11) and heavy metals like lead, mercury, selenium, cobalt, nickel and etc. (12-14). The cardiovascular events (CVE) are not distributed randomly and the pattern can be shown spa-

tially using Geographical Information System (GIS) (15, 16).
The city of Yazd is as populated as about 430000 people (17) and is becoming an industrial pole in Iran. Yazd industrial site installation is located in northwest of the city and consisted of different types of industries such as metal, chemical, electrical, textile, leather, nonmetal and pharmacy. However, some major industries like steel industries are still working outside the specific area and due to the city's development are getting closer to city's boundaries despite the strict rules of being further. According to climatology studies the main compass rose (windrose) of the region is northwest to southeast (18) that possible results would be carrying the pollutants all over the city in its pathway that may cause health problems.
The current study's objectives were to find any possible spatial patterns and hotspot of cardiovascular events and to perform a correlation study to find any possible relevance between CVE and location of industrial installation said above.

Materials and Methods

Hospital admission data

This ecological study was conducted in Yazd, Yazd Province, Iran during 2013, to assess the correlation of health problems and industrial installation. Hospitals admission data was supplied by hospital information system (HIS) in three main hospitals (Afshar, Shohadayekargar, and Shahidsadughi) with cardiovascular care units (CCU) during 2013. The International Classification of Diseases, Injuries, and Causes of Death (ICD, 10th revision) code I20 (acute myocardial infarction (AMI)) in the HIS was considered. This inclusion criterion was independent from outcome results (dead or alive).
These hospitals were taken since they are indicators of CVD admission in the city (19) and they are located in three separate locations and cover the city geographically the best. Afshar hospital admission records covered approximately 61.3% of whole admission records (267 of 437 records) since it is a specialized hospital for CVDs and the referenced hospital in the region. Date of admission, gender, age and patients address were included in the hospitals records.
It is nevertheless true to say that ascertaining the relevance of residence in which Yazd's inhabitants are living in with CVEs is difficult, since they tend to move about the city and the time spent at home is not permanent. Therefore, the data is assumed the fact that a remarkable amount of people's daily life is spent at home (e.g. at night or weekends).

Geographical information system database

GIS is a scientific tool for health studies, spatial distribution studies and the relevance investigations (20-22). Baseline city data, including city base maps and population blocks (based on population census of 2008), was supplied with the help of Yazd University Geography Department. The industrial distribution map was gained from the Yazd Industrial Installation Mapping Project, 2009. The admission data was entered to GIS as points according to the addresses that were gotten; each point represents an AMI event and includes date of admission, gender and age of the patient.
GIS technology was applied to create a fishnet over the city using GIS data management tools_ create fishnet. Fishnet cell-size (2km*2km) was obtained by testing different cell-sizes to find a minimum size with at least one event record. Fishnet said above was converted and stored in polygon format for later analysis. Attribute tables data was joined with created fishnet using GIS spatial join tool. To count CVD events and at-risk population in each fishnet cell we used a free extension for GIS called "Hawth's Tools". Hawth's Tools is an add-on created for ArcGIS that provides a set of spatial analysis tools not included in the ArcGIS software. It is very useful to calculate distances between points, point in polygon and polygon-to-polygon analysis (23). Long-term exposure to air pollutants may cause CVDs (24, 25), so the at risk population (>40 yr old) was considered as the denominator of the rate fraction (26, 27). Event rate for each cell was calculated as below using GIS Field Calculator function:

$$Event\ Rate = \frac{Number\ of\ CVD\ events\ during\ 1\ yr.}{At\ risk\ population\ during\ 1\ yr.} \quad (1)$$

GIS Spatial Statistics Tools was applied to the layer containing event's rate information and the hotspot was determined in two runs. The first run showed four cluster cells to be significantly different (Fig. 1). To figure out the possibility of significant difference in other parts of city we omitted the four spotted cluster cells and run the hotspot test again (Fig. 2). Different industries with different levels of activity were mapped using GIS union tool to unify different industries layers and to form a general distribution view of whole (Fig. 3).

