

Physiography and Cardiovascular Disease Mortality: Exploring the Relationship in Rural Bist Doab (Punjab, India)

Abstract

Cardiovascular diseases are the leading cause of mortality in Punjab (India). The aim of the present paper is to examine the role of topography in determining the spatial patterns of cardiovascular diseases in rural areas of Bist Doab region of Punjab. The data on cardiovascular disease mortality was obtained from village-wise Death Registers of Bist Doab for the year 2009. The study area was divided into four physiographic units based on the variation in altitude. Robinson's method of slope analysis was applied to calculate average slope in degrees. Karl Pearson's coefficient of correlation was calculated to estimate the association between average slope and proportional cardiovascular mortality rate at the block level. The results show that the eastern hilly areas of the region have low incidence of cardiovascular mortality due to physically active lifestyle of the native population and the consequent low prevalence of obesity. The flat upland plain and the flood plain have high rates of cardiovascular mortality due to sedentary lifestyle, rich dietary intake and high level of air pollution.

Keywords: Physiography, Cardiovascular Mortality, Slope Analysis

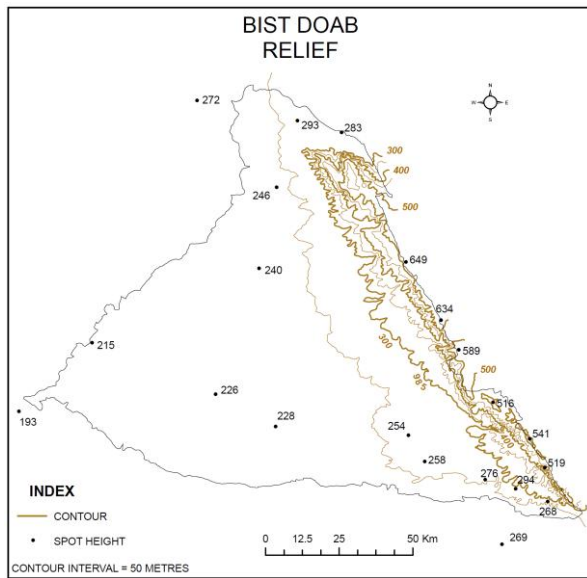
Introduction

The physical geography of a region is considered to play a significant role in determining cardiovascular health of the concerned population. The components of physical setup of an area, especially physiography is thought to be related to prevalence of cardiovascular diseases through direct and indirect causal pathways. A study conducted by Lanska (1993) has observed a consistent pattern of marked geographic variation in stroke mortality within the United States with very high rates reported in the southeast Atlantic coastal plain and very low rates in the mountain census division. Cardiovascular diseases are the leading cause of mortality in Punjab. Nearly half of deaths in the state are caused by disorders of the cardiovascular system. Traditionally, the state is divided into three distinct cultural regions namely, Majha, Malwa and Bist Doab. The Bist Doab region (situated between rivers Beas and Satluj) has its own distinctive geographical identity in Punjab. It has varied physiography, giving rise to significant intra-regional variations in slope distribution, which can have probable association with cardiovascular disease prevalence by influencing the extent of physical activity of the people. The aim of the present paper is to examine the role of topography in determining the spatial patterns of cardiovascular diseases in rural areas of Bist Doab.

