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Assessing the prevalence of water borne diseases in Muktsar district of Punjab, India

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Abstract

Water related diseases are a worldwide concern and the Muktsar district in Punjab is no exception, where, apart from typhoid; malaria and dengue are the two emerging water borne diseases in recent years as experienced during 2013-2017. The changing disease ecology within the district is of great concern for the population at risk and the most vulnerable, as the study shows a large number of cases reported in the working population in the age group of 20-49. The study identifies the hotspots of malaria and dengue using Kernel Density Estimation and Inverse Distance Weighting (IDW) interpolation that shows the northern part of the district is at higher risk of disease diffusion and higher concentration of infectious diseases.

Keywords: *Water-borne disease, Kernel Density Estimation, Inverse Distance Weighting (IDW) Interpolation.*

Introduction

The terms prevalence and incidence of the disease have distinct connotations. The former denotes the number of existing cases of diseases in a population for a defined area and time. The incidence of disease refers to the measuring of new cases of the diseases that develop in a population during a specified period (Keiding, 1991) and the population that is at risk. While addressing the issue of the prevalence of diseases, it is inevitable to study the incidence of a new disease as identification of new cases of diseases is crucial to understanding the potential risk involved.

Water borne diseases are emerging not only due to consumption and ingestion of contaminated water but also improper sanitation and an unhygienic lifestyle (Griffiths, 2017). The pathogens are transmitted into the human body through the ingestion of contaminated water when utilized for domestic purposes. Water related diseases also emerge due to direct or indirect alterations in the quantity or quality of water (Ramírez-Castillo et al., 2015). In India, about 37.7 million people are affected annually by waterborne diseases which leads to 73 million days lost having an economic burden of $600 million a year (Khambete, 2019).

The children under the age of five and the elderly are more susceptible to get infected from water related diseases due to low immunity. It is also observed that in India among all the water borne diseases, diarrhea is responsible for 13% of all deaths every year in children under 5 years of age

(Lakshminarayanan & Jayalakshmy, 2015). In India alone, there are 37.5 million people who are infected by waterborne diseases every year (World Bank Group, 2017) exerting considerable pressure on available health infrastructure and the economy.

The situation of water borne disease is more serious in most developing countries especially in the rural areas that lack the provision as well as access to safe drinking water, poor drainage and sanitation. These countries are also faced with the dual challenge of economic growth and expenditure on poor health conditions of the population. The most serious concern in developing countries is the lack of adequate water of good quality (Markandya, 2004). Besides, emerging waterborne diseases caused by multi-resistant organisms are a serious health problem in India (Chugh, 2008). In neighboring country of Sri Lanka, the coastal areas have reported high numbers of cholera, diarrhea, hepatitis A and E and typhoid cases (Ameer, 2017) where the improper drainage management, addition of effluents with water sources from industries and lack of awareness among common people are leading causes of the emergence of water-borne diseases. Poverty exasperates the problem even more as evident from a study by Sharma (2003) which based on statistics at the state level finds a clear positive relationship between poverty and the incidence of malaria in India.

The present study on Muktsar district, Punjab, investigates the prevalence of water borne diseases, which was one of the most affected from malaria incidences out of eight districts in 2017. The district has the distinction of being the second highest Hepatitis C incidence with 2400 patients (Singh & Singh, 2017). Study conducted by Lata et al., (2017) that was based on clinical reports, laboratory tests and interaction with the patients in the Muktsar district shows that there was just a single registered case of dengue in the year 2011 but increased to 399 by December 2011 and have exponentially increased to 1,047 reported cases by 2015 (Banerji, 2016). As evident from available literature, water contamination and lack of access to safe drinking water (Ahmed and Gaur, 2019) and poor water quality (Kaur et al, 2017) aggravate the situation of health arising out of the prevalence of water borne diseases (Khurana and Sen).

The present paper analyses the prevalence of water borne disease in Muktsar district of Punjab and its emerging patterns by identifying the hot spots of water borne diseases, the rate of infection across age groups in the district and the population that are vulnerable to this disease.

Data and methodology

The research used communicable and non-communicable disease data as available from reports in Punjab's Muktsar district from 2013 to 2017compiled by the Department of Health and Family Welfare. Data pertaining to population and general information about the district and cases of water borne disease was collected from Census of India, 2011. Geospatial technique was employed to study the distribution of water borne diseases in the district.

