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Urbanization and Vector Borne Diseases in Uttarakhand. A Review

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ABSTRACT

Owing to population growth, poor levels of hygiene and increasing urban poverty, the urban environment in many developing countries is rapidly deteriorating. Density packed housing in shanty towns or slums and inadequate drinking water supplies, garbage collection services, surface water drainage systems combine to create favourable habitats for the proliferation of vector and reservoirs of communicable diseases. As a consequence, vector borne diseases such as malaria, dengue, lymphatic filariasis are becoming major public health problems associated with rapid urbanization in many tropical countries.The problems in controlling these diseases and eliminating vectors and pests can be resolved by decision- makers and urban planners by moving away from the concept of "blanket" applications of pesticides towards integrated approaches. Sound environmental management practices are community education and participation from the mainstay of some of the most outstanding successes in this area.

Introduction

Globally urban areas are growing at an alarming rate. The percentage of the global population residing in urban areas has increased from 32% in 1955 to 38% in 1975 and 45% in 1995 (Anon, 1998) similarly in India the urban population increased from 18% in 1961 to 31.16% in 2011. This urban population mostly concentrated in class I towns (towns having population more than 1 lakh).(Gupta, 2013).

In Uttarakhand, urban population increased from 13.74% of the total population in 1961 to 16.30 % in 1971, 20% in 1981, 22.97% in 1991, 25.59% in 2001 and 30.55% in 2011(Mani, 2017)

At the present time, the urban health authorities in many countries are alarmed by the rise in vector-borne diseases, due to increased density of vectors and other pests which present ever greater burdens on their vector and pest control programme. This escalation of disease is closely related to overcrowded urbanization, which is the result of population growth and rural –to -urban migration taking place much faster than even before since the dawn of man. In many cities, slums and poor neighborhoods are spreading, where the appalling living and working conditions, lack of safe drinking water and sanitation, and exposures to emissions from traffic and , in many places, also from factories are the daily burden of a rapidly growing proportion of city dwellers (Halstead, 1990).

The vector borne diseases (VBDs) are a group of communicable diseases transmitted by mosquitoes and other vectors. People suffer from a significant disease burden from these disease in local and focal areas of India, which is reflected in the form of morbidity and mortality from Malaria, Dengue, Japanese Encephalitis (JE), Kala-azar, lymphatic filariasis and chikungunya. The epidemiology of these vector borne diseases increases on account of rapid urbanization.

Topography

Uttarakhand is one of the hilly states in the Indian Himalaya. Formerly a part of Uttar Pradesh (UP), Uttarakhand (formerly called Uttaranchal) was created as the 27th state of the Indian Union on 9 November, 2000 by carving out the 13 hill districts of UP. It lies in the northern part of India between the latitudes 28°43′ N and 31°27′ N and longitudes 77°34′ E and 81°02′ E, having a maximum dimensions of 301 km in the east-west direction and 255 km in the north-south and covering an area of 53,483 km2. The elevation ranges from 210 to 7817 m. The state shares its border with China (Tibet) in the north, Nepal in the east, inter-state boundaries with Himachal Pradesh in the west and north-west and UP in the south. The total population, according to the 2011 census, is 1.01 crore, with an annual growth rate of 5.3 percent. Four district, Dehradun, Haridwar, Nainital and Udham Singh Nagar account for 55 percent of the state's population.

Uttarakhand is the rural centered state, presently facing rapid pace of urbanization especially in the popular district like- Dehradun, Nainital, Haridwar and Udham singh Nagar. Dehradun is the most urbanized district of Uttarakhand. In 1961 the percentage of urban population was 46.84% and then by 2011 it was 55.72% (Mani, 2017).

Plain areas of Uttarakhand is facing high urban growth in current years due to the migration from the remote hill areas. Dehradun, Haridwar, Haldwani, Roorkee and Rudrapur are cities facing heavy crowed of people from across the state. Plain districts have more developed infrastructure than the hills, so the migrants from the hill areas are attracted to better health, education and employment opportunities.