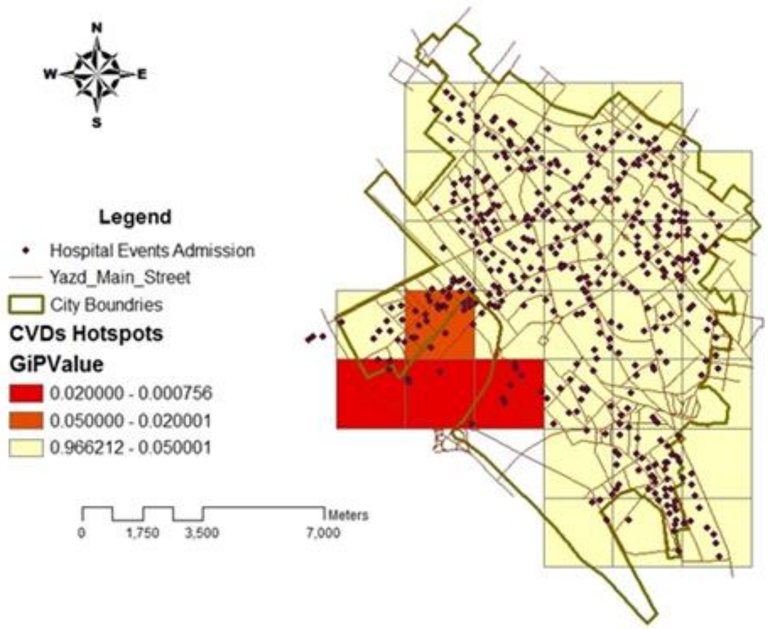

Fig. 1: First round AMI events hotspots, dark and light red color presents the cluster of AMI events in Yazd

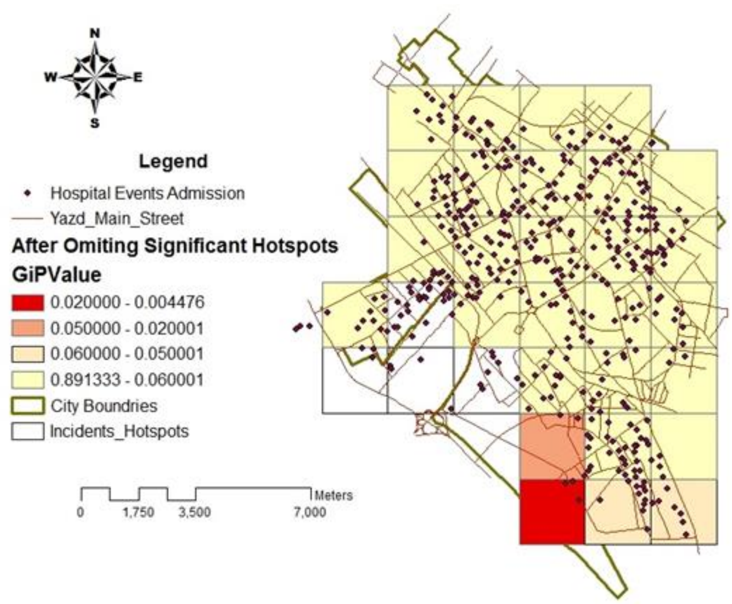

Fig. 2: Second round CVEs hotspots, dark and light red color presents the cluster of AMI events in Yazd