The cases of water borne diseases were isolated from all the communicable and non-communicable diseases for the period 2013to 2017 and the relative importance of the prevalence rate were analyzed by examining their changing composition and growth over the reference period. Cases of malaria and dengue were considered separately as emerging water borne diseases and the prevalence pattern was analyzed at lower aggregative units such as the development blocks and was classified by age group and sex.

Each reported case of dengue and malaria was geo-coded using the latitude and longitude of the patient's residential village, which were calculated using Google Earth v 7.3. A database was generated containing age, gender, and location of patients. The spatial points that resulted were then projected into the WGS84 coordinate system. The disease data was aggregated by village boundaries to assess spatial pattern of the population at risk. Annual disease frequency was calculated for each village from 2013 to 2017.

Kernel Density Estimation (KDE) was used to investigate the geographical distribution pattern (Hu et al., 2019) of water-borne cases at the district level. Since this method is based on points, information was linked to a precise location in space. KDE is a non-parametric method that estimates densities of specified features at specific locations using local information described by windows (also known as kernels). The kernel density estimator method, according to (Hu et al., 2019) is as:

$$\hat{f}(x) = \frac{1}{nh^2} + \sum {}_{i}^{\mathrm{n}} = 1\ K \left\{ \frac{x - X_i}{h} \right\}$$

Where h represents the bandwidth or smoothing parameter, K represents the Kernel, and (x) represents the estimator of the probability density function f. The X represents the n sample values (objective function value of the solutions obtained by the stochastic search method after n iterations). As a result, the Kernel estimator (Hu et al., 2019) is influenced by bandwidth (h) and Kernel density (k). The surface value is the largest at the point position and decreases as one move away from the point, eventually reaching zero at the search radius distance. It is only feasible to create a circular neighborhood. The volume beneath the surface is equal to the point's population field value or one if none is supplied. KDE can be used to detect the type of distribution pattern as well as the spatial distribution pattern, such as substantial hot spots, medium places, and cold spots. Based on their associated case densities, six categories were created, ranging from low to very high.

Inverse Distance Weighting (IDW) interpolation method has been used in dengue and malaria cases by mapping the spatial distribution and potential areas by using points and converting it into surfaces. It is commonly used in GIS programs to produce surfaces with the help of interpolation of scatter points and widely applicable for epidemiology by assuming that all points have their local influence (Chang, 2016) by giving weight to the area close to center/control points and that decreases with distance.

Study area

Situated in the south-west of Punjab state, Muktsar district is located between 30° 69' to 29° 87' North latitude and 74°21' to 74°86' East longitudes and is divided into four health blocks namely Chakk Shere Wala, Alamwala, Doda and Lambi (Fig 1). The district is overwhelmingly rural in its population composition with 72 percent of the total population residing in villages of varying size (Census, 2011). The total population of the district is 9,01,896 persons (4,75,622 males and 4,26,274 females).