The history gives the evidence of urbanization in Uttarakhand. These towns were originally rural settlements converted into towns in the later stages. The basic reason behind this is the tourism because the state is the heart of famous pilgrimages. Originally these small towns were the stoppage centre of the pilgrims during yatra seasons. Slowly because of number of commercial activities, these stoppage places developed into the small towns, small to medium town. These towns converted into mega cities in later stage. This is being the regular pattern of urban development in the state. Population pressure in the cities not only

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causing unavoidable burden on the available infrastructure facilities but also hinders the social and economic development process of the cities.

Unplanned development, together with rapid urban growth and the inflow of tourists and pilgrims has made critical impact on the urban environment of Uttarakhand. Major environmental concerns associated with such unplanned urban development are depletion of forest area, loss of biodiversity, potential urban pollution in the form of air, water, noise, solid and liquid waste discharges and landslide.

The cities of Dehradun, Haridwar and Nainital are covered under the Jawahar lal national urban renewal mission (JNNURM) and thus, as mission cities, gets benefit of a range of urban development interventions, including the development of city sanitation plans. In Uttarakhand common vector borne diseases are : Malaria, Dengue, Japanese encephalitis (JE), Kala-azar, Filaria and Chikunguniya.

1. Malaria

Malaria is an acute parasitic illness caused by *Plasmodium vivax or Plasmodium falciparum* in India. The main clinical presentation is fever with chills; however, nausea and headache can also occur. The diagnosis is confirmed by microscopic examination of a blood smear and Rapid Diagnostic Tests. Majority of the patients recover from the acute episode within a week. Malaria continues to pose a major public health threat in different parts of the country including Uttarakhand, particularly due to *Plasmodium falciparum* due to which severity may develop and may cause fatality, if not treated early.

In India, out of 9 species of Malaria vectors, the major vector for rural malaria is *Anopheles culicifacies*, found all over the country and breeds in clean ground water collections while *An. Stephensi* is main vector of malaria in urban and semi urban areas. In Uttarakhand, particularly in Dehradun (capital of Uttarakhand) main vector of malaria are *An. stephensi*, and *An. fluviatilis* (Pemola and Jauhari, 2006).

In urban areas, malaria is mainly transmitted by *Anopheles stephensi* which breeds in man-made water containers in domestic and peri-domestic situations such as wells, over head tanks, cisterns, and stored water in a variety of containers, standing rain water in the buildings, sumps, seepages, ponds, channels, artificial containers and rain water collections, which are more or less of permanent nature and hence can maintain density for malaria transmission throughout the year. Increasing human activities, such as urbanization, industrialization and construction projects with consequent migration, deficient water and solid waste management and indiscriminate disposal of articles (tyres, containers, junk materials, cups, etc.) create mosquitogenic conditions and thus contribute to the spread of vector borne diseases. (NVBDCP, Annual report, 2015-16).

In Uttarakhand, district Nainital has been hyper-endemic for malaria since the 1920s (Hehir, 1927). *An. minimus* was reported to be the principal vector of malaria and *An. fluviatilis* as a zoophilic non vector species (Clyde, 1931), during 1983 resurgence of malaria in Gadarpur district Nainital, Choudhury et.al, (1983) reported *An. culicifacies* and *An. fluviatilis* were the vector species in this region. Pemola and Jauhari (2004a) recoded six species of Anopheles from Garhwal region of Uttaranchal. In another study on altitudinal distribution of mosquitoes in mountainous area of Garhwal region they recorded 14 species of Anopheles (Pemola and Jauhari, 2004b and 2013) Pemola et al (2013) while studying mosquito and mosquito borne disease in Dehradun district, Uttarakhand recorded 14 species of *Anopheles*. Some other workers who worked on diversity of mosquitoes in Uttarakhand are Saini et al(2013), Tyagi and Parvez(2018) and Sadeura (2018).

2. Dengue Fever/Dengue Haemorrhagic Fever

Aedes aegypti is the primary vector of dengue fevers has a global distribution and it is invading areas under urbanization. *Aedes albopictus* is the second dengue vectors has already invaded in many countries. Both *Aedes aegypti* and *Ae. albopictus* are widely distributed and major vector of Dengue in Uttarakhand. *Aedes aegypti* mosquitoes prefer to breed in man-made containers, viz., cement tanks, overhead tanks, underground tanks, tyres, desert coolers, pitchers, discarded containers, junk materials, etc, in which water stagnates for more than a week. This generally bites during early morning and late afternoon hours and prefers to rest in dark place inside or outside the houses where there is cool and shade. *Aedes albopictus* prefer to breed in natural habitats like tree holes, plantation etc. The risk of dengue has increased in recent years due to rapid urbanization, and deficient water management including improper water storage practices in urban, peri-urban and rural areas, leading to proliferation of mosquito breeding sites.