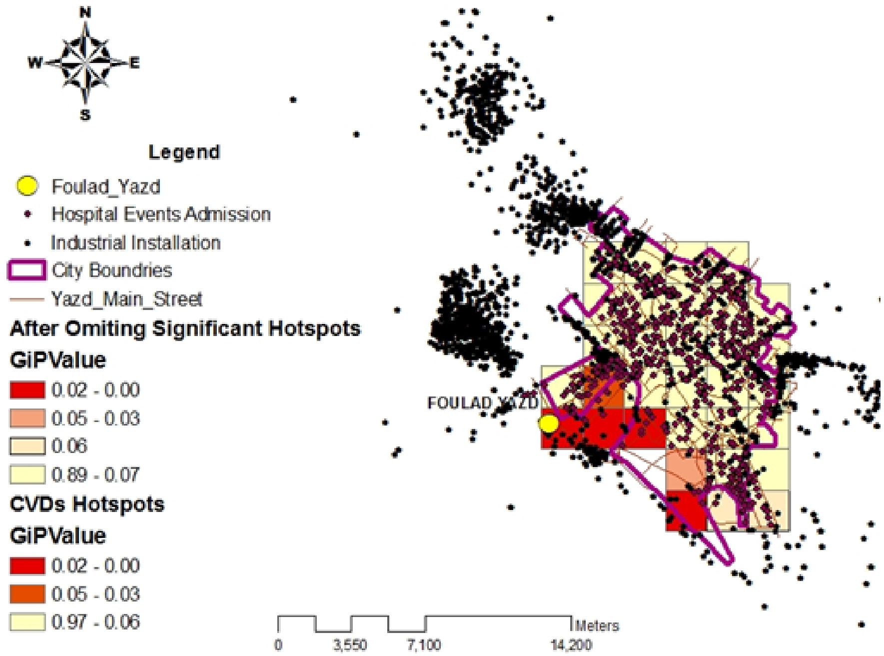

Fig. 3: Spatial distribution of industries in Yazd, each black point presents a single factory; the yellow point presents the steel plants inside the city boundaries

Statistical Analysis

The two-tailed *t*- test was used to examine the differences in age, and the X^2 test was used to compare the frequencies of both genders. We used Microsoft Excel 2013 for the purpose.

Results

Four hundred forty hospital admission records from three hospitals during 2013 were entered in this study. According to gender, 233 men (52.9%) admission records were seen. Women seem to be older when they show myocardial infarction occurrence leading to hospital admission (mean age 65.60 yr versus mean age 61.29 yr for men ($P< .001$). Total mean age of myocardial Infarction occurrence during 2013 in Yazd was 63.26 yr. Out of 440 admission records 270 admissions were recorded in Afshar Hospital, 91 in Shohadayekargar Hospital and 79 in Shahidsadughi Hospital (Table 1). Calculated rates, in each fishnet cell, for the at risk population (>40 yr old), according to equation [1] differ in a range of 0.00169 to 0.06153. Myocardial infarction incidence rate was 531 per 100 000 person-year among men, 458 per 100 000 person-year among women and 783 per 100 000 person-year as total.

Table 1: Hospital admissions statistical summery

Hospital	Afshar			Shohadayekargar			Shahidsadughi		
	Female	**Male**	**Total**	**Female**	**Male**	**Total**	**Female**	**Male**	**Total**
Records Count	135	132	267	37	54	91	29	50	79
Mean Age	63.82	60.60	62.23	72.12	63.32	66.45	67.25	60.4	62.69
Total	Female			Male			Total		
Records Count	198			239			437		
Mean Age	65.80±13.80			61.17±13.73			63.28± 13.98		

Result of running hotspot analysis showed a significant difference in four cluster cells with *P* Value of 0.000756, 0.000139, 0.006469 and .033682 respectively (Fig. 1). Thirty-one CVEs were in the four cluster cells and gender proportion was 17/14 (54.8%) for females. The mean age of 31 CVEs happened in Hotspot areas was calculated as 68.05, 61.07 and 64.9 yr for females, males and in total, respectively. No significant difference was observed between the clustered cells and the total 437 incidents, in round one.

Four more cluster cells, located in a close distance from the first four, showed significant difference from the rest (Fig. 4) with *P* of 0.0044, 0.0298, 0.0537 and 0.0597 respectively. Mean age of 23 CVEs occurred in these cluster cells was calculated as 59.26 yr. Age and sex as main confounders were evaluated in the cluster areas in comparison to other areas (Cells). We observed no significant difference regarding sex (59% in cluster cells versus 55% in total for men, P=0.47) and age (62.21±14.7 in cluster cells versus 63.28± 13.98 in total for men, P=0.62).

