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Periodic Research

Geographical Association Between Seasonal Temperature Variation and Cardiovascular Deaths: A Study of Bist Doab (Punjab, India)

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Abstract

The aim of this research paper is to examine the role of seasonal variation in temperature in determining the spatial patterns of cardiovascular diseases in rural Bist Doab. The data and information on temperature conditions were acquired from the website of India Meteorological Department, the Meteorological Observatory of Air Force Station at Adampur (Jalandhar district) and various newspaper reports. The month-wise deaths caused due to cardiovascular and non-cardiovascular diseases were noted down for the year 2009 from village-wise Death Registers (Civil Registration System) of Bist Doab The map of climatic zones of Punjab was obtained from the Department of Soil and Water Conservation, Punjab. Blockwise maps of cardiovascular mortality recorded in January 2009 and June 2009 were prepared in ArcGIS software using choropleth method. The results show that the incidence of cardiovascular mortality displays a characteristic rhythm with respect to the seasons in rural Bist Doab. The peak summer and peak winter season experience the highest number of deaths caused due to cardiovascular ailments. The areas in the central parts of the region, recording extreme temperature conditions, have higher rate of cardiovascular mortality. Climatic stress has been found to be an important factor in determining the spatial distribution of cardiovascular mortality.

Keywords Cardiovascular mortality, Seasonal temperature, Climatic Stress

Introduction

The group of disorders of the heart and blood vessels are termed as cardiovascular diseases. In India, cardiovascular diseases have been projected to be the largest cause of death and disability by 2020, which will account for 42% of the total mortality from all causes (The World Health Report, 2002). Within the country, the highest cardiovascular mortality rate (50%) is recorded in the state of Punjab. These diseases are typically multi-causal in which several factors are implicated. The influence of physical environment on health and well-being of people has been appreciated since ancient times. In 6th century B.C., Hippocrates, the father of Medicine, stated that "Whoever wishes to study medicine properly should proceed thus: In the first place to consider the seasons of the years…. the waters….the ground and the mode in which the inhabitants live and what are their pursuits, whether they are fond of eating and drinking to excess and given to sedentary living or, are fond of exercise and labour" (Adams, 1849). Eng and Mercer (2000) have found seasonal variation in cardiovascular deaths in many countries, with the highest levels occurring during the coldest months of the year.

As far as the seasonal temperatures in Punjab are concerned, the lowest temperature is recorded at Adampur (near Jalandhar), situated almost in the centre of Bist Doab region (one of the three traditional cultural regions of Punjab, the other two being Majha and Malwa). Therefore, the seasonal variation in cardiovascular disease mortality can be most effectively studied in this region. This region lies between Beas and Satluj rivers (30□ 57' N to 32□ 7' N latitude and 75□ 4' E to 76□ 38' E longitude). The eastern boundary of the region is marked by the Shiwaliks, while the rest of the region has an almost flat surface. The climate of the region is of continental monsoon type. According to 2001 census, the population of Bist

Doab is 4,770,477 which accounts for 19.64% of Punjab's total population. Out of this 71.58% people live in rural areas. The aim of this research paper is to examine the role of seasonal variation in temperature in determining the spatial patterns of cardiovascular diseases in rural Bist Doab.

Data and Methods

The data and information on temperature conditions of the study area were acquired from the website of India Meteorological Department, the Meteorological Observatory of Air Force Station at Adampur (Jalandhar district) and various newspaper reports. The month-wise deaths caused due to cardiovascular and non-cardiovascular diseases were noted down for the year 2009 from village-wise Death Registers of Bist Doab and were aggregated and plotted month-wise for the entire region using multiple-line graph. The map of climatic zones of the study area was prepared from the corresponding larger map of Punjab state, obtained from the Department of Soil and Water Conservation, Punjab. The method of visual comparison was used to investigate the potential influence of climatic conditions on the spatial patterns of cardiovascular mortality in the study area. Blockwise maps of cardiovascular mortality recorded in the study area in January 2009 and June 2009 were prepared in ArcGIS software using choropleth method.

