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Original Research Article

Trends of myocardial infarction morbidity and its associations with weather conditions

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ABSTRACT

Objective: The aim of this study was to assess the trends of myocardial infarction (MI) morbidity and evaluate the associations with some meteorological factors.
Materials and methods: Data on MI morbidity were collected from Kaunas ischemic heart disease registry and information about meteorological factors from Kaunas meteorological station was collected.
Results: The overall morbidity rates of acute MI among men aged 25–64 increased by 2.0%/yr. ($P = 0.02$), whereas among women did not change significantly (+1.2%/yr., $P = 0.2$) during 1995–2007. Among men aged 65–84 the overall morbidity rates of MI were without significant changes (−1.0%/yr., $P = 0.3$) and among women decreased significantly by −1.7%/yr. ($P = 0.03$). During 1995–2000, a weak inverse significant correlation between atmospheric air temperature and morbidity of MI ($r = -0.05$, $P = 0.019$) was documented (in women and the elderly $r = -0.045$ and −0.048, respectively, $P < 0.05$). Weak correlation between atmospheric air wind speed and MI morbidity in women ($r = -0.042$, $P = 0.05$) and in population of older age ($r = -0.056$, $P = 0.099$) was determined. In men and in elderly population a direct weak correlation between atmospheric pressure and MI morbidity was found ($r = 0.114$ and 0.166, respectively, $P < 0.01$). In this study monthly and seasonal variation of MI rates were observed. In winter period MI rates were higher to compare with other seasons ($\chi^2 = 18.682$, $df = 3$, $P < 0.0001$).
Conclusions: The overall morbidity rates of MI increased among Kaunas men aged 25–64 and tended to increase among women, whereas among men aged 65–84 MI morbidity trends were without statistically significant changes and significantly decreased among women

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during 1995–2007. Weak inverse correlations between atmospheric air temperatures, rainfall level and direct correlation between air wind speed, atmospheric pressure and MI morbidity were established. Months/seasonal variations during analyzed period were observed.

1. Introduction

The half of all death causes, one-third for disability and 15%–20% of visits to health care institutions are responsible cardiovascular diseases (CVD) in Lithuania [1,2]. The research on morbidity and mortality from CVD in Lithuanian population showed that during the past two decades these rates has been increasing more rapidly than in the other Baltic countries [3]. It was determined, that some socio-demographic and behavioral factors as arterial hypertension, dyslipidemias, smoking and others influenced morbidity and mortality from CVD, especially from coronary heart disease (CHD) [4]. Some researcher's occurrence of myocardial infarction (MI) associated with meteorological conditions such as atmospheric air temperature, relative humidity, wind speed, air pressure and others [5–8]. Other investigators increased incidence of MI associated with weather seasonal variations and rapid changes of meteorological factors during a day [9]. Weather associations with morbidity and mortality from CHD have been reported in different countries [10,11]. This phenomenon has been attributed to weather components variations. In particular, some studies have reported increased CHD incidence and mortality during winter period [12,13]. Consensus is lacking, however, on whether this phenomenon reflects variations in incidence of MI and in case lethality. Variations in emergency admission rates and trial recruitment of patients suffering from MI [6,14] are well described, and a number of epidemiological studies have reported a highest winter MI incidence, with similar seasonal trends in all studied subgroups, including men and women, middle-aged and elderly patients, patients from northern and southern countries and different types of MI [15]. This relationship could be actually U-shaped, with higher incidence and mortality also in extremely low or high temperatures [16]. These seasonal changes do not seem universal and as they are absent near the equator or in sub-polar regions with less temperature fluctuations unlike those found in temperate regions [17,18]. Up to now the effect of weather variables on MI has not been assessed in Lithuania, a country with an averaged cold and wet climate. Some meteorological factors other than air temperature were less frequently studied. A better understanding of these meteorological patterns may provide additional measures in CVD prevention.