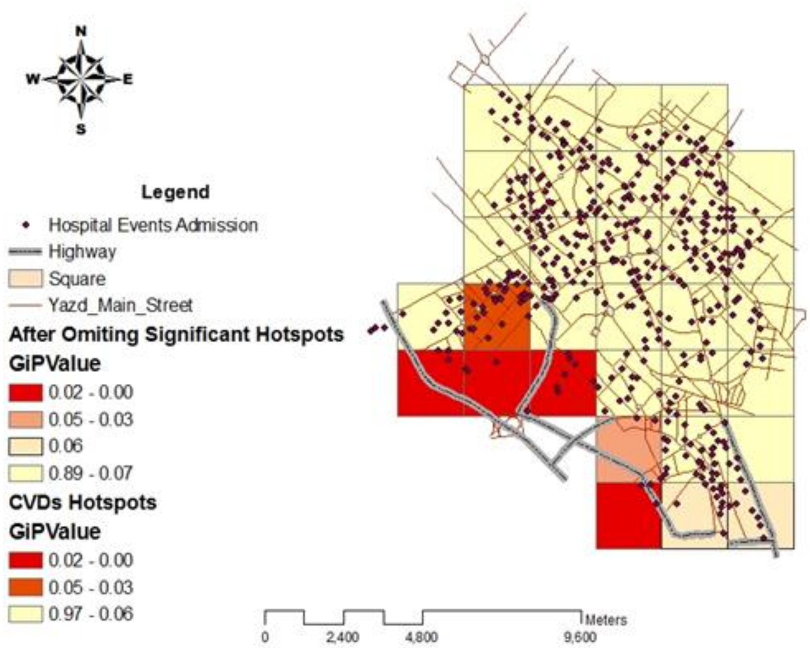

Fig. 4: Spatial position of some main highways (grey lines) in clustered areas

Discussion

The frequency of AMI in Yazd residents has not been published prior to this study. We found a 531 per 100,000 person-year rate among men, 458 per 100,000 person-year among women and 783 per 100,000 person-yr totally. In comparison with other population-based studies, the incidence rate of AMI in residents of Yazd, Iran (783 per 100,000 population), is considerably higher than the incidence rate of initial AMI observed in the San Juan, Puerto Rico (163 per 100,000 population) (28). The incidence rate of initial AMI in Finland in 1998 was 786 and 256 for men and women respectively, which is slightly higher than our results (29). Moreover, the incidence rate in a study in Denmark, 2014 showed a considerable difference in women AMI rate (405 and 238 for men and women) (30).

Mean age in AMI events was 63.28± 13.98 yr, which showed a considerable difference with a study in Esfahan, Iran (mean age 73.39±6.10) (31), and a slight difference with a study in US (mean age 67.7±12.9) and remarkably similar to the study in Puerto Rico, (63.2 +/- 13.7 for men and 68.6 +/- 13.3) (28).

Hotspot analysis showed two clusters in spatial distribution of CVEs in Yazd. Age and sex as major confounders were controlled and no significant difference was observed in cluster cells.

Industries as major point-source pollutants in urban areas are suggested to be associated with health problems (32). Chu et al. reported an association between PM concentration and industrial and urban areas of Taiwan (33) and the association between PM concentration and health problems specially Cardiovascular disease and hospital admission was proved by several studies (4, 19, 34, 35). Yazd with a record of about 3600 various industries can be considered as an industrial city. As shown in Fig. 3 proximity of AMI events to industrial installations can be seen. A study showed an association between Lung cancer risk and residential proximity to industrial installations (21). Other similar studies showed the possibility of proximity to industries and health problems (36-39).

We suggest that the observed cluster could be a result of proximity to industries cluster specifically a steel industry located inside the city borders (Fig. 3). Though there could be an association between road-related pollutants especially particular matters (PM), NOX, CO, SO3 and O3 and the observed sets of cluster due to the proximity exists between rather crowded highways nearby the cells. According to all ecological studies, ecological fallacy should take into consideration .This paper studied the spatial correlation of events; the temporal correlation cannot be deducted. Absence of an efficient net air pollution monitoring system in the city was a great limitation to the current study is founding to be compared with pollutants concentrations.

We suggest a follow up study in company with air pollution map database, based on air pollution monitoring system data to be done. We also suggest a differential industries ranking system to be created according to type of industry and the amount of pollutants it makes, therefore industrial installation base-maps can be produced and new hypothesis for the association between CVEs and industrial installation can be developed.

Conclusion

We found proximity of AMI events cluster to industries installations, and a steel industry, specifically. There could be an association between road-related pollutants and the observed sets of cluster due to the proximity of rather crowded highways with the events cluster.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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