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Predictive Factors of Hospital Mortality Due to Myocardial Infarction: A Multilevel Analysis of Iran's National Data

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ABSTRACT

Background: Regarding failure to establish the statistical presuppositions for analysis of the data by conventional approaches, hierarchical structure of the data as well as the effect of higher-level variables, this study was conducted to determine the factors independently associated with hospital mortality due to myocardial infarction (MI) in Iran using a multilevel analysis.

Methods: This study was a national, hospital-based, and cross-sectional study. In this study, the data of 20750 new MI patients between April, 2012 and March, 2013 in Iran were used. The hospital mortality due to MI was considered as the dependent variable. The demographic data, clinical and behavioral risk factors at the individual level and environmental data were gathered. Multilevel logistic regression models with Stata software were used to analyze the data.

Results: Within 1-year of study, the frequency (%) of hospital mortality within 30 days of admission was derived 2511 (12.1%) patients. The adjusted odds ratio (OR) of mortality with (95% confidence interval [CI]) was derived 2.07 (95% CI: 1.5–2.8) for right bundle branch block, 1.5 (95% CI: 1.3–1.7) for ST-segment elevation MI, 1.3 (95% CI: 1.1–1.4) for female gender, and 1.2 (95% CI: 1.1–1.3) for humidity, all of which were considered as risk factors of mortality. But, OR of mortality was 0.7 for precipitation (95% CI: 0.7–0.8) and 0.5 for angioplasty (95% CI: 0.4–0.6) were considered as protective factors of mortality.

Conclusions: Individual risk factors had independent effects on the hospital mortality due to MI. Variables in the province level had no significant effect on the outcome of MI. Increasing access and quality to treatment could reduce the mortality due to MI.

Keywords: Mortality, multilevel analysis, myocardial infarction

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INTRODUCTION

Cardiovascular diseases are the most important medical challenge worldwide including Iran.[1-3] 30% of the mortality and 10% of the global burden of diseases are attributed to cardiovascular diseases.[4] Cardiovascular diseases are the reason for approximately 40% of the mortality in Iran. Myocardial infarction (MI) has the highest contribution among cardiovascular diseases in Iran.[5,6] In 2012, only 4% of 45–64 years old population and 1% of 15–44 years old population were free of cardiovascular diseases risk factors in both men and women in Iran.[7] Individual risk factors of MI and the associated mortality have been examined in different countries, including Iran.[8,9] The association of seasons, income, socioeconomic status, individual and clinical risk factors, and geographic and environmental factors with mortality due to MI has been already investigated.[6,10-13] Mechanisms of geographic and environmental factors could explain the association between cardiovascular diseases and temperature.[10] Activation of the sympathetic nervous system and secretion of catecholamine are increased in response to cold temperature, which could result in an increase in blood pressure through increased heart rate and peripheral vascular resistance.[10] In addition, experimental studies suggested that alterations in temperature might influence vascular function through an effect on endothelial nitric oxide synthase and the bioavailability of nitric oxide. In rats, acute and short-term exposure to elevated environmental or core body temperatures has been shown to increase endothelial nitric oxide synthase expression.[11,12] In different population and communities, the pattern of MI incidence and outcomes varies.[13,14] To identify the clinical and nonclinical (environmental) characteristics and the factors associated with the mortality due to MI, and to innovate in and implement the program for preventing and controlling the mortality, we need to do a multilevel analysis. In addition, because of the graded provision of services in Iran's health system and hierarchical structure of the patients' data, multilevel analysis is the most appropriate approach to determining the factors associated with mortality in MI patients.[15-19] No study has been yet conducted worldwide using multilevel analysis and examining concomitant effects of individual and nonindividual variables on MI outcome in different levels considering confounding variables and the interaction among the variables. This study was conducted to determine the factors independently associated with hospital mortality due to MI in Iran using a multilevel analysis.