Dengue virus (DV) belongs to family Flaviridae and there are four serotype of the virus referred to as DEN-1, DEN-2, DEN-3 and DEN-4. All four serotype can cause the disease dengue fever (DF) and a severe disease that may be fatal, the dengue hemorrhagic fever (DHF)/dengue shock syndrome (DSS)(Gupta et.al., 2012).

Dengue is a self limiting acute disease characterized by fever, headache, muscle, joint pains, rash, nausea and vomiting. There is no vaccine or medical treatment for dengue fever. Thus the only way to prevent the disease is by eliminating the chance of human exposure.

The first epidemic of clinical dengue like illness was recorded in Madras (now Chennai) in 1780 (Gubler, 1997) and the first virologically proved epidemic of DF in India occurred in Calcutta (Kolkatta) and eastern coast of India in 1963-1964 (Sarkar et. al., 1964, Chatterjee et. al., 1965 and Carey et. al., 1966), and the first major wide spread epidemics of DHF/DSS occurred in India in 1996 involving areas around Delhi (Dar et. al., 1999) and Lucknow (Agarwal et.al., 1999) and then it spread to all over the country (Singh et al., 2000 and Shah et. al., 2004).

Dengue is endemic in 29 states and 6UTs (except Lakshadweep). During 2015, a total of 99,913 cases and 220 deaths were reported from 29 state and 6 UTs(NVBDCP, annual report, 2016-17).

In recent decades, the geographical distribution of the virus and the mosquito vector has expanded, so the epidemic activity increased, and DHF has emerged in new geographical regions (Gubler, 2002). It is due to demographic factors like uncontrolled population growth, unplanned urbanization resulting in substandard housing and poor solid waste disposal and need of water storage aided vector proliferation and hence increased exposure(Dhar, 2013).

In Uttarakhand, the first two cases of dengue were reported in Haldwani town situated in the foothill of the kumaon hills in the western Himalayas, in 1996 (Shukla and Sharma, 1999). Thereafter eight cases of dengue with one death were reported from Uttarakhand in 2003 (unofficial report from CMO office). As per the records of health department, during 2006 -2012 the numbers of dengue cases

in Uttarakhand were 12, 67, 140, 76, 4140, 454 and 538. However, during 2010 a major outbreak of dengue was reported in this state in which eight deaths occurred(unofficial report from CMO office).

Four species of *Aedes* namely *Ae. aegypti*, *Ae. albopictus*, *Ae. vittatus* and *Ae. pesudotaeniatus* were identified in Haridwar Uttarakhand during 2015. (IDVC annual report 2015-16).

An outbreak of dengue was reported in Lal kuan town, nainital district of Uttarakhand during 2009 (Singh et. al., 2010) in which Ae aegypti and Ae. albopictus were reported, their breeding indices and adult densities have been recorded above the critical level imply their potential for future outbreaks. Some workers who worked on various aspects on dengue mosquito in this state are Pemola and Jauhari (2012), Singh et. al.,(2010, 2013), Dhar et. al.(2013), Mondal et. al., (2014), Singh et. al., (2014) Sarkar et.al,(2015), Sudan et.al.,(2016), Singh et.al., (2017) and Tyagi and pervez (2018) and Sadeura(2018) .In a study on mosquitoes and mosquito borne disease in Dehradun District Pemola Devi et. al., (2013) recorded 12 species of Aedes mosquitoes.

A large number of cases were found in this state as 4140 during 2010 it causes 08 deaths.

The factors responsible for global resurgence of DF/DHF are unprecedented population growth, unplanned and uncontrolled urbanization, increased air travel, absence of an effective mosquito control programme and deterioration of public health infrastructure. The risk factors for infection with DV are the increased density of the mosquito vector, reinfestation with Ae. aegypti of a new geographical area, warm and humid climate, increased population density, water storage pattern in the houses, storage of junk in open spaces, including tyres, etc. that trap rain water and introduction of new serotype of the viruses, etc. Vaccines or antiviral drugs are not available for dengue virus: the only effective way to prevent epidemic is to control the mosquito vectors and prevent its bite.(Chaturvedi and Nagar, 2008).