The aim of this study was to determine the trends of MI morbidity and evaluate the correlations of meteorological factors such as atmospheric air temperature, rainfall, wind speed, atmospheric pressure and morbidity of myocardial infarction.

2. Materials and methods

Myocardial infarction morbidity data were obtained from Kaunas population-based ischemic heart disease (IHD) registry. The methods used for the MI data collection were those applied by the WHO for the international MONICA (MONItoring of trends and determinants in CArdiovascular disease) project and were described in detail elsewhere [19].

The morbidity trends of MI among Kaunas population were evaluated during period from 1995 to 2007 years. According to the IHD register data, during this period 6753 cases of MI, 3895 (57.7%) in Kaunas men and 2858 (42.3%) in women were reported. The event number of MI occurring during the same period was 2999 (44.4%) in persons aged 25–64 years and 3754 (55.6%) in persons aged 65–84 years.

Weather conditions such as atmospheric air temperature, wind speed, rainfall and atmospheric pressure were analyzed in 1995–2000. Data about weather conditions such as atmospheric air temperature ($n = 2192$ days), level of rainfall ($n = 2192$ days), wind speed ($n = 2192$ days) and atmospheric pressure ($n = 365$ days) were collected from Kaunas meteorological station. Daily variations of atmospheric air temperature were measured in absolute temperature units in Celsius scale. Level of rainfall is measured in millimeters (mm) per day, level of wind speed is measured in meters per second and level of atmospheric pressure is measured in mm of Hg as averaged per day. Months/seasonal atmospheric air temperature, level of rainfall, wind speed and atmospheric pressure and MI rates variation were measured during four seasons: spring (from March to May), summer (from June to August), autumn (from September to November) and winter (from December to February) months.

2.1. *Statistical analysis*

Statistical data analysis was performed using the SPSS program version 13.0 and MS Office Excel software package. MI morbidity rates were calculated per 100 000 inhabitants per year and were age-standardized using the direct method and the Segi's world population as a standard. Trends were analyzed using the method of linear regression on logarithms of the age-standardized annual overall morbidity rates. The regression coefficient multiplied by 100 is given as an average yearly change. Spearmen correlation and linear regression analyses between events of MI and weather conditions levels was assessed. Month/seasonal variations were calculated by nonparametric χ^2 criterion. A P value of <0.05 was considered as statistically significant.

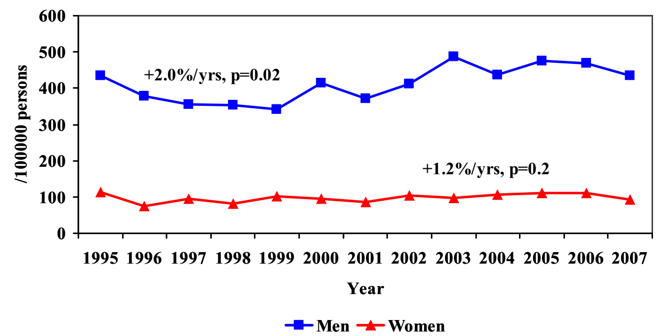

Fig. 1 – Trends of overall morbidity of myocardial infarction among Kaunas men and women aged 25–64 years during 1995–2007 (IHD registry data).

3. Results

According to the data of IHD register, during 1995–2007, the mean overall morbidity from MI was 412.4/100 000 and 97.8/100 000 among Kaunas men and women aged 25–64 years. Among men, the overall acute MI morbidity rates were about 4-fold higher compared to women. The trends of overall morbidity rates of MI among the middle-aged men and women are shown in Fig. 1. According to the results of regression analysis, the overall morbidity rates of MI were increasing by 2.0% per year ($P = 0.02$) among men and were without significant changes among women (+1.2% per year, $P = 0.2$) during the study period.