METHODS

Study design and participants

In this hospital-based, nationwide and cross-sectional study, the data of 20750 new MI patients between April, 2012 and March, 2013 in Iran were used. Iran is a country in Western Asia, the Middle East, Central Asia, and the Caucasus. Iran is one of the world's large countries, which range from 25° and 3' to 39° and 47' north latitude, and 44° and 5' to 63° and 18' east longitude. As Iran is located in the high latitudes, the difference between the seasons is large. Iran has special geographical features and variable climates. Annual average precipitation in some cities in South Iran does not exceed 40 mm while it has been reported to exceed 600 mm in Western regions. These variations could be seen for other weather elements such as temperature and humidity, as well.[20] The data used in this study were accessed with observance of all rights of the patients, and ethical considerations in research as well as the approval of the university's Ethics Committee and noncommunicable diseases management center of Iran's Ministry of Health and Medical Education. In addition, the patients' individual data were dealt with as confidential, and no data contributing to the identification of the patients were used.

Variables assessment

The hospital mortality due to MI was considered as the outcome of the disease and hence a dependent variable. Definition of World Health Organization (WHO) and World Heart Federation (ICD: I21) was adopted for MI diagnosis (as the inclusion criteria). Echocardiography (ECG) was used to differentiate between the two types of MIs based on the shape of the tracing. An ST section of the tracing higher than the baseline is called ST-segment elevation myocardial infarction (STEMI) which usually requires more invasive treatment. For a person to qualify as having STEMI, the ECG must show new ST elevation in two or more adjacent ECG leads.[18] The patients with definite diagnosis of MI by the cardiologist were enrolled into the study. The patients with MI history and no MI diagnosis were excluded from the study. In view of the inclusion and exclusion criteria, census enrollment of the patients from all hospitals across the country, and data gathering per a single form, the biases of enrollment, and data were minimized as much as possible.

The demographic data and clinical and behavioral risk factors at individual level including age, gender, literacy, place of residence, smoking, type 2 diabetes, hypertension, dyslipidemia, and complications, and place and type of MI were gathered from the patients' electronic medical file in Iran Myocardial Infarction Registry in 2012.[19] The hospital at which the patient was hospitalized at the county (place of residence) level was defined as the second level analysis. For the second level analysis, valid and reliable geographical and environmental data such as mean temperature, mean minimum and maximum temperature, mean relative humidity, altitude, and mean precipitation for each month were obtained from Iran Meteorological Organization[20] and the ratio of cardiac care unit beds was obtained from treatment deputy of Iran Ministry of Health and Medical Education. The province where the patient was living was determined as the third level analysis. As with the first two levels, for the third level analysis, valid and reliable data on noncommunicable diseases risk factors were used, including prevalence of type 2 diabetes, hypertension, mean body mass index, smoking and hookah smoking, high cholesterol, obesity and overweight, physical inactivity, and the frequency of fish, vegetables, fruits, and fried food in household food basket; these data were gathered per stepwise approach of WHO.[7,21-23]

Statistical analysis

Multilevel logistic regression models were used to analyze the data. Deviance information criterion, Akaike's information criterion (AIC) and Bayesian information criterion (BIC) were used to select the best model. Any model with lower AIC or BIC was considered as a more appropriate model for the data fitness. Modeling was done throughout three steps. In the first step, the null model (random intercept model) was run with no independent variables. The null model was defined as empty model to recognize the variance among the levels. In the second step, only the variables at the individual level were entered into the model one. The slope of the first level variables was considered as fixed, as opposed to random, because we did not assume *a priori* that the effect of these variables on mortality varies among the provinces. In the model two, the variables at the community level (district/hospitals) were introduced into the model one. In the model three, the variables at the community level (province) were added to the model two. After running the third model, we decided to do the analysis at two levels, because the amount of variance was approximately zero at the third level (province). Measures of association were calculated and reported by odds ratio (OR) (confidence interval [CI] 95%). Measures of variance were reported by separate variance coefficients and percentage of variation. The quantitative data were reported as mean ± standard deviation (SD) and the grouped variables as frequency and percentage. Quantitative variables (age and temperature) were entered in the model as standardized. Data were analyzed by Stata software (Stata Corp. 2011. Stata statistical software: Release 12. College Station, Stata Corp LP, TX, USA).