3. Japanese Encephalitis (JE)

Japanese Encephalitis (JE) is a mosquito borne zoonotic viral disease, transmitted by vector mosquito mainly belonging to ***Culex vishnui*** group. The virus belongs to the family Flaviviridae and genus Flavivirus. The virus is maintained in animals, birds, pigs, particularly the birds belonging to family Ardeidae (e.g., Cattle egrets, pond herons etc) which act as the natural hosts. Pigs & wild birds are reservoirs of infection and are called as amplifier hosts in the transmission cycle, while man and horse are 'dead end hosts i.e. JE is not transmitted from one infected person to other. The virus does not cause any disease among its natural hosts and transmission continues through mosquitoes. Vector mosquito is able to transmit JE virus to a healthy person after biting an infected host with an incubation period ranging from 5 to 14 days.

As the vector species prefers to breed in large water bodies rich in aquatic vegetation, in rice fields, so, the distribution of JE coincides with rice growing areas.

Outbreaks are common in those areas where there is close interaction between pigs/ birds and human beings.

JE is a disease of major public health importance in India, because of its epidemic potential, high case fatality rate and presence of life long complication in survivors.

JE is reported under the umbrella of Acute encephalitis syndrome (AES). The disease is endemic in 22 states of India (annual report 2016-17). There is no specific cure for this disease.

The first case of Japanese Encephalitis (JE) was reported in India in 1955 from Vellore, Tamil Nadu (Namachivayam and Umayal (1982). The first major JE outbreak was reported in 1973 from Burdwan district of West Bengal. Since then JE/AES has been reported from 171 districts of 19 States in the country. A major outbreak of Japanese Encephalitis was reported from eastern UP mostly confined to Gorakhpur during 2005 resulting of more than 6000 cases and 1500 deaths (Tiwari, et. al.,2012).

In India, the endemicity of JE was confined to seven state in 2008,15 states in 2011 and 13 states in 2013 with 1086 cases(Pavani,2014) indicating geographical spread. Kumar and Sharma (2013) reported 7 cases of JE from Uttarakhand.

In Uttarakhand, JE cases were mainly found from Udham Singh Nagar Distt (58 during 2006, 8 during 2008, 7 cases from Dehradun during 2010 and 02 in 2011).

4. Kala-Azar

Visceral Leishmaniasis commonly known as Kala-azar is a parasitic disease prevalent in 4 states viz., Bihar, Jharkhand, West Bengal and Uttar Pradesh, Bihar alone contributes more than 60% of the cases. Currently 54 districts in the states of Bihar, Jharkhand, Uttar Pradesh and West Bengal are endemic for Kala-azar.

Kala-azar (KA) or Visceral Leishmaniasis (VL) is caused by a protozoan parasite *Leishmania donovani* and spread by sand fly (*Phlebotomus argentipes).* Incubation period varies from 10 days to > 2 years in general but from four months to one year in India. Disease found across all age groups. Males are more afflicted than females.

The sandfly *(Phelbotomus argentipes)* breeds in shady, damp and warm places in cracks and crevices in the soft soil, in masonry and rubble heaps, etc. Proper sanitation and hygiene are critical to prevent sand fly breeding. In pursuance to achieve the elimination goal, case detection and treatment compliance the programme strengthened Rapid Diagnostic Test for Kala-azar and single day single dose Liposomal Amphotericin B injection and shorter duration of combination drug regimen. This disease is associated with malnutrition, human migration, poor housing, immunodeficiency and lack of resources (Abdalla, 2011).

Kala- azar is endemic in 54 districts (33 in Bihar, 4 in Jharkhand, 11 in west Bengal and 6 in eastern UP.) Annual Report, 2016-17.

The disease were appeared in Uttarakhand since 2007 as 02 cases found, during 2009 again 02 cases, in 2010, 01 cases from Haldwani then in 2012, 02 cases each from Haldwani and Chamoli distt.