During 1995–2007, the mean overall morbidity rate of MI was 1285.2/100 000 and 750.3/100 000 among Kaunas men and women aged 65–84 years, respectively. Among men, the MI morbidity rates were about 1.5-fold higher compared to women. The trends of overall morbidity rates of MI among men and women aged 65–84 are shown in Fig. 2. According to the results of regression analysis, among men, the overall morbidity rates of MI were without significant changes (−1.0% per year, $P = 0.3$) and among women decreased significantly by −1.7% per year ($P = 0.03$) during the study period.

Associations between weather conditions and MI events stratified by gender and age are shown in Table 1. It was estimated that only atmospheric air temperature was inversely significantly associated with MI morbidity level ($r = -0.05$, $P = 0.019$) and tended to be directly associated with atmospheric pressure levels ($r = 0.102$, $P = 0.051$) among Kaunas population. Relationships between MI morbidity rates with the other weather conditions such as rainfall and wind speed were not detected.

During correlation analysis stratified by gender it was estimated that among Kaunas men only atmospheric air pressure level was directly associated with MI event rate ($r = 0.114$, $P = 0.03$). In Kaunas men all the other analyzed weather conditions such as atmospheric air temperature, rainfall and wind speed and MI event rate were not significantly associated. Data analysis in Kaunas women population revealed that only atmospheric air temperature level was inversely associated with MI event rate ($r = -0.045$, $P = 0.037$). In addition, among women the wind speed tended to be directly associated with the MI rate ($r = 0.042$, $P = 0.05$). Rainfall and atmospheric air pressure did not significantly correlated with the MI event rate among Kaunas women.

Among persons aged 25–64 years, the correlation analysis of the all the analyzed weather conditions variables and MI event rate stratified by age revealed no any associations. Data analysis in Kaunas population aged 65–84 years revealed that atmospheric air temperature level was inversely associated with the MI event rate ($r = -0.048$, $P = 0.024$) and wind speed,

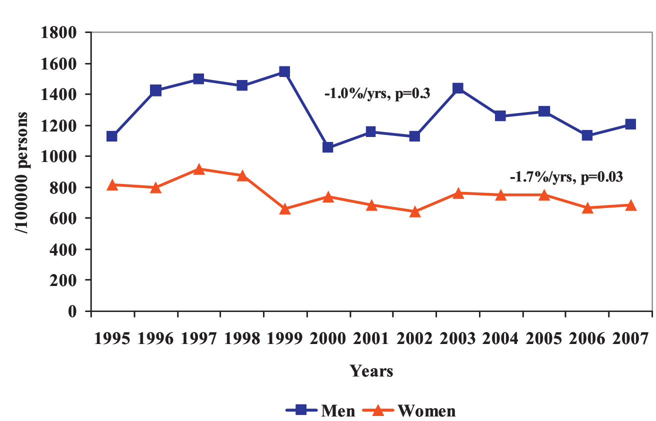

Fig. 2 – Trends of overall morbidity of myocardial infarction among Kaunas men and women aged 65–84 years during 1995–2007 (IHD registry data).

Table 1 – Correlation between weather conditions and myocardial infarction morbidity among Kaunas inhabitants aged 25–84 years during 1995–2000 by gender and age groups.

	Atmospheric air temperature		Rainfalls		Wind speed		Atmospheric pressure	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*
All	−0.05	0.019	−0.035	0.099	0.024	0.261	0.102	0.051
Men	−0.026	0.221	−0.026	0.216	0.002	0.937	0.114	0.03
Women	−0.045	0.037	−0.022	0.302	0.042	0.05	0.032	0.538
25–64 years	−0.023	0.292	−0.017	0.438	0.02	0.339	0.01	0.844
65–84 years	−0.048	0.024	−0.037	0.087	0.056	0.009	0.166	0.001

whereas atmospheric air pressure was directly associated with the MI event rate ($r = 0.056$, $P = 0.009$ and $r = 0.166$, $P = 0.001$, respectively). Among Kaunas population aged 65–84 years, all the other analyzed weather conditions were not significantly associated with the MI rates.

