Geographical variation and temporal trend of myocardial infarction hospital admissions in Calgary

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Abstract

Coronary heart disease is a leading public health concern. The etiology of myocardial infarction may include both individual and contextual factors which are not fully accounted for in existing research. Spatial and temporal analysis of disease data provids a strategy for identifying influencing contextual factors in areas with high MI disease burden and may generate new hypotheses on determinants of the disease. Temporal analysis is applied to investigate the temporal trends in monthly age and gender stratified myocardial infarction hospitalizations from 2004 to 2013 in Calgary. Ripley's K function is performed for spatial pattern analysis, and complemented by hot spot analysis to identify MI clusters. The trend analysis exhibits a statistically significant declining trend for all the goups. Most groups show a peak of MI occurrence in fall and winter. The group over 75 features the highest incidence of MI, and males account for a larger proporation of MI. Spatial analysis suggests MI incidence is clustered in communities with a larger proportion of older people, lower socioeconomic status, and closer to the airport and industrial areas.

Background

Cardiovascular disease is a leading public health concern, contributing to 30% of global mortality and inflicting severe consequences on individuals and society ((Mendis et al., 2010). The rate of death caused by cardiovascular disease has decreased steadily in the past decades (Kesteloot et al., 2005), and the rate of hospitalization for acute coronary syndrome decreased by 9.2% in Canada from 1994 to 2004 (Tu et al., 2009). Whether such declines are occurring to a similar degree among different age and gender groups is uncertain; yet, it may be important to study these trends for different population groups, to understand potential factors driving the decline. This may further identify individual and contextual factors (socioeconomic status and demography) that influence the etiology of myocardial infarction, yet is not fully accounted for in existing research ((Majlund et al., 2016). The contextual spatial information on where an event (e.g. disease or death) occurs may provide information on why it occurs (Waller & Gotway, 2004). Investigating the spatial distribution and clusters of MI provides potential for identifying determinants in areas with high MI disease burden and may generate new hypotheses on determinants of the disease.

Methods and Data

Study area and data

Calgary is the largest city in Alberta, with a population of approximately 1.2 million (Statistics Canada, 2012), and industry located in the east side of the city (Bertazzon et al., 2015). This study explores the monthly temporal trend and spatial pattern of myocardial infarction hospitalizations from 2004 to 2013 in Calgary. The analysis is conducted at the dissemination area level. The MI data is provided by Alberta Provincial Project for Outcome Assessment in Coronary Heart disease (APPROACH), which collects and processes information to improve cardiac care. Data on the background population are acquired from the Calgary 2014 civic census (The City of Calgary, 2014), where age and gender information is collected twice in each 5 year period: 2004, 2006, 2009, 2011 and 2014. Among 12,389 patients with acute coronary syndrome from 2004 to 2013, 6,142 were admitted to hospitals with myocardial infarction as primary or secondary diagnosis registered in APPROACH. Only 49 (0.7%) persons under 35 years were diagnosed with MI, therefore this age group is excluded from the following analyses. Individuals are grouped by age and gender, forming 6 groups in total: Females (35 to 64; 65 to 74; and 75+), and Males (35 to 64; 65 to 74; and 75+)(Majlund et al., 2016; The City of Calgary, 2014). All the MI hospital admissions are normalized by age and gender.

Method

In this study, time series of hospitalizations for each group are decomposed into 3 temporal components: trend, seasonal and random, within an additive approach. A linear regression models the trend component using time as the independent variable. Two spatial analytical techniques are used: Ripley's K function and hotspot analysis. The distance threshold is determined by calculating spatial autocorrelations at different distances. According to the average size of DAs in Calgary, we select 2800m as threshold distance for spatial analysis where spatial autocorrelation is most statistically significant and begins to decline. Ripley's K function is an indicator of global spatial autocorrelation, which compares the distance (L(d)) between observed pairs with the distance between randomly generated points by examining 99 permutations over the study area (Kao et al., 2010). It summarizes the spatial dependence between cases over a distance range (Majlund et al., 2016). The null hypothesis of complete spatial randomness is rejected if the observed distance falls above the simulated distance at a 95% confidence level, indicating a more clustered distribution at that distance. The starting distance considered is 200m, with 100m increments, for a total of 30 increments. We further apply hot spot analysis based on the local Gi* statistic, which compares local averages to global averages and identifies areas where MI incidence is more clustered. We create a spatial weight matrix with a 2,800m threshold distance and including at least 2 neighbors. All analyses are performed in R and ArcMap software.