Garhwal region of Uttarakhand state started reporting Kala-azar cases since 1984(Dhiman, 2010) after 1984 many workers could detect and confirm Kala-azar cases with more frequency and intensity (Singh et al., 1999: Verma et.al., 2007and Kumar and Sharma, 2014). Sporadic cases have been reported from sub Himalayan parts of North India including Uttarakhand by Naik et al., 1979; Singh et. al., 1999 and Raina et.al., 2009. Bhat et. al.(2017) said that the high altitude hilly Garhwal region of Uttarakhand can be considered as new emerging hot spot of VL in India, encouraging transmission of the protozoa. It is due to the construction of the huge Tehri dam and a number of hydroelectric power projects, initiated migration of skilled and manual laborers from the western Uttar Pradesh and Bihar which are endemic for VL.

5. Lymphatic Filariasis

Lymphatic filariasis (LF) is a serious public health problem in India. Filariasis is the common term for a group of diseases caused by parasitic nematodes belonging to superfamily Filarioidea. Adult worms live in the lymphatic system, cutaneous tissues or body cavity of the humans and are transmitted through vectors. Filariasis caused by nematodes that live in the human lymph system is called Lymphatic Filariasis (LF). Three nematode parasites causing LF in human are *Wuchereria bancrofti, Brugia malayi* and *Brugia timori*. Of these, only *Wuchereria bancrofti* and *Brugia malayi* are found in India. *Wuchereria bancrofti* transmitted by the vector, *Culex quinquefasciatus*, which breeds in all types of peri-domestic and domestic dirty and polluted water such as drains, ponds, stagnant streams, pools, tanks, barrels, tins, wells, sewage lines and other artificial containers. Adults are strongly domestic, bite man in the night indoors and outdoors, rest during day in the dark corners of bed rooms, shades, culverts, and observed flight up to 11 kms. But 3 km is the normal flight. The infection is prevalent in both urban and rural areas. Lymphatic filariasis is more prevalent among urban poor and affects all segments of rural population. The infection starts in childhood and accumulates through adulthood, resulting in irreversible chronic disease conditions such as Lymphedema, Elephantiasis and Hydrocele. The disease inflicts stigma, mental suffering, social deprivation and economic loss and is a major cause of poverty in the affected communities.(NVBDCP, 2018)

The disease is also caused by another parasite namely *Brugia malayi* which is transmitted mainly by mosquito *Mansonia annulifera* which is the principal vector of this parasite. *M. uniformis* also plays a role in transmission of the disease and, therefore, is the secondary vector for transmission of *brugia* infection. As per reports available, prevalence of *brugia* infection is restricted to small foci in Kerala State. The control of this vector is very difficult because of its ubiquitous breeding and adult become rapid resistant to insecticides. Vector control is expensive and requires major drainage works which are beyond the financial capacity of developing countries.This is the disease of urban areas but due to rapid environmental degradation and water stagnation the disease is now common in the rural areas.

The disease is prevalent in rural and urban areas of 256 distt of 16 states and 5Union territories.(NVBDCP, 2018). Thapliyal et. al.,(2009 and 2011) recorded the first case of filariasis in Uttarakhand which is non endemic hill state of India for this disease. However ,Satyawali et.al.,(2014) reported a case of concurrent malaria, Filaria and Dengue from the terai region of Uttarakhand, suggesting appearance of filariasis in this state. National health policy has aimed to eliminate filariasis by 2015. The dead line was extended to2017 and now has been shifted to 2020.(Times of India, Nov, 2017)

6. Chikungunya

Chikungunya fever is a viral disease caused by an arbovirus and transmitted by the bite of infected *Aedes* mosquitoes. Both *Ae. aegypti* and *Ae. albopictus* can transmit the disease. Chikungunya virus (CHIKV) is single stranded RNA of the genus Alphavirus, in the family Togaviridae. The mosquitoes bite throughout day light hours, although peaks of activity are in the early morning and late afternoon.

The virus show two types of transmission cycle-Urban cycle (man-mosquito- man) or Sylvatic cycle (animal-mosquito-man), the transmission of chikungunya in Africa is maintained in a sylvatic cycle i.e, monkeys-mosquito-man) while in India` man to man transmission through *Ae. aegypti* mosquito is known (Dhiman, 2014).