In this study, months and seasonal variations of MI rates were observed. In December (8.5%) and January (9.4%) months and in winter period (25.9%), MI rates were higher to compare with June (7.5%), July (7.3%) months and summer period (22.9%) ($\chi^2 = 43.603$, $df = 11$, $P < 0.0001$ and $\chi^2 = 18.682$, $df = 3$, $P < 0.0001$, respectively).

The seasonal and monthly variations and association between mean monthly atmospheric air temperature and MI events number among Kaunas population aged 25–84 years is shown in Fig. 3. In winter months (especially in December) with less than average air temperature levels (from 0 °C to −5 °C) the number of MI events was higher, whereas in summer months (especially in June and July) with higher than average air temperature (from 15 °C to 20 °C) the number of MI events was lower. Correlations among MI rates levels in separate seasons and mean air temperature revealed average inverse correlation among seasons (from spring to winter) and air temperature levels ($r = -0.575$, $P < 0.0001$). Linear regression analysis showed that increased air temperature by 1 °C on average decreased the MI rate in by 2.2 units ($P < 0.0001$). Despite these tendencies, during the analyzed period in May the highest number of MI events was observed when the air temperature in average reached 10–15 °C.

The seasonal and monthly variations and association between mean monthly rainfall levels and MI events number among Kaunas population aged 25–84 is shown in Fig. 4. Analysis of 1995–2000 data revealed, that in winter months with less than average rainfall levels (from 1 mm to 2.0 mm) the number of MI events was higher, but in summer months (especially in June and July) with higher than average rainfall levels (from 2 mm to 2.5 mm) the number of MI events was less. Correlations among MI rates levels in separate seasons (from spring to winter) and mean rainfall revealed weak inverse correlation among seasons and rainfall levels ($r = -0.225$, $P < 0.0001$). Linear regression analysis revealed that increased rainfall by 1 mm on average decreased the MI rate by 50.5 units ($P < 0.0001$).