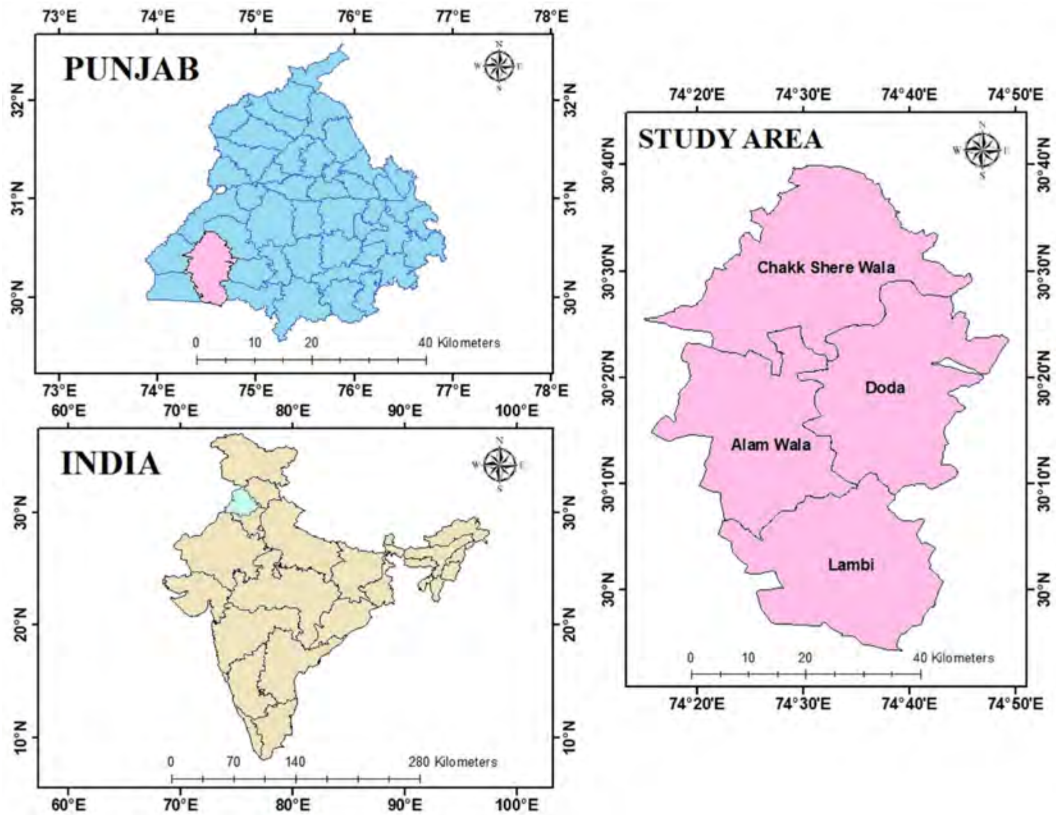

Fig. 1: Location of Muktsar district, Punjab

Over the last decade, the district has reported many cases related to water borne disease which include Typhoid (Enteric Fever), diarrhea, Amoebiasis, Dengue, Hepatitis and Malaria. Of the all such cases during January to November 2021 in the state as a whole, reported dengue cases have been significant in seven worst affected districts (Hoshiarpur, Mohali, Pathankot, Ludhiana, Amritsar, Bathinda and Muktsar) and Muktsar district recorded the highest positivity rate which stood at 64.28 percent in the district (Kumar, 2021). The positivity rate in the remaining worst-hit districts was much less and was only 46.82 percent in Pathankot, 45.77 percent in Mohali, 34.64 percent in Hoshiarpur and 33.78 percent in Ludhiana district.

Degradation of groundwater due to industrial and agricultural activities, in the district, has resulted in many health risk (Sharma, 2014) and three-fourth of the ground water unsuitable for drinking (Central Ground Water Board, 2013) as well as for domestic purposes. Moreover, water logging and flooding (Ding et al., 2014) has potential breeding sites for dengue and malaria which is relevant for almost whole of the district, where the district is severely affected with water logging in the southern and northwestern parts (Central Ground Water Board, 2013).

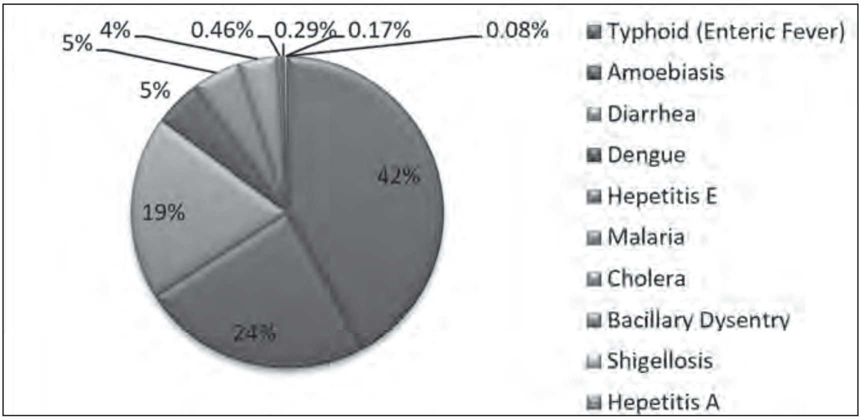

Fig. 2: Reported cases of water borne diseases (2013-2017)

Source: Health and Family Welfare Department, Punjab (Annual reports 2013, 2014, 2015, 2016, 2017)