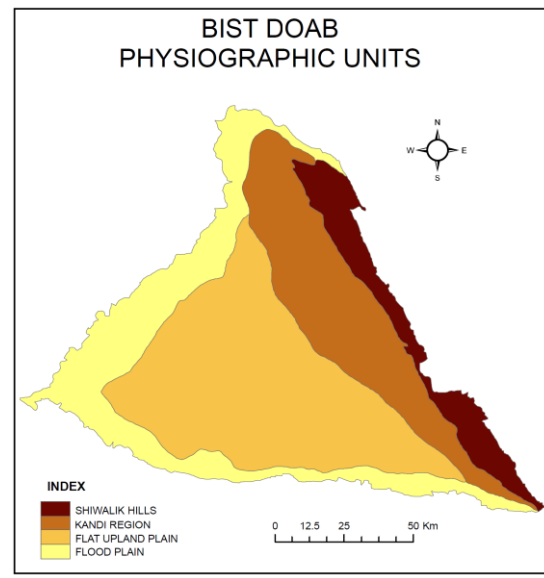
Data and Methods

The data on cardiovascular disease mortality was obtained from village-wise Death Registers (maintained under Civil Registration System) of Bist Doab for the year 2009. The data was aggregated at block level and proportional mortality rate was calculated blockwise. The resultant block-level values were depicted through a choropleth map. The study area was divided into four physiographic units based on the variation in altitude. The topographical sheet of the region prepared by Defense Mapping Agency Topographic Center, Washington, D.C. (U.S.A.) was used. This toposheet was downloaded from the website of University of Texas, USA and a contour map of the region was prepared from it on a contour interval of 50 metres. The data on cardiovascular mortality noted down from the village-wise Death Registers was aggregated for each physiographic unit. The method of visual comparison was used to explore the relationship between cardiovascular mortality and underlying physiography of the region. Subsequently, Robinson's method of slope analysis was applied to compute average slope in degrees. Karl Pearson's coefficient of correlation was calculated to estimate the association between average slope and proportional cardiovascular mortality rate at the block level.

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Map 1



Map 2

The Study Area

The study area selected for the present research is the Bist Doab region (30°57' N to 32°7' N latitude and 75°4' E to 76°38' E longitude) of Punjab. It is a triangular-shaped natural region lying between Beas and Satluj rivers. River Beas forms its western boundary and River Satluj flows along its southern border. The eastern boundary of the region is formed by the Shiwalik hills. Thus the eastern parts of the study area are hilly and undulating while the rest of the region has an almost flat terrain. The region is spread over 17.6% (8844 sq. km.) of Punjab's total geographical area and is one of the three traditional cultural regions of the state, the other two being Majha and Malwa. The climate of the region is of continental monsoon type. The soils are fertile and alluvial in origin. According to 2001 census, the total population of Bist Doab is 4,770,477. Out of this 71.58% people live in rural areas. The literacy rate of the region is 77.33% and 67.5% of the population is engaged in non-agricultural activities. There are 3528 villages, 35 towns and 2 cities (Jalandhar and Hoshiarpur) in the region. The present study has been conducted for the cardiovascular deaths registered in rural areas of the study area.

Results and Discussion

The role of physiography in determining the spatial patterns of cardiovascular mortality has been explored through visual comparisons between physiography and the associated proportional cardiovascular mortality rates of different parts of the study area. For this purpose, the study area has been divided into the following four physiographic units based on variation in altitude (Maps 1 and 2):

- I. The Shiwalik Hills
- II. The Foothill Plain
- III. The Upland Plain
- IV. The Flood Plain

The Shiwalik Hills

The Shiwalik hills extend along the far eastern parts of Bist Doab region in north-west to south-east direction along the Himachal Pradesh border. The entire stretch of the hilly area has a length of about 130 km and breadth ranging from 5 to 12 km. The height of these hills increases gradually from 400 m to 600 m from west to east. The highest point (741 m) of Bist Doab is located in Mukerian tehsil of Hoshiarpur district. In Garhshankar and Balachaur tehsils, the Shiwalik hills are known as '*KatarDhar*'. They form a rolling and dissected plateau-like upland towards the east of Garhshankar town, which is popularly called '*Beet Manaswal*'. The Shiwaliks are mainly composed of sand, gravel, pebble, shale, sandstone and clay. Both the eastern and western slopes of the hills are badly dissected by numerous short ephemeral streams locally known as '*choes*' and '*khads*', which are seasonal in nature. The Shiwalik hills impart a pleasant variety to the otherwise dominantly level topography of Punjab. They look diminutive when backed by the abruptly rising outer Himalayas, but independently they present a look of folded, highly eroded, steeply sloping and patchily forested hills (Punjab State Gazetteer, 2000).