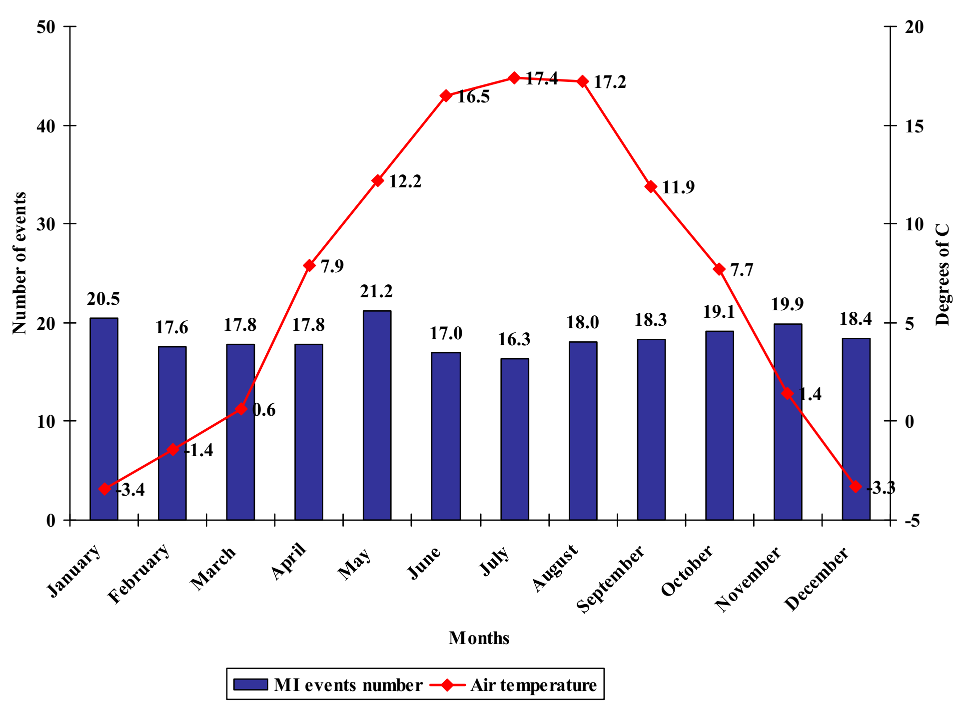

Fig. 3 – Averaged monthly atmospheric air temperature and numbers of myocardial infarction events per day by the month of the year among Kaunas inhabitants aged 25–84 years during 1995–2000 ($\beta = -2.165$, $P < 0.0001$).

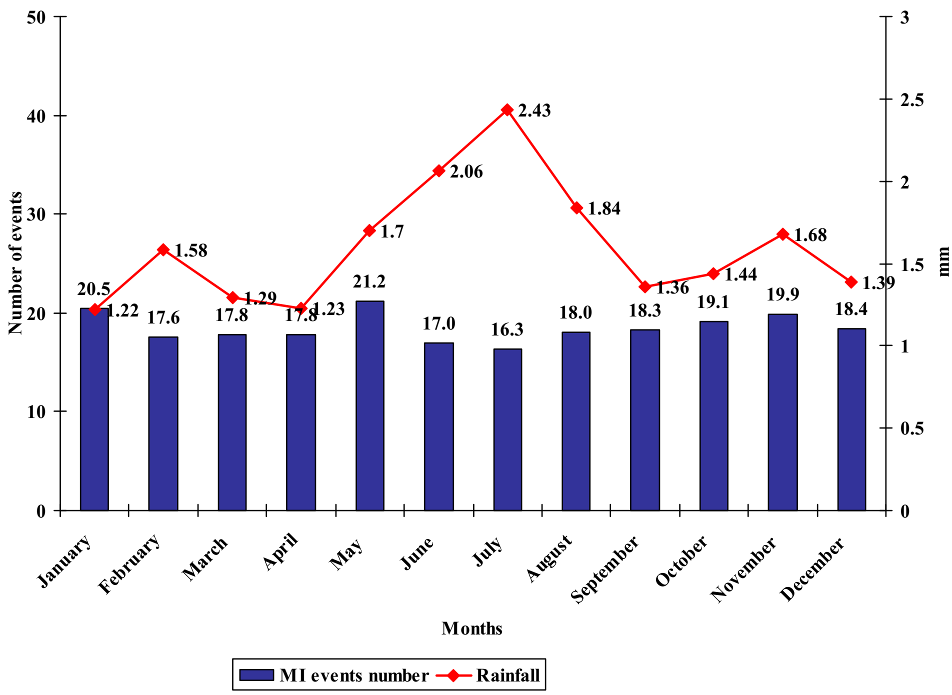

Fig. 4 – Averaged monthly rainfall level and numbers of myocardial infarction events per day by the month of the year among Kaunas inhabitants aged 25–84 years during 1995–2000 (β = −50.465, P < 0.0001).

The seasonal and monthly variations and association between mean monthly weather wind speed and MI events number in Kaunas population aged 25–64 years is shown in Fig. 5. Analysis of the data revealed, that in late autumn and winter months (October, November and January) with higher than average wind speed (from 7 m/s to 8 m/s) the number of MI events was the highest. Whereas in summer months (especially in July) when the wind speed was higher than average (from 6 m/s to 7 m/s) the number of MI events was less. Correlations among MI rates levels in separate seasons (from spring to winter) and mean wind speed revealed direct correlation among seasons (from spring to winter) and wind