RESULTS

Totally, 20750 patients were enrolled into the study from 208 countries across 31 provinces of Iran. 72.4% of the patients were men. Mean (± SD) age at MI and mortality incidence was 61.2 (±13.4) and 65.2 (±15.2) years, respectively. Within 1-year of study, 2511 (12.1%) patients were deceased. 855 (34.1%) of the mortality occurred in women and the rest in men. The individual characteristics of all patients and the deceased and survived patients after MI are shown in Table 1 for MI outcome.

56.3% of the deceased patients and 44.9% of the survived were illiterate. Relative frequency (%) of the academic education in the deceased and survived patients was, respectively, 5.6% and 6.2%. The prevalence of smoking, hypertension, and diabetes in the deceased patients was derived, respectively, 31%, 37.8%, and 24.3%. The prevalence of right bundle branch block (RBBB), left bundle branch block, atrial fibrillation (AF), and ventricular tachycardia (VT) in the deceased patients was obtained, respectively, 3%, 3.1%, 4.6%, and 10.5%,

Table 1: Characteristics of the study population

Characteristics	Total *n* (%)	Deceased *n* (%)	Survived *n* (%)	*P*
Age (years)				
<30	129 (0.62)	11 (0.44)	118 (0.65)	0.001*
30-64	12,375 (59.60)	1187 (47.20)	11,188 (61.30)	
65-84	7477 (36.00)	1016 (40.40)	6461 (35.40)	
≥85	769 (3.70)	297 (11.90)	472 (2.60)	
Gender				
Men	15,033 (72.40)	1656 (65.90)	13,377 (73.30)	0.001*
Women	5717 (27.60)	855 (34.10)	4862 (26.70)	
Education				
Illiterate	9611 (46.30)	1414 (56.30)	8197 (44.90)	0.001*
Primary	4941 (23.80)	540 (21.50)	4401 (24.10)	
Guidance	1940 (9.30)	155 (6.20)	1785 (9.80)	
High school	2992 (14.50)	260 (10.30)	2732 (14.90)	
University	1266 (6.10)	142 (5.60)	1124 (6.20)	
Smoking	5443 (26.20)	776 (31.00)	4667 (25.60)	0.001*
Hypertension	7376 (35.50)	950 (37.80)	6426 (35.20)	0.011*
Type 2 diabetes	4612 (22.20)	610 (24.30)	4002 (21.90)	0.008*
Dyslipidemia	3710 (17.80)	442 (17.60)	3268 (17.90)	0.699
Chest pain	2229 (10.7)	873 (34.70)	1356 (7.40)	0.001*
RBBB	289 (1.40)	74 (3.00)	215 (1.20)	0.001*
LBBB	383 (1.80)	78 (3.10)	305 (1.60)	0.001*
AF	688 (3.30)	116 (4.60)	572 (3.10)	0.001*
VT	1198 (5.80)	264 (10.50)	934 (5.10)	0.001*
STEMI	13105 (63.20)	881 (4.25)	12,224 (58.91)	0.001*
Non-STEMI	7645 (36.84)	1630 (7.86)	6015 (28.99)	0.001*
CABG	539 (2.60)	70 (0.34)	469 (2.26)	0.523
PCI	1431 (7.00)	77 (0.37)	1354 (6.53)	0.001*
No thrombolytic therapy	9222 (44.50)	1513 (60.20)	7709 (42.20)	0.001*
Hospital stay (days)	6.55±14.62	6.43±14.37	6.57±14.65	0.647
Age (mean±SD) years	61.20±13.40	65.24±15.27	60.65±13.03	0.001*

*P<0.01 was significant. RBBB=Right bundle branch block, LBBB=Left bundle branch block, AF=Atrial fibrillation, VT=Ventricular tachycardia, STEMI=ST-segment elevation myocardial infarction, CABG=Coronary artery bypass grafting, PCI=Percutaneous coronary intervention, SD=Standard deviation

all higher than survived patients. The predominant MI was STEMI (63.2%). Use of percutaneous coronary intervention (PCI) was obtained 3.1% in the deceased patients, <7.4% in the survived.