Results and Discussion

The Bist Doab region experiences continental monsoon type climate. The summers of the region are hot and winters are cold. The mean temperature during the summer season varies from 30º to 32º C. A hot wind called *'loo'* blows around noon during the months of May and June, which increases the temperature considerably. The maximum temperature in the region can go upto 45º C. The winter season is moderately cold. The mean winter temperature ranges between 10º and 15º C. January is the coldest month, with temperature falling below the freezing point on many occasions. Fog and night frost is common during December and January. The lowest temperature of Bist Doab as well as Punjab has been often recorded at Adampur. In the year 2007, mercury declined to a low of -3.8°C at Adampur, while in 2008 the temperature went down to a freezing low of -5°C. Till date, it was the year 1972 in which Adampur recorded the lowest ever temperature of -5.2°C which threw the normal life out of gear (The Tribune, 6th January 2011; 19th January 2011).

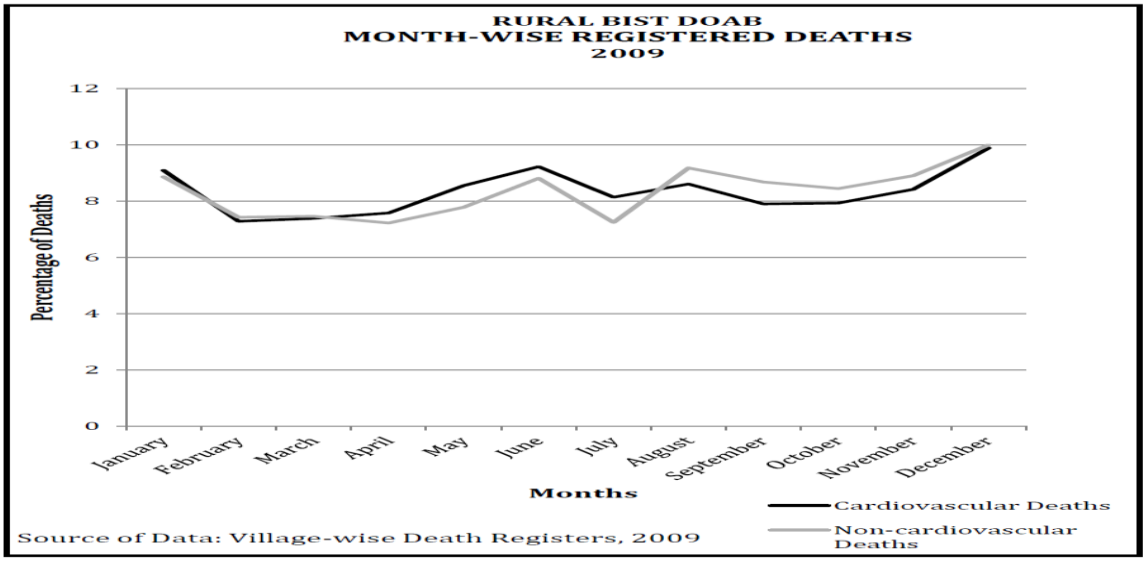


Fig 1 - Rural Bist Doab: Month-wise Registered Deaths (2009)

The month-wise distribution of deaths caused by cardiovascular diseases (Fig 1) reveals that most of the cardiovascular deaths in the study area have occurred either in the intense cold month (January) or the extreme hot month of the year (June). Although the percentage of deaths recorded from cardiovascular diseases and non-cardiovascular diseases is almost the same during most part of the year, however there are two significant departures from this similarity of trends. The first point is that the mortality from cardiovascular diseases is higher than the mortality from other causes during the hot summer months of May, June and July. The extreme hot months of May and June accounted for around 18% of total cardiovascular mortality in the rural areas of Bist Doab region. The second observation is that after the month of August, the mortality occurring due to non-cardiovascular diseases shows an almost uniform distribution, while the deaths caused by cardiovascular disorders register a considerable decline upto October and then rise drastically during the winter months of December and January. These peak winter months recorded nearly 20% of all cardiovascular deaths.