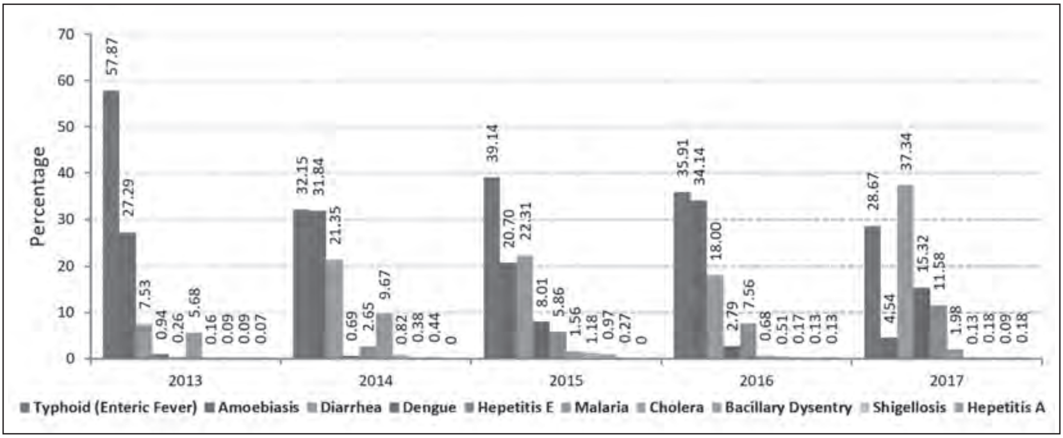

Fig. 3: Composition of water borne diseases (2013 -2017)

Source: Health and Family Welfare Department, Punjab (Annual reports 2013, 2014, 2015, 2016, 2017)

Water Borne diseases: prevalence pattern

Figure 2 shows that typhoid (42%), amoebiasis (24%) and diarrhea (19%) constitute the most prevalent water borne diseases found in the Muktsar district. The study however does not discount the presence of other diseases like cholera, bacillary dysentery, shigellosis, hepatitis-A, that were reported during the study period and prevalent in the district in some measure.

Fig. 3 depicts the changing composition of water borne diseases with a special focus on the newly emerging water borne diseases in the district which may soon become a concern. At present, these diseases are less prevalent and hence not taken seriously in comparison to those highly prevalent cases. Of all the cases reported between 2013-2017, four diseases namely, cholera, bacillary dysentery, shigellosis, and hepatitis-A are less prevalent throughout the study period.

However, the increasing trend in the reported cases of these diseases is worth taking note of, as they are emerging diseases. Significantly widely prevalent diseases like typhoid (enteric fever) show continuous decline in the reference period.

Fig. 3 also reveals that the prevalence of typhoid is found to be the highest all through the study period except for the year 2017 when it is second to shigellosis- a waterborne diarrheal disease which is often bloody and is an intestinal infection caused by a family of bacteria known as shigella. This is a sign of the changing disease prevalence composition in the district which is further corroborated by the continuously declining cases of typhoid from 57.87 in 2013 to 28.67 percent in 2017. A similar trend can be seen in respect of the prevalence of amoebiasis in the district. In sharp contrast, the cases of diarrhea, dengue and hepatitis-E have shown an increasing trend. Diarrhea cases increased to 37.34 percent in 2017 from a low of 7.53 percent

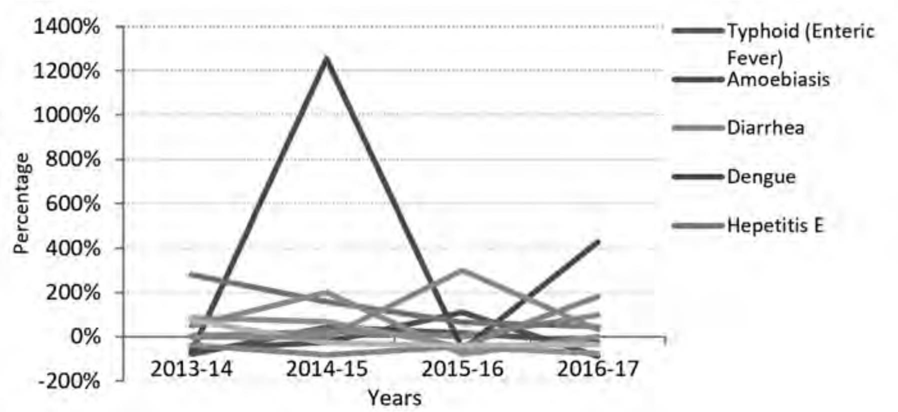

Fig. 4: Growth rate of water-borne diseases (2013-2017)
Source: Health and Family Welfare Department, Punjab, (Annual reports 2013, 2014, 2015, 2016, 2017)