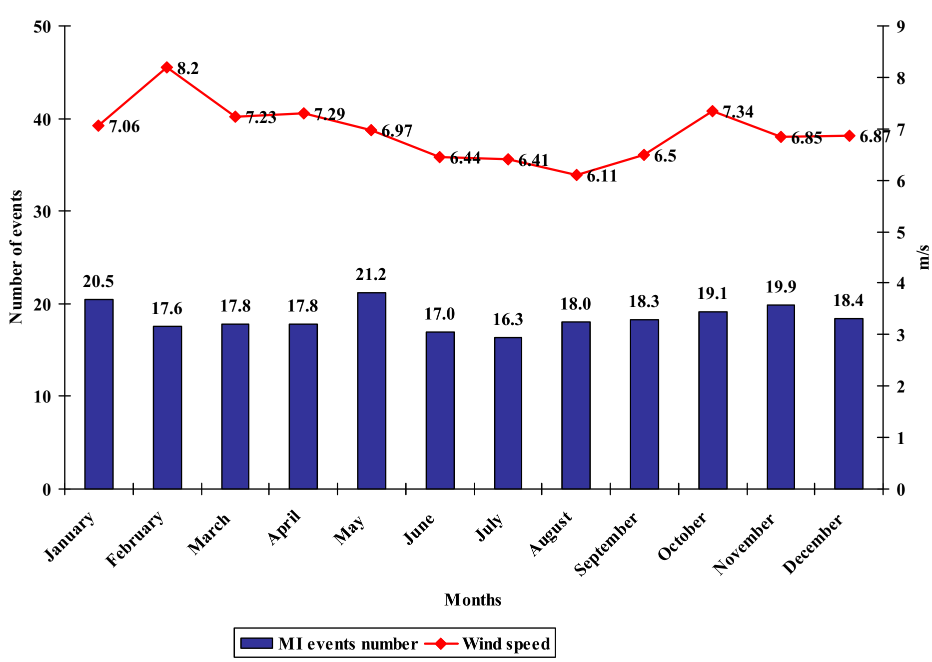

Fig. 5 – Averaged monthly wind speed level and numbers of myocardial infarction events per day by the month of the year among Kaunas inhabitants aged 25–84 years during 1995–2000 (β = −35.491, P < 0.0001).

speed levels ($r = 0.232$, $P < 0.0001$). Linear regression analysis revealed that increased wind speed by 1 m/s on average decreased the MI rate by 35.5 units ($P < 0.0001$).

4. Discussion

During 1995–2007, the overall morbidity of AMI among Kaunas men aged 25–64 years increased significantly and among women was tended to increase. The rates in overall morbidity of MI among men were on average 4 times higher than among women during the study period. In general, the rates of morbidity of AMI, especially among men, were rather high and were similar to same rates of countries such as Estonia, Latvia, Poland, Russia and some other neighboring states [2,3]. Recent data of the risk factors survey performed in Kaunas during past decade showed that the prevalence of arterial hypertension among both middle-aged men and women significantly decreased, the prevalence of hypercholesterolemia remained stable, and the prevalence of smoking among men was stable, but among women increased [4,20]. The changes of the morbidity rates are related not only to the decrease of the prevalence of the main IHD risk factors, but also to changes in socio-economic factors, educational level, alcohol drinking and nutrition habits, as well as the newest diagnostic and treatment possibilities [21,22]. The growing morbidity of MI is not a random event but on the contrary is associated with several known-triggering factors, including environmental variables. In our study we detected, that some meteorological factors, such as atmospheric air temperature and rainfall level were directly correlated to morbidity of MI. Other analyzed meteorological factors such as air wind speed and atmospheric pressure were inversely correlated with the morbidity of MI. The present results are also consistent with the other studies in Europe that highlighted the negative contribution of cold weather on the incidence of MI [23–25], although, in accordance with other studies [26,27]. Results of a stronger effect of cold weather on the middle-aged adult population than in the elderly were also found in similar studies [26,27]. One possible explanation for this ''protective effect'' in the elderly is that younger people may be more likely involved in outdoor activities and, therefore, more exposed to cold weather [28]. In the presented study stronger effect of cold was estimated among elderly population. However, further research is needed in order to fully understand the individual conditions and cold exposure. In the Worcester Heart Attack Study it was estimated, that a decrease in an interquartile range in apparent temperature was associated with an increased risk of acute MI on the same day (Hazard ratio = 1.15). Extreme cold during the 2 days prior was associated with an increased risk of acute MI in average by 36% [29].