The high rates of cardiovascular mortality recorded in peak summer and peak winter season can be attributed to the role of climatic stress in influencing cardiovascular health of the people (Cheng and Su, 2010). Extremely high temperature

can trigger the onset of cardiovascular events in vulnerable population (Koken, 2003; O'Neill et al., 2009; Vidale et al., 2010; Yu et al., 2010). Heat waves negatively affect the proper functioning of the cardiovascular system (Michelozzi et al., 2009). High environmental temperatures put excess stress on the heart. In hot environment, the body attempts to dissipate excess heat (mainly by sweating and by radiating heat from the skin) to maintain a reasonably normal body temperature. The need to dispel heat places additional stress on the cardiovascular system (Fogoros, 2012). High temperatures also increase platelet and red cell count, blood viscosity and serum cholesterol levels. Moreover, heat-related mortality particularly affects individuals with lower level of socio-economic status because they have no access to indoor air conditioning (O'Neill et al., 2009). All these factors explain the high occurrence of cardiovascular mortality in the extreme summer conditions.

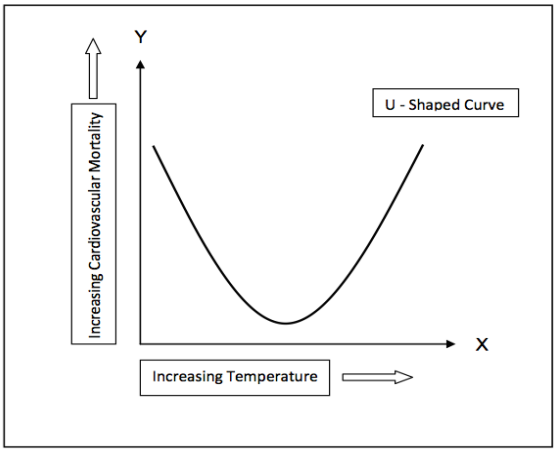
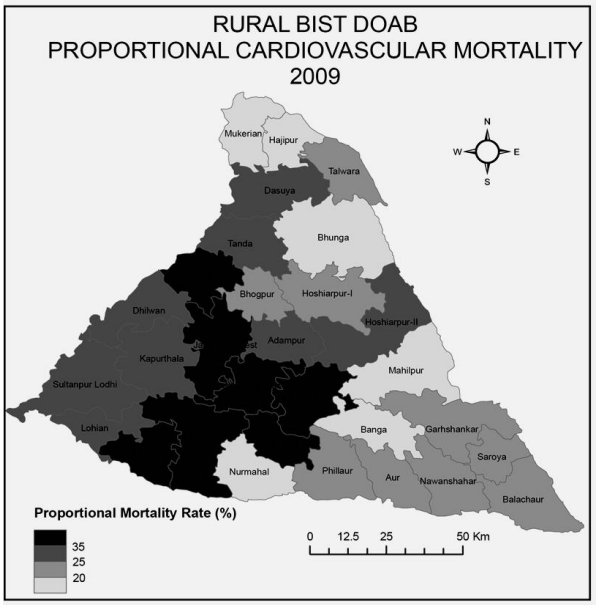


Fig 2 - Relationship between Temperature and Cardiovascular Mortality

In the study area, the months of July and August have higher relative humidity than the rest of the year. Around 70% of the rainfall is received during the rainy season spanning from July to September. The rainfall in the months of July and August occurs due to the moisture-laden south-western monsoon winds, while that in September is caused by the retreating monsoons flowing in reverse direction. The entire rainy season experiences heavy showers interspersed with alternate dry spells. The higher level of relative humidity is also associated with higher mortality due to cardiovascular diseases (Cheng and Su, 2010).