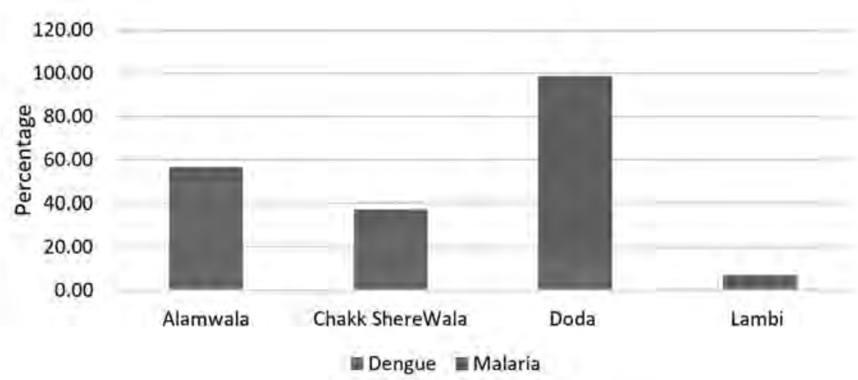

Fig. 5: Distribution of dengue and malaria cases at block level (2013-2017)
Source: Health and Family Welfare Department, Punjab, (Annual reports 2013, 2014, 2015, 2016, 2017)

in 2013. This change may be partly attributed to changes in waterborne disease composition which may have been due to a drastic fall in a few other types. An analysis of the growth/decline trends of reported cases point to changing disease ecology in the district within a short period of five years indicates emergence of new waterborne diseases which were rather few in the beginning. Fig. 4 provides the details.

Significantly, reported dengue cases have shown an exponential growth in 2014-2015 (1255%) and similarly for 2016-2017 (427%) (Fig. 4). The fastest decline in growth rate is in the reported cases of typhoid (79.4%, 43%, 16.8% and -23.4% respectively in 2013-14, 2014-15, 2015-16 and 2016-17). Malaria is another case after dengue, having highest growth rate (181%) in the year 2016-17. Among the marginal water borne diseases, Shigellosis has shown an increase from -40% (2015-16) to -33% (2016-17) and bacillary dysentery from -77.8% to a positive 0.0% in 2015-16 and 2016-17 respectively. While the study indicates the emerging trend of dengue and malaria case in the district, understanding the population at risk becomes another interesting component for the two diseases.

Muktsar district is divided into four development blocks and the emerging cases of malaria and dengue were analyzed for these four development blocks. At the block level, prevalence of malaria is largely concentrated in just one development block namely Doda. Dengue is far more widespread across all the blocks, but more prevalent in Alamwala followed by Chakk Sherewala block. In these two blocks, the cases of dengue were far fewer unlike that of the two remaining blocks (Fig. 5).

The Kernel Density Estimation (KDE) and Inverse Distance Weighting (IDW) interpolation methods have been used for analyzing spatial clustering and potential risk areas. Here KDE indicates hot spots (Fig. 6) having highest occurrence of incidences of dengue and malaria during 2013 to 2017. IDW interpolation method was applied to find dengue and malaria potential risk areas (Fig. 6) during the 2013 to 2017 in Muktsar district. These maps reflect (Fig. 6) how the disease ecology is changing within the short span of time.

Kernel Density map (Fig. 6) shows the spatial clustering of dengue and malaria during the 5 years preceding 2017. The red color indicates the highest concentration of dengue and malaria incidence and green color as having lesser or zero concentration. It has been observed that Alamwala health block located on the western part of the district has high concentration of the disease's occurrence while Lambi block is devoid of dengue and malaria incidence.

Inverse Distance Weighting (IDW) while showing areas of malaria and dengue incidence, it also shows the area of potential risk circled with buffer zones to analyze the influential area. The results clearly show that the health block of Alamwala is a highly potential candidate for the concentration of the two diseases along with a few patches located in Chakk Shere Wala and Doda health block (shown in red color) also indicating potentiality of dengue and malaria incidence.

The incidence data were further analyzed for different age-groups for understanding the prevalence across the population and, also to understand the most venerable age group. Fig. 7 shows the combined malaria and dengue cases across different age-group for the year 2013-17 for the four development blocks.