Descriptive characteristics of the second level (district) and third level (province) variables, such as temperature and humidity, are shown in Table 2.

The mean maximum temperature, relative humidity, precipitation, and altitude of the studied counties was 23.9°C, 37.5%, 418.9 mm, and 1027.8 m. The prevalence of hypertension, obesity, type 2 diabetes, smoking, hookah smoking, physical inactivity, vegetables consumption, and fish consumption was obtained, respectively, 16.4%, 44.8%, 9.5%, 10.5%, 2.2%, 35.6%, 11.6%, and 27%.

OR (CI 95%) is shown in Table 3 for the factors associated with the patients' mortality at different levels of the analysis. For the avoidance of residual confounding, age was entered in the model as a quantitative rather than grouped variable. With an increase in mean age by one SD, the OR for mortality increased by 1.54. OR for mortality in patients with primary and secondary school education was significantly less than illiterate patients, both less than the patients with academic education. Use of angioplasty was also derived as a protective variable in hospital mortality. The highest risk of hospital mortality was obtained for ischemic heart pain with chest pain resistant to treatment (OR = 5.2: 4.63–5.9).

Although hospital mortality due to MI was inversely correlated with increase in temperature (OR = 0.97 [95% CI: 0.93–1.02]) and directly correlated with decreased temperature (OR = 1.04 [95% CI: 0.99–1.1]), the association was not derived as significant in view of the calculated OR (95% CI).

Precipitation had a protective effect on the mortality due to MI (OR = 0.79). In contrast, an increase in relative humidity was a risk factor of mortality due to MI. OR (CI 95%) is shown in Table 4 for risk factors associated with the patients' mortality at a two-level model of the analysis.

DISCUSSION

In this study, the association between hospital mortality due to MI and individual, group, and environmental variables was investigated by a multilevel analysis. The strengths of the present study were the avoidance of biases of selection and data, and conduction of a hospital-based, large study with the findings potentially generalizable to the whole country. As the study data were gathered from all Iran's provinces, they are generalizable to the whole country. A study in Australia reported annual mortality due to MI in the aboriginals and nonaboriginals, respectively, 10.7% and 1.2%,[24] both lower than 12.1% obtained in the present study. Another study conducted in 24 countries between 1998 and 2000 to investigate and determine the real or unreal difference in the outcome of MI reported that the differences after MI were mainly due to the variables at individual levels.[25] Hospital-level factors and national level factors have a minor effect on the outcome of MI. The findings of Austin *et al*. study are consistent with our study. In our study, the variables age, gender, education, smoking, family history of heart disease, diabetes, chest pain, type of MI, heart failure, and the type of conducted therapies as significant variables at individual level and humidity and precipitation as collective and environmental variables were significantly associated with mortality from MI. Out of the advantages of our study was the determination

Table 2: Descriptive characteristics at the place of residence (study level) in patients with myocardial infarction

Place of residence	Variable	Maximum	Minimum	Median	IQR*	Mean±SD
District (level 2)	Minimum temperature (°C)	32	1.30	10	6	10.9±5
	Maximum temperature (°C)	39	12.90	22.8	8.1	23.9±5
	Relative humidity (%)	79	14.00	33	17	37.5±14
	Precipitation (mm)	2914.2	33.10	312	290	418.9±394
	Altitude (m)	2490	−23.60	1299	1105	1027.8±637
Province (level 3)	Hypertension (%)	20.8	12.80	16.3	2.1	16.4±1.6
	Obesity (%)	55.1	29.90	46.6	8.2	44.8±5.5
	Type 2 diabetes (%)	27.6	4.00	9.6	3.5	9.5±3.2
	Smoking (%)	14.8	0.16	11.2	3.4	10.9±2.4
	Hookah smoking (%)	12.5	0.5	1.6	1.8	2.2±1.7
	Physical inactivity (%)	47.8	22.2	36.1	8.6	35.6±6
	Vegetables (%)	28.8	2.1	9.8	6	11.6±4.5
	Fish (%)	35.8	17.7	26.6	7.5	27±5
	Fried food (%)	25	3.4	8.6	6.7	9.9±4.4
	BMI (kg/m^2)	26	22.5	25.2	1.7	24.8±0.9
	CCU** bed	1099	10	173	192	241±279