On the other hand, cold temperature in the winter can also lead to increase in cardiac workload and higher blood pressure (Manfredini et al., 1999; Cheng, 2009). Cold stress can aggravate hypertension in hypertensive patients (Peng et al., 2002). There are increased chances of the occurrence of heart attack in winter months (Mustad et al., 1996). Many other studies conducted in different parts of the world have documented an increase in cardiovascular events during peak winter season (Mercer et al., 1999; Cheng, 2005; Goerre et al., 2007; Widlansky et al., 2007; Vidale, 2010; Diaz et al., 2012). The cold season may also be associated with the flu season and the enhancement in the upper respiratory tract infection can adversely affect the cardiovascular system (Cheng and Su, 2010). The dense foggy conditions experienced during December and January can also affect the response times to treatment of both the patients and the medical care providers, thereby increasing the overall rates of cardiovascular mortality recorded during the peak winter season (Cheng, 2009).

In short the relationship between temperature and cardiovascular mortality can be visualized as a U-shaped curve (Fig 2), with high mortality rate in extreme low and high temperature and lower number of deaths in moderate temperature conditions. Scholars like Pan (1995), Goncalves et al. (2007) and Huang et al. (2012) have also found a similar association between cardiovascular mortality and the atmospheric temperature conditions.



Map 1

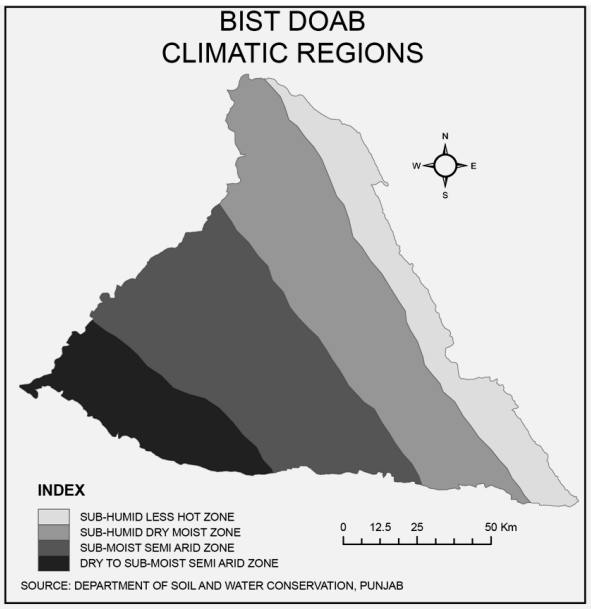
The spatial patterns of cardiovascular mortality in rural Bist Doab have been shown in Map 1 and discussed elsewhere (Saini, 2013). As far as climate is concerned, Bist Doab region can be divided into four climatic zones according to the classification adopted by Department of Soil and Water Conservation, Punjab (Map 2). These four climatic zones are:

(i.) Sub-humid less hot zone (covering the Shiwalik hill areas in the eastern parts of Bist Doab region)

(ii.) Sub-humid dry moist zone (corresponding to the foothill plain adjacent to the Shiwaliks in Hoshiarpur and Nawanshahr districts)

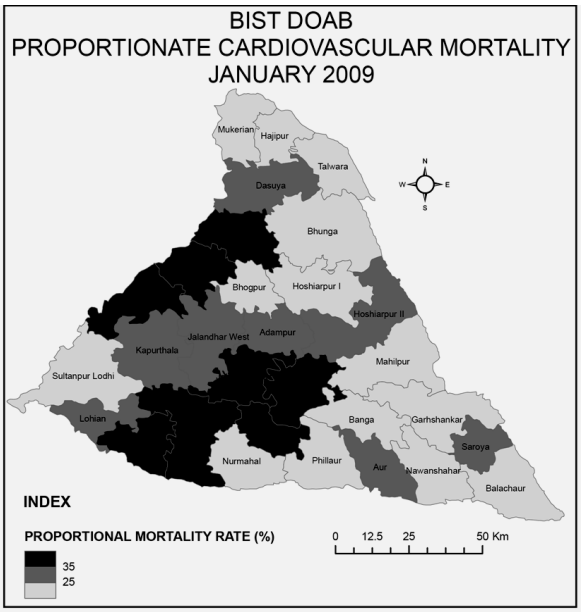
(iii.) Sub-moist semi-arid zone (covering most of the upland plain and flood plain of central parts of the study area in Jalandhar and Kapurthala districts)

(iv.) Dry to sub-moist semi-arid zone (situated in the extreme western parts of the study area).