Results

Temporal analysis

Among the MI population, males aged 35 to 64 make the greatest contribution (41%) to MI, followed by males aged 65 to 74 (16%) and males over 75 (16%). The overall contribution of males (73%) is three times as high as females (27%) (Figure 1). By comparing the proportion of each group to the background population and the MI population respectively, results show that the MI population features a higher proportion of people over 65 (50%), which group accounts only for 11% of the background population. The proportion of males over 75 in the MI population is 8 times as high as it is in the background population, followed by males 65 to 74, which is about 5 times.

Table 1 Summary statistics for age and gender stratified populations

Gender	Age	Background Population		MI Population		%MI/%Pop
		N=1090936	%Pop	N=6142	%MI	
Females	35-64	226836	21%	568	9%	0.43
	65-74	31150	3%	353	6%	2
	75+	27701	3%	729	12%	4
Males	35-64	235497	22%	2528	41%	1.86
	65-74	28508	3%	956	16%	5.33
	75+	19156	2%	959	16%	8

The higest MI incidence for people over 75 and Males 65 to 74 happened in fall and winer 2005, while the lowest MI incidence for all groups happended in 2012 (Figure 1 and 2). Most groups exhibit a clear association between MI and seasonality: higher MI happened in colder months, which is consistent with previous studies (Fares, 2013).