*IQR=Inter quartile range, **CCU=Cardiac care unit, SD=Standard deviation, BMI=Body mass index

Table 3: Factors associated with the patients' mortality at levels (place of residence) of analysis

Level	Characteristics	OR (95% CI)		
		Model 1*	Model 2**	Model 3***
Individual variable (level 1)	Age	1.54 (1.46-1.63)	1.51 (1.43-1.59)	1.54 (1.46-1.63)
	Gender (women)	1.30 (1.17-1.46)	1.25 (1.12-1.39)	1.30 (1.17-1.46)
	Education			
	Illiterate	Reference	1	1
	Primary	0.85 (0.75-0.97)	0.86 (0.76-0.97)	0.85 (0.75-0.96)
	Guidance	0.79 (0.64-0.97)	0.77 (0.63-0.94)	0.79 (0.64-0.97)
	High school	0.82 (0.69-0.98)	0.85 (0.72-1.00)	0.82 (0.69-0.98)
	University	1.09 (0.87-1.35)	1.16 (0.94-1.43)	1.09 (0.87-1.35)
	Smoking	1.19 (1.06-1.33)	1.10 (1.01-1.21)	1.20 (1.09-1.38)
	Family history	2.37 (2.12-2.65)	2.31 (2.12-2.86)	2.35 (2.12-2.62)
	Type 2 diabetes	1.20 (1.06-1.34)	1.20 (1.06-1.34)	1.20 (1.06-1.34)
	Hypertension	0.78 (0.70-0.87)	0.78 (0.70-0.87)	0.78 (0.70-0.87)
	PCI	0.52 (0.40-0.60)	0.52 (0.40-0.68)	0.52 (0.40-0.68)
	No thrombolytic therapy	1.99 (1.79-2.21)	1.99 (1.70-2.21)	1.99 (1.70-2.21)
	Chest pain	5.23 (4.60-5.95)	5.22 (4.59-5.94)	5.22 (4.59-5.93)
	RBBB	2.09 (1.51-2.88)	2.06 (1.49-2.85)	2.06 (1.50-2.85)
	VT	1.80 (1.50-2.14)	1.79 (1.50-2.13)	1.79 (1.70-2.13)
	STEMI	1.51 (1.32-1.72)	1.52 (1.33-1.73)	1.52 (1.33-1.73)
	Heart failure	1.77 (1.51-2.08)	1.77 (1.51-2.07)	1.77 (1.51-2.07)
Level 2 (district) covariates	Temperature (minimum)	-	0.98 (0.94-1.03)	0.99 (0.94-1.03)
	Temperature (maximum)	-	0.96 (0.75-1.24)	0.99 (0.76-1.29)
	Humidity	-	0.86 (0.65-1.13)	0.84 (0.75-1.17)
	Altitude	-	0.86 (0.66-1.12)	1.04 (0.64-1.11)
Level 3 (province) covariates	BMI	-	-	1.20 (0.96-1.49)
	Inactivity	-	-	1.01 (0.94-1.04)
Intercept	Constant	0.02:0.009-0.04	0.02:0.009-0.04	0.0001
Variance	Level 2 variance	1.07:0.79-1.44	1.06:0.78-1.43	1.04:0.78-1.39
	Level 3 variance	0.01:0.001-3.2	0.01:0.00001-5	0.0001:<0.0001
Likelihood ratio test	Compared to previous model	−7010	−6011	−6008
AIC		14,026	12,067	12,074