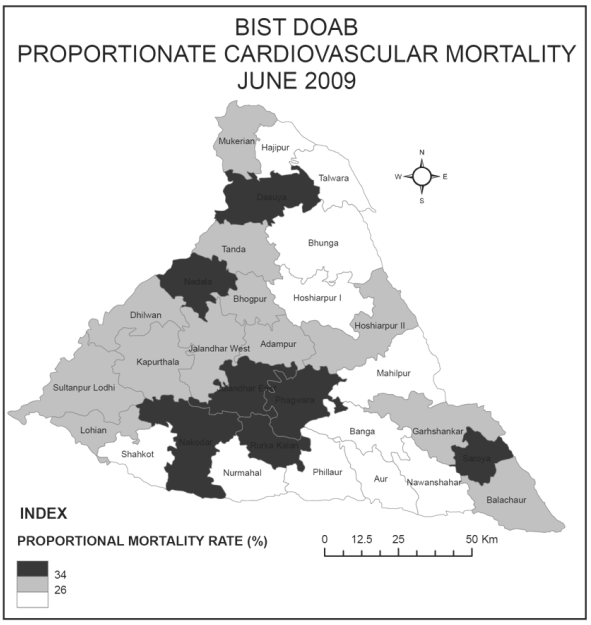


Map 2

The spatial arrangement of these climatic regions shows that temperature conditions are comparatively moderate in the eastern parts of the study area, whereas temperature extremes become more prominent as one moves westwards. Visual comparisons of spatial patterns of cardiovascular mortality in Bist Doab (Saini, 2013; Map 1) and climatic zones of the region (Map 2) show that the areas of Jalandhar and Kapurthala district experiencing severe winter and summer temperature conditions also record higher rates of cardiovascular mortality. In January 2009, the rural areas around Adampur, experiencing lowest winter temperature witnessed very high incidence of cardiovascular deaths (Map 3). There are two clearly noticeable continuous belts of very high proportional cardiovascular mortality (more than 35%) running from west to east on both sides of Adampur. These belts include the blocks of Dhilwan, Nadala and Tanda, situated to the north of Adampur and blocks Shahkot, Nakodar, Jalandhar East, Rurka Kalan and Phagwara lying south of Adampur. The spatial incidence of winter cardiovascular deaths goes on decreasing towards the eastern margins of the study area. With a few exceptions, almost all the blocks lying in comparatively moderate climatic zones, viz. sub-humid less hot zone and sub-humid dry moist zone have recorded low occurrence of cardiovascular mortality (proportional mortality rate of less than 25%).



Map 3



Map 4

The geographical pattern of cardiovascular mortality recorded in June 2009 (Map 4) shows that the blocks falling in sub-moist semi-arid zone and dry to sub-moist semi-arid zone have recorded high proportional mortality rate (more than 34%). These blocks include Nadala in the north-central parts and Nakodar, Jalandhar East, Phagwara and Rurka Kalan in the south-central parts of the study area. The mortality rates are again low (less than 26%) in the eastern hilly areas and Kandi region, with exceptions of Dasuya and Saroya blocks. The summers are less hot in the eastern parts of the study region due to the moderating effect of the Shiwalik hills.

Thus it has been observed that the areas experiencing extreme climatic conditions have recorded high mortality from cardiovascular diseases, whereas the areas with comparatively less extreme

temperature conditions have registered lower rates of cardiovascular mortality. Therefore the seasonal variation in temperature exerts a strong influence on the spatial distribution of cardiovascular mortality.

Conclusion

In the end, it can be concluded that the incidence of cardiovascular mortality displays a characteristic rhythm with respect to the seasons in rural Bist Doab. The peak summer and peak winter season experience the highest number of deaths caused due to cardiovascular ailments. The areas in the central parts of the region, recording extreme temperature conditions, have higher rate of cardiovascular mortality. Climatic stress has been found to be an important factor in determining the spatial distribution of cardiovascular mortality in Bist Doab region.

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