There are 181 villages falling in this physiographic unit and a total of 1458 deaths were registered from all causes in these villages in 2009. Out of this total, 269 deaths (18.45%) occurred due to cardiovascular disorders. The figures given in Table 1 clearly show that the proportional cardiovascular mortality recorded in this hilly tract is much lower as compared to other physiographic units. This low incidence can be attributed to the physically demanding lifestyle of the people living in hilly areas. The uneven topography naturally provides opportunities to the inhabitants to develop a physically active lifestyle. In general, the level of physical activity has decreased in modern era as compared to the olden times because there is no need for man to remain physically agile anymore for his survival. Consequently, in recent times the health benefits of

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being active are derived through voluntary and not obligatory physical activity (Durnin, 1992). However, people residing in uneven terrain like Shiwalik hills are still obliged to be physically active. Even moderate levels of physical activity are known to impart significant health benefits (Giles-Corti et al., 2002).

Table 1 - Bist Doab: Physiography and Cardiovascular Mortality, 2009

Physio-graphic Unit	Altitude (in metres)	Total Deaths (from All Causes)	Cardio-vascu-lar Deaths	Proportio-nate Cardio-vascu-lar Mortality out of Total Deaths (in percent)
The Shiwalik Hills	400 - 600	1458	269	18.45
The Foothill Plain	300 - 400	7064	1667	23.60
The Upland Plain	210 - 300	12910	3782	29.29
The Flood Plain	200 - 210	4943	1640	33.18

Source: Data aggregated from Village-wise Death Registers, 2009

Hill walking has a significant role in curtailing obesity. It has been established that the people residing in uneven sloping terrain have comparatively higher levels of physical activity than those living in plain areas (Brownson et al., 2001; Sierra-Johnson et al., 2008). Consequently, the prevalence of obesity is low in hilly areas. Walking and living in hilly areas gives sufficient exercise (Bedford Borough Council, 2012). The Shiwalik region is economically less developed as compared to rest of the study area and hence the density of road network is also low. The rural folk generally follow kutchra trails on foot for commuting over short distances, which has resulted in the lower prevalence of obesity.

Moreover, this physiographic unit experiences relatively moderate climatic conditions due to higher altitude and rainfall than the rest of the study area, which reduces the stress related with extreme climatic conditions on the cardiovascular health of the people. The level of air pollution also decreases with increase in elevation, which is again an added advantage to cardiovascular well-being, since air pollution is also an important risk factor in the development of cardiovascular diseases.

Studies have also confirmed that living at moderate elevations results in protection against death from cardiovascular diseases (Ostadal et al, 2007; Theiss et al., 2008). People who are born at comparatively higher altitudes enjoy better cardiovascular health than their counterparts born at sea level (Faeh et al., 2009). Sloping terrain has better quality of green spaces which encourage physical activity (Davies et al., 2008). Hilly areas also correlate with more scenic backgrounds which promote physical activity (Brownson et al., 2001). The Shiwalik hills have much better tree cover than the rest of Punjab and offer many picturesque locales. The natural environmental conditions are in general less disturbed by human developmental

activities. Working in natural environmental settings results in lowering of psychological stress. People who walk in natural environment have higher ratings of overall happiness and lower ratings on anger and aggression (Hartig et al., 1991; Maas et al., 2007). Living in such tranquil surroundings promotes cardiovascular health of the concerned population.

The Foothill Plain

The foothill plain is situated on the western side of the Shiwalik range and is locally known as '*kandi*'. It is an uneven and dissected plain, running parallel to the hills between the contour lines of 300 to 400 m. The whole plain is strewn with innumerable choes, which are seasonal water channels. In fact, this piedmont plain has been formed due to the coalescence of alluvial fans formed by the choes flowing down the Shiwaliks. The material deposited in this region primarily consists of sand, with pebbles predominating near the hills. However, as one moves westwards, away from the hills, the deposition of clay becomes abundant.

The foothill plain is spread over 987 villages. In the year 2009, these rural areas registered 7064 deaths from all causes, out of which 1667 deaths (23.60%) occurred due to cardiovascular diseases. A comparison of this proportionate cardiovascular mortality with other physiographic units (Table 1) shows that this figure is higher than that for the Shiwalik hills, but lower than the other two physiographic units viz. the upland plain and the flood plain. In other words, this region forms a sort of transition zone between low cardiovascular mortality hilly belt and the flat plains lying below 300 m altitude. Due to their close proximity, the Shiwaliks exercise a moderation effect on the climate of this foothill zone. This area is also economically less developed and the local population is mostly engaged in primary activities like farming and animal husbandry. The level of affluence among the people is low and thus the mortality from lifestyle diseases like cardiovascular ailments is low.