*Model 1=Adjusted OR of mortality for age, gender, education, smoking, family history, type 2 diabetes mellitus, hypertension, PCI, thrombolytic therapy, chest pain, RBBB, VT, STEMI, heart failure, **Model 2=Adjusted OR of mortality for variables in model 1 (above model) and level 2 (district) covariates (temperature, humidity, altitude), ***Model 3=Adjusted OR of mortality for variables in model 1, model 2 (above models) and level 3 (province) covariates (BMI, inactivity). PCI=Percutaneous coronary intervention, RBBB=Right bundle branch block, VT=Ventricular tachycardia, STEMI=ST-segment elevation myocardial infarction, BMI=Body mass index, AIC=Akaike's information criterion, OR=Odds ratio, CI=Confidence interval

of the factors associated with hospital mortality in multilevel analysis. This analysis is much more accurate than the conventional logistic regression analysis.[25] A hospital-based study by Koren *et al.*, obtained the prevalence of hypertension, dyslipidemia, type 2 diabetes, and smoking 39%, 38%, 24%, and 52%, respectively, which is higher than the present study findings. In Koren *et al.* study, the rate of coronary artery bypass grafting (CABG) was reported 7%, which is significantly higher than that in our study.[26] Willey *et al.*, compared Hispanic and non-Hispanic MI patients with regards to cardiac mortality. Hispanic patients were at lower risk of cardiac mortality. The mean age of patients was 68.8 years and the history of hypertension, diabetes, and smoking was obtained, respectively, 3.72%, 4.20%, and 9.17%. In Willey *et al.*, study, the percentage of cardiac mortality was 7%, which is lower than that in our study.[27] Another study by Nicolau *et al.*, in Brazil reported that post-MI survival followed by thrombolytic therapy was higher in men than women. Nicolau *et al.*, study reported a lower risk of mortality in men than women. After adjusting the relationship for age and other variables, the relationship between the genders was not significant for the risk of mortality. In our study, the ratio of mortality for women in the presence of other variables was significant. Gender was derived as a significant variable in the presence of other risk factors in our study, which is consistent with Nicolau *et al.*, study.[28] Various studies reported age, gender, family history of heart disease, hyperlipidemia, hypertension, type 2 diabetes, smoking, educational level, obesity, and physical inactivity as risk factors of heart diseases,[29-32] which confirms our findings. The results of our study are consistent with the studies reporting that type 2 diabetes, hypertension, and smoking were higher

Table 4: Factors associated with the patients' mortality in final multilevel analysis model

Level	Characteristics	Adjusted OR (95% CI)
Individual variable (level 1)	Age	1.50 (1.42-1.58)
	Gender (women)	1.33 (1.18-1.48)
	Education	
	Illiterate	Reference
	Primary	0.85 (0.76-0.97)
	Guidance	0.76 (0.97-0.94)
	High school	0.84 (0.72-1.00)
	University	1.16 (0.94-1.43)
	Smoking	1.22 (1.09-1.36)
	Family history	2.19 (1.97-2.43)
	Type 2 diabetes	1.20 (1.07-1.35)
	Hypertension	0.78 (0.70-0.87)
	PCI	0.52 (0.40-0.68)
	Lack of thrombolytic	1.99 (1.70-2.21)
	Chest pain	5.27 (4.63-5.99)
	RBBB	2.07 (1.50-2.85)
	VT	1.79 (1.50-2.13)
	STEMI	1.52 (1.31-1.72)
	Heart failure	1.77 (1.51-2.07)
Level 2 (district) covariates	Temperature minimum	1.04 (0.99-1.10)
	Temperature maximum	0.97 (0.93-1.02)
	Humidity	1.25 (1.17-1.35)
	Precipitation	0.79 (0.74-0.84)
Intercept	Constant	0.02 (0.009-0.04)
Variance	Level 2 variance	0.19 (0.07-0.46)
Likelihood ratio test	Compared to previous model	−6328
AIC		12,706