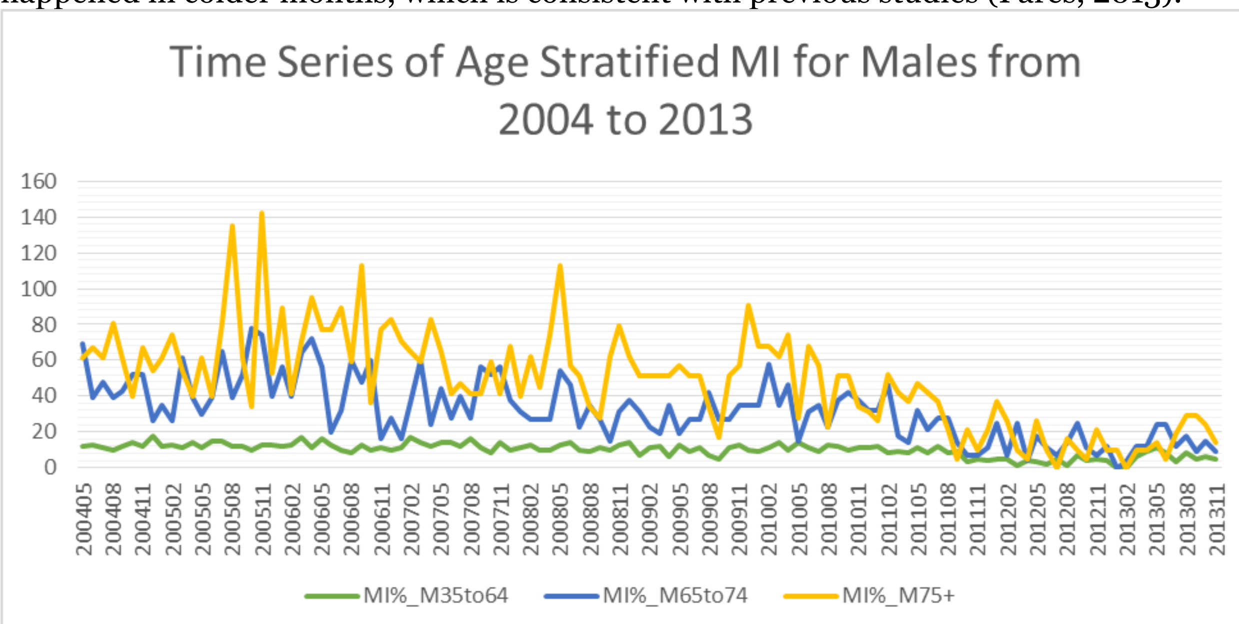

Figure 1 Time series of age stratified MI for males

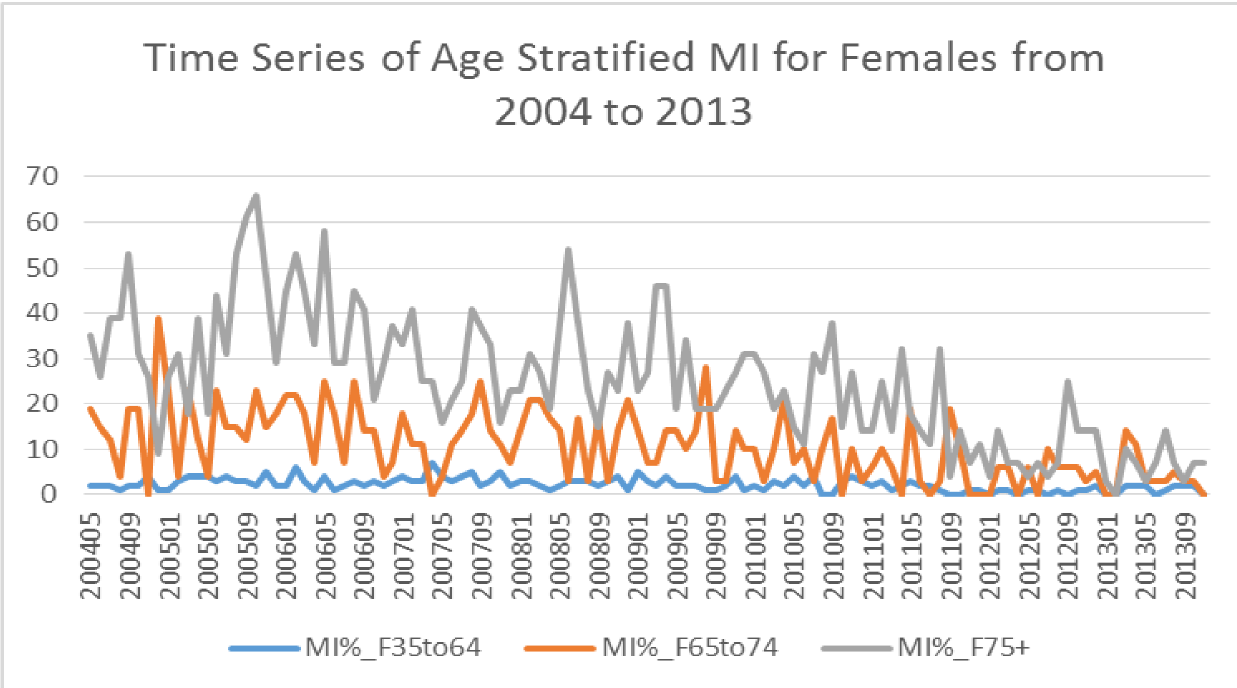

Figure 2 Time series of age stratified MI for females

All the population groups feature a statistically significant declining trend (Table 2). Generally people over 75 features the sharpest decreasing trend with a monthly change of 0.61, followed by males 35 to 64 old (0.37). The highest intercept of the linear regression model is with Males over 75 (85.19), followed, in the order, by Male 65 to 74 (53.88), Female over 75 (44), Female 65 to 74 (18.51), Male 35 to 64 (15.13) and Female 35 to 64 (3.73), which is consistent with the frequency distribution and summary statistics of MI. The R squared ranges from 0.70 to 0.88, suggesting the models explain the data well.