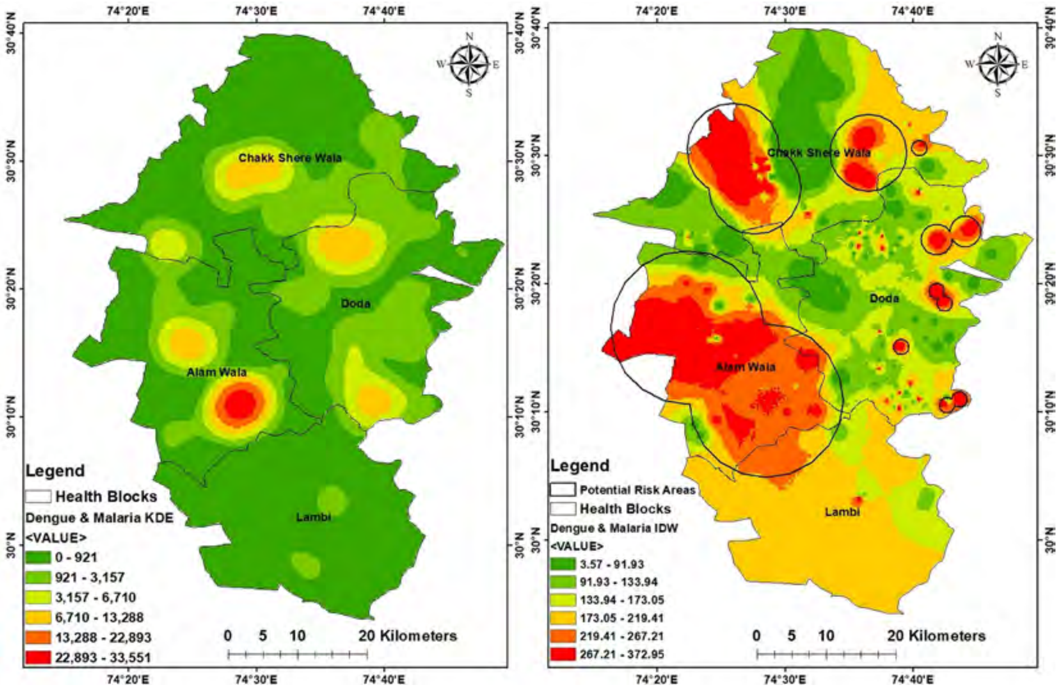

Fig. 6: Hot spots of waterborne diseases in Muktsar District (2013-17)
Source: Health and Family Welfare Department, Punjab (Annual reports 2013, 2014, 2015, 2016, 2017)

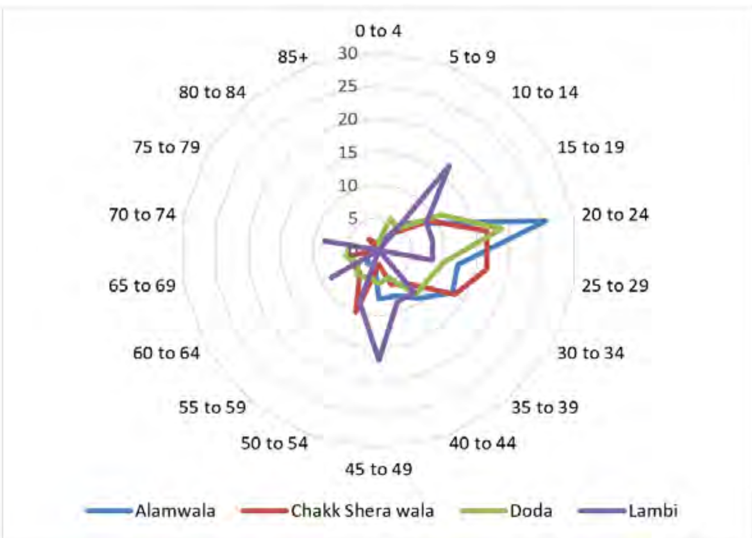

Fig. 7: Combined dengue and malaria cases in age group and block wise, (2013–17)
Source: Health and Family Welfare Department, Punjab (Annual reports 2013, 2014, 2015, 2016, 2017)