PCI=Percutaneous coronary intervention, RBBB=Right bundle branch block, VT=Ventricular tachycardia, STEMI=ST-segment elevation myocardial infarction, AIC=Akaike's information criterion

in deceased patients due to MI than survived patients. In the present study, age, education, lack of thrombolytic therapy, type 2 diabetes, chest pain before arriving at the hospital, heart failure, family history of cardiovascular disease, RBBB, VT, and STEMI were determinants of hospital mortality due to MI, consistent with studies in other countries such as Japan and Korea.[29-32] In our study, hypertension and hospital mortality were significant in univariate analysis, but the OR for mortality, in multiple analysis, was lower in the patients with hypertension than without hypotension. It seems that the control of hypertension with treatment plays an important role in the mortality due to MI. In Japan, hypertension-related mortality was significant in MI patients,[32] which is inconsistent with our study. In Thomas *et al*. study, age, lack of thrombolytic therapy and VT were the most important determinants of mortality in patients with MI, which is similar to our results. Hypertension, type 2 diabetes, and smoking in Thomas *et al*. study were derived 49%, 53%, and 30%, respectively, and in the multiple regression model were significant risk factors for mortality.[33] In a study in which 73% were male and the mean age was 68.1 years, the findings were similar to our findings. History of CABG, PCI, and type 2 diabetes was reported 4.4%, 12.5%, and 25.3%, respectively,[34] higher than the corresponding values, respectively, 2.6%, 3.2%, and 22.2% in our study. In our study, AF was one of the determinants of hospital mortality, which is consistent with a study in France.[35] In India, 30.4% of patients had type 2 diabetes, 37.7% hypertension, and 40% were smokers; in the present study, the corresponding figures were obtained 22.2%, 5.35%, and 2.26%, respectively. In India, despite the high prevalence of risk factors, the rate of mortality was obtained 6.7%, which is lower than the mortality rate in our study.

Since 63.2% of the patients in Iran with STEMI diagnosis, higher than non-STEMI, have been registered and the registered figures for diagnosis of the MI type in Iran is inconsistent with those in the USA,[36] under-registration of non-STEMI cases is probable in Iran, which could be explained by the fact that the majority of the patients with non-STEMI deceased before arriving at the hospital and hence are not included in hospital figures. The findings indicated that the rate of use of common therapies for MI patients is lower than other countries and hence further use of these therapies, particularly PCI, is recommended to reduce hospital mortality from MI, and training of the patients to refer early and undergo therapies at golden time is critical to preventing avoidable deaths.

Temperature, precipitation, and relative humidity were derived as the determinants of the MI mortality, which is consistent with the studies investigating the relationship alone and/or considering other variables.[37,38]

Although the mechanism effect of temperature, precipitation, and humidity on heart disease has not been established well, temperature reduction leads to increased pressure, impaired inversion layer height, and increased concentration of pollutants in the confined space. High temperature causes increased ozone level and other air pollutants, with direct impact on the severity and worsening of cardiovascular diseases. Moreover, the precipitation reduces air pollutants and their concentrations and is inversely correlated with cardiovascular morbidity and mortality.[39-41] Although air pollution has been already reported to have no effect on the outcome of MI in the investigation of the temperature and precipitation association with MI outcome, in our study, air pollution could be a confounding factor. Due to lack of information needed to control air pollution as a confounding variable, it should be considered in future studies. The knowledge of the role of environmental and biological factors could be used to improve prevention measures and educational strategies, especially in people at risk of diseases.[42-44] A limitation of the present study was failure to gather the data on ejection fraction as it is one of the predictive factors of mortality, needing to be addressed in future studies. Prospective cohort study and follow-up of the patients for the event of interest at frequent intervals are recommended in future investigations.

CONCLUSIONS

The individual variables had a determining effect on the mortality due to MI. Hence, individual interventions in healthcare centers, clinics, and community at large for lifestyle changes contribute importantly to preventing and controlling mortality. Less importantly, the variables related to the living environment such as temperature, relative humidity, and precipitation may determine the mortality in patients. Variables at the province level had no significant effect on the outcome of MI. Implementing educational strategies, motivating people to visit doctors early, and increasing access to treatment especially in the individuals at MI risk could reduce the mortality due to MI.

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