Table 2 Temporal trend models for age and gender stratified groups

Trend model	Intercept	Trend_Coefficient	R2	Adj. R2	RSE
F35to64	3.73	-0.02	0.70	0.70	0.48
F65to74	18.51	-0.13	0.88	0.88	1.45
F75+	44.00	-0.31	0.83	0.83	4.32
M35to64	15.13	-0.09	0.77	0.76	1.46
M65to74	53.88	-0.37	0.83	0.83	5.05
M75+	85.19	-0.61	0.82	0.81	8.85

Spatial analysis

The Ripley's K function indicates that the observed K value is higher than expected K at a distance range from 500m to 2,800m, indicating the distribution is more clustered than a complete random distribution at this distance scale. Hot spot analysis (Figure 3) suggests the most significant hot spot is identified in south Calgary, defined as the area enclosed by Bow River in the east, Glenmore Trail in the north, 14^{th} street in the west and Anderson Road in the south. The communities included are: Eagle Ridge, Kelvin Grove, Kingsland, et al.

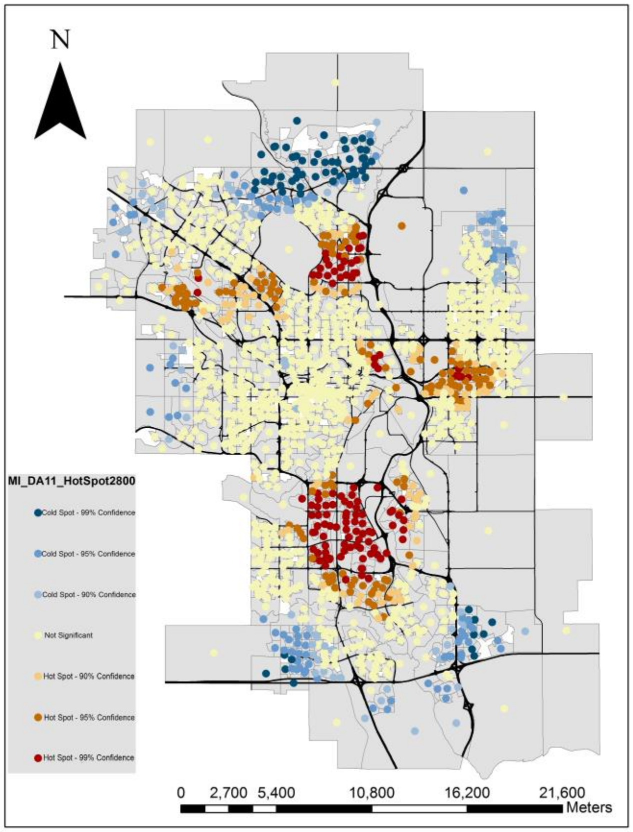

Figure 3 Hot spots of MI in Calgary

Another hotspot exists in the northeast communities of Calgary around the Calgary international airport and the intersection of Memorial drive and Deerfoot Trail, including the communities of Marlborough and Forest Height among others. The only hot spot in the northwest stretches from Brentwood to Bowness. Analyzing the communities' age structure, the communities in the south and northwest hotspot feature a large proportion of people over 65. This may explain why high MI hospitalization rates tend to concentrate in these areas. The northeast hotspot features communities with a lower social economic status, and close to airport and industrial area, which may be a reason for the cluster.

Conclusions

We investigated the temporal trend and spatial pattern of MI hospitalizations from 2004 to 2013 in Calgary. The data used for trend analysis is stratified by age and gender. All the groups show a statistically significant decreasing trend over 10 years, which is consistent with previous studies that document a declining trend in Canada. In addition, higher MI incidence tend to happen in fall and winter for most groups, which may have an association with environmental factors (outdoor temperature) and lifestyle (physical exertion) (Fares, 2013). In general, males tend to have a higher risk of MI, especially males over 75. The magnitude of the decline varies from 0.02 (females 35 to 64) to 0.61

(males over 75). Further research shall be performed to identify the driving factors of the decline in each group and to understand the factors associated with the difference between males and females. Spatial analysis suggests higher MI incidence tends to concentrate in the communities with larger proportion of older people, and those with lower social economic status. Further research shall investigate the demography and social economic status in the areas where clusters are detected, and investigate factors potentially associated with MI. By identifying the potential disease determinants cluster areas, new hypotheses may be formulated of MI etiology to help target resources and efforts to the population most in need.

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