The Upland Plain

It is a flat alluvial plain situated to the west of the foothill plain. This plain has been formed by the depositional work of rivers Beas and Satluj. It is a very fertile plain and is formed of old alluvium (*bangar*). The slope of this plain is very gentle and varies between 300 m in the east to 210 m in far west near the confluence of the two rivers. The region is primarily composed of clay and silt, with some mixture of sand and lime. Low sand dunes exist in the south and central parts of Kapurthala district and the south-western parts of Jalandhar district.

There are as many as 1332 villages situated in this physiographic unit, which together recorded 12910 deaths from all causes in the year 2009. Out of this total mortality, 3782 deaths (29.29%) resulted from cardiovascular ailments. This proportionate

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Table 2 - Bist Doab: Average Slope and Cardiovascular Mortality, 2009

S. No.	Block	Average Slope (degrees)	Proportional Cardiovascular Mortality Rate
1	Bhunga	92	19.24
2	Balachaur	63	23.32
3	Talwara	56	20.93
4	Mahilpur	52.5	18.44
5	Garhshankar	43	24.65
6	Hoshiarpur-II	41	27.22
7	Saroya	37	25.00
8	Dasuya	27	31.06
9	Hoshiarpur-I	25	21.93
10	Banga	11.5	11.33
11	Hajipur	9.5	17.11
12	Aur	8.5	20.15
13	Nawanshahar	6.5	23.83
14	Mukerian	5.5	17.91
15	Phagwara	1	45.27
16	Dhilwan	0	29.62
17	Kapurthala	0	25.44
18	Nadala	0	53.41
19	Sultanpur Lodhi	0	26.78
20	Tanda	0	31.62
21	Adampur	0	28.61
22	Bhogpur	0	21.68
23	Jalandhar East	0	43.49
24	Jalandhar West	0	35.50
25	Lohian	0	27.73
26	Nakodar	0	45.20
27	Nurmahal	0	19.32
28	Phillaur	0	21.83
29	Rurka Kalan	0	37.28
30	Shahkot	0	40.78

Source: Data aggregated from Robinson's Method of Slope Analysis

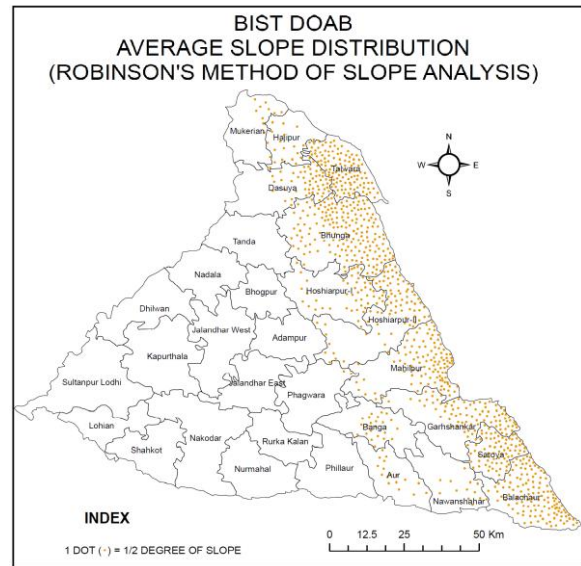
cardiovascular mortality is quite higher than that recorded for the Shiwalik hills and the foothill plains, but it is lower than the flood plain. The upland plains represent the economically most developed part of the study area. The geographical environment is obesogenic, with people having sedentary lifestyle coupled with rich dietary intake. The extreme summer and winter temperatures are recorded in this zone, both of which are positively associated with cardiovascular mortality. Owing to the flat surface, the road density is high and hence the level of air pollution from vehicular traffic and industries is high, particularly in and around the big urban centres of Jalandhar and Phagwara. The rural cardiovascular mortality is high along all the major roads connecting the urban centres of this physiographic unit. Residents living in a neighbourhood with high traffic exposure have been found to report high self-rated stress (Yang et al., 2010). Biologically, traffic noise induces the release of stress hormones, which in turn

adversely affects the cardiovascular health of the people. Fortunately, most of the private cardiovascular specialty hospitals are situated in this area, which offer better health care facilities to the concerned population.