In our study in winter months (especially in December) MI events number was higher, but in summer months (especially in June or July) it was lower. Arntz et al. in the German survey observed peak periods in December and January, with minimum of events in July [30]. Gonzales et al. based on their analysis in Spain, revealed the highest incidence of MI events in January, with a minimum number of events in August [31]. Halberg et al. suggested that the occurrence of MI is the highest in March and December, while there were a minimum numbers of events in June and July [32]. The smaller increases in colder climates suggest that some events in warmer climates are preventable. When atmospheric air temperature is lowering, a risk of heart attack is higher in winter than in summer. Results of our study are a bit different from those previous findings, and this difference may be due to geographical and climatic variations. The law of nature regulates seasons, and the natural environment significantly influences the related pattern of the incidence of MI events, however its role is not exclusive. Based on our results the incidence of MI events shows a peak period during spring months with a second peak during late autumn and minimum incidence during the summer season. Data in other studies showed that the impact of changes in seasonal patterns on mortality from IHD was investigated in Japan cities – Okinawa and Osaka. The study determined the inverse correlation between mean month atmospheric air temperature and death rate due to IHD in Okinawa population ($r = -0.794$, $P = 0.01$) and in Osaka population ($r = -0.837$, $P = 0.001$) [33]. In 1985–1995 the study in Norway and Finland determined that death event rate from IHD was the highest in January and the lowest in April. A comparison of the numbers of death from IHD in January and April determined that in January the death number from IHD was higher by 22% in Norway and by 35% in Finland. In Finland more than in Norway the death rate from IHD increased with a decrease in temperature of atmospheric air [34]. In the study carried out in Oslo and Dublin the inverse relationship between air temperature and mortality from IHD events rate was determined [34]. Canadian investigators studied high meteorological variations and their influence to the number of heart attacks in Calgary city and surrounding areas. The study did not determine any relationship between atmospheric air changes and heart attack event rate [35].

Some investigators attributed this winter effect to the difference in the photoperiod (number of sunlight hours) between winter and summer [36]. Women and elderly persons, as well as people with elevated arterial blood pressure and high level of cholesterol who suffered from heart attack were more susceptible to the low atmospheric air temperature [37,38]. Cold exposure increases blood pressure, sympathetic nervous output and platelet aggregation [39]. The sympathetic system probably plays a major role in defining seasonal rhythms of acute MI. In addition, acute-phase factors, as prognostic elements in unstable angina, such as C-reactive protein, fibrinogen and factor VII activity are higher in winter [40,41].

A limitation of our study may be due to not controlling other meteorological factors and its fluctuation during day, week and months. On the other hand, a limitation of the present study was that we relied on central station monitoring for meteorological factors instead of measurements of personal exposure to environmental variables and individual relations between the risk factors and the outcome (MI) could not be estimated. Additional experimental and clinical research is necessary to ultimately confirm the existence of the direct effect and to better characterize the biological mechanisms involved.

5. Conclusions

MI morbidity rates significantly increased in Kaunas men aged 25–64 years and tended to increase among women during 1995–2007. Among Kaunas men aged 65–84 the overall morbidity rates of MI did not change significantly but decreased among women from 1995 to 2007. A significant correlation between 4 weather parameters (low atmospheric air temperature, rainfall level, higher air wind speed, higher atmospheric pressure) and morbidity of MI was observed. Seasonal variations during analyzed period were observed: highest myocardial infarction rates were in the winter season as compared with the summer season.

Conflict of interest

The authors declare that they have no competing interests.

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