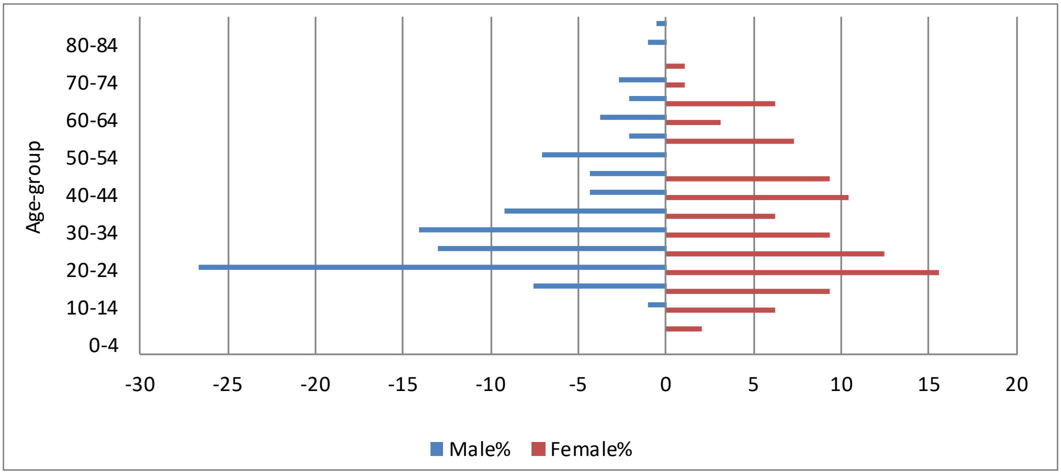

Fig. 8: Sex composition of dengue incidence (2013-2017)

Source: Health and Family Welfare Department, Punjab (Annual reports 2013, 2014, 2015, 2016, 2017)

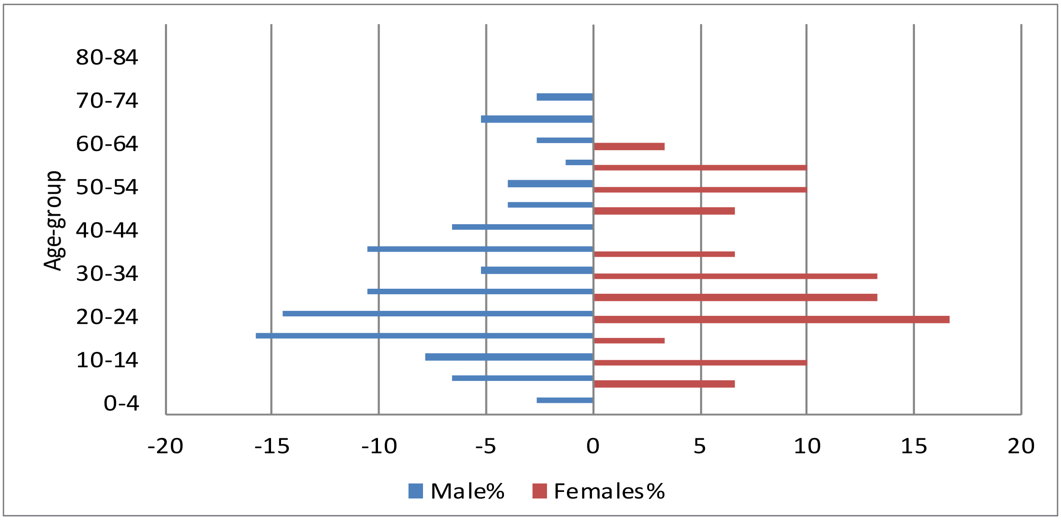

Fig. 9: Sex composition of malaria incidence (2013-2017)

Source: Health and Family Welfare Department, Punjab (Annual reports 2013, 2014, 2015, 2016, 2017)

The combined data of malaria and dengue cases shows that there are more reported cases in the age group of 20 to 49 compared to the upper and lower age-groups. The incidence is extremely high for age-group of 20-24 in Alamwala block, while it is the 10-14 and 45-49 age-groups in Lambi block which is more prone to these diseases. Overall, the age-group 20 to 49- the working age group-is greatly affected by these diseases that appear to be prone to dengue and malaria.

As far as prevalence of dengue is concerned fig.8 shows that young adults in the age group of 20 to 24 reported the highest prevalence both for males and females. Population in the working age-group 20 to 49 is also found to be more exposed to dengue infection. The children and the elderly reveal significant resistance to these diseases with far fewer reported cases. Malarial cases affected most to relatively younger sections of 15 to 19-year males and females aged 20 to 24 years (Fig. 9). The female population is far more vulnerable to malaria than dengue across most age groups.

Conclusion

In the years between 2013 and 2017, the water borne disease cases of malaria and dengue in Muktsar district are found prominently among the working age group. However, the emerging trend of increasing cases of cholera, bacillary dysentery, shigellosis, and hepatitis-A could be of a concern as it has potential to become far more prevalent in the coming years.

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