(iv.) The Flood Plain

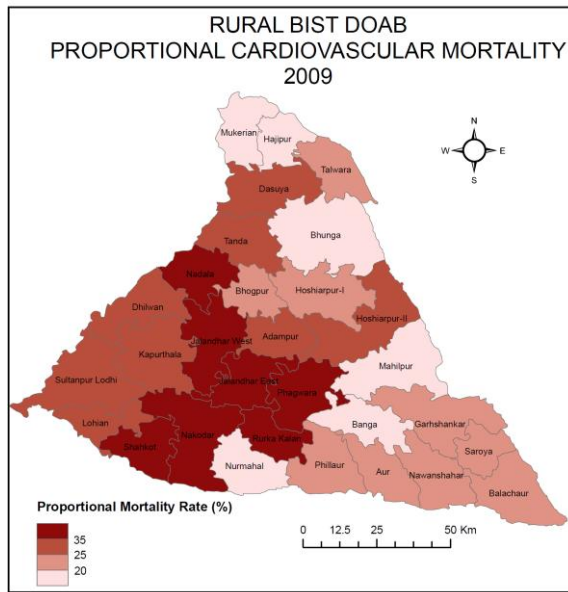
The flood plain has been formed by rivers Beas and Satluj and exists in the form of elongated belts along the two rivers. These belts are 5 to 7 km wide and are composed of new alluvium (*khadar*) consisting of silt, sand and clay. The flood plain is locally known as '*bet*' and is separated from the upland plain by a 3 to 5 m high bluff called '*dhaya*'. The *bet* area is absolutely flat and is prone to annual floods of the rivers. The whole area is marked by the presence of oxbow lakes, abandoned channels, mud, swamps and sand bars.

This physiographic unit contains 957 villages, in which 4943 deaths were registered from all causes in the year 2009. Out of this total mortality, as many as 1640 deaths (33.18%) occurred due to cardiovascular diseases. This physiographic unit recorded the highest proportion of cardiovascular mortality as compared to the rest of the region. The geographical conditions of this region are quite similar to those of the upland plain. Alcohol consumption is very high in this area. The geographic conditions are suitable for sugarcane cultivation, which in turn is used as a raw material for producing illicit alcohol. Consequently, this area leads in the production and consumption of illegal liquor, which is a major contributing factor for the recorded high cardiovascular mortality.



The results of Robinson's method of slope analysis have been shown in Table 2 which portrays the distribution of average slope in the study area. The blocks with high degree of average slope are Bhunga (92°), Balachaur (63°), Talwara (56°), Mahilpur (52.5°), Garhshankar (43°) and Hoshiarpur-II (41°), all of which fall in the eastern parts of Bist Doab region (Map 3). The distribution of average slope decreases westwards and almost all blocks falling in

the physiographic units of upland plain and flood plain have nil average slope.



Map 4

In order to analyse the effect of slope and uneven terrain on the incidence of cardiovascular mortality, Karl Pearson's coefficient of correlation was calculated for the block level data of proportional cardiovascular mortality rate (Map 4; Saini, 2013) and average slope. The value of correlation coefficient worked out to be -0.4, which clearly proves that there is negative association between the two variables. The areas with higher degrees of average slope have lower incidence of cardiovascular mortality and vice versa. Thus it can be inferred from the above results that physiography has an important role to play in determining cardiovascular health of the people in the study area.

Conclusion

In the end, it can be concluded that topography has an important role to play in determining the spatial patterns of cardiovascular mortality in Bist Doab. The eastern hilly areas of the region have low incidence of cardiovascular mortality due to physically active lifestyle of the native population and the consequent low prevalence of obesity. The flat upland plain and the flood plain have high rates of cardiovascular mortality due to sedentary lifestyle, rich dietary intake and high level of air pollution. Thus it is recommended that the health policies of the state government should also take into account the role of physiography in determining cardiovascular well-being of the population. Location-specific targeted health-care plans and awareness drives should be launched to control the mounting peril of cardiovascular diseases.

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