Humans are considered to be the major source or reservoir of Chikungunya virus. Therefore, the mosquitoes usually transmit the disease by biting infected persons and then biting others. The infected person cannot spread the infection directly to other person (i.e. it is not contagious disease). Symptoms of Chikungunya fever are most often clinically indistinguishable from those observed in dengue fever. However, unlike dengue, hemorrhagic manifestations are rare and shock is not observed in Chikungunya virus infection. It is characterized by sudden fever, chills, headache, nausea, vomiting with severe joint pain (arthalagia) and rash. Chikungunya outbreaks typically result in large number of cases but deaths are rarely encountered. Joint pains sometimes persist for a long time even after the disease is cured. There is neither any vaccine nor drugs available to cure the chikungunya and the cases are managed symptomically.

In India, the disease resembling the symptoms of chikungunya was reported from India in 1824 (WHO, 1990) and the first recorded chikungunya outbreak was in Kolkata in 1963. This was followed by epidemics in Tamil Nadu, Andhra Pradesh and Maharastra in 1964-65 and in Barsi in 1973 (Parashar and Patil, 2012). CHICK virus then seems to have disappeared from India. The virus re-emerged in 2006 after a gap of 32 years and caused an explosive outbreak affecting 13 states.(Cecilia, 2014) (2) the clinically suspected cases reported every year but gradually declined till 2014. (Annual report, 2015-16) however in few state, the disease shows an upward trend in 2015 (Karnataka) and 2016 (Delhi and nearby state). As on date, the cases were reported from 28 state of India. Both urban and rural areas were affected. All age groups were affected and no sex differentiation reported from any of the states. (IV m manual (NVBDCP, 2015 PAGE94).

In Uttarakhand, 7 cases of Chikungunya were reported from Dehradun during 2011(unofficial record from CMO office).

Conclusions

Main problem to control of vector borne diseases are : lack of epidemiological services, control approaches, lack of infrastructure and supervisory tier, shortage of man power, lack of finances, lack of inter-sectoral coordination and urban planning, poor drainage etc. uniform legislative measures must be applied all over the country to ensure that people do not create mosquitogenic conditions in their premises.

Another problem is migration of people for job, construction of dams, improvement of road links, increase in the number of pilgrims in hilly region, it causes problems such as water logging, and lack of proper sanitation may have caused an ecological shift in vector proliferation leading to an emergence of vector borne disease in this region.

Health impact assessment in the environment impact assessment should be made compulsory.

Mining in the city and in the surrounding should be prohibited; all water storage containers should be hermetically sealed following the methods available with the corporation. All drains should be de-silted before the onset of rain. Solid waste disposal should be organized in such a way that it does not lead to pollution and production of mosquitoes. Weekly source reduction, destruction of

mosquito breeding sites, application of larvivorous fishes, treatment with expanded polystyrene beads, spraying of *Bacillus thuringiensis* should be followed wherever required. Implementation of these methods will greatly reduce vector borne diseases.

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References

1)Abdalla:, N.M.(2011): Lesihmania parasite: Leishmaniasis among nomadic Sudanese tribes. Sci. Parasitol., 12: 93-7.

2)Agarwal, R., Kapoor, S., Nagar, R. Misra, A. Tanodn , R. and Mathur, A.(1999): a clinical study of the patients with dengue harmorrhagic fever during the epidemic of 1996 at lucknow, India. Southeast Asian J, Trop. Med. Public Health: 30:735-40.

3) Anon, World Health report, 1984, World Health Organization
hhttp://www.who.int/whr/1998/en/whr98_en.pdf.last Accessed july 25,2013.

4)Bhat, N.K., Ahuja, V., Dhar, M., Ahmad, S., Pandita, N., Gupta, V., and Chandra, S.(2017): Changing epidemiology: A New focus of Kala-azar at high altitude Garhwal region of North India. Journal of Trop Ped., 63, 104-108.

5)Cecilia, D.(2014): Current status of dengue and Chikungunya in India. WHO South-East Asian J Public Health., 3(1): 22-27

6)Chatterjee, S.N., Chakravarti, S.K., Mitra A.C. and Sarkar, J.K. (1965): Virological investigation of cases with neurological complications during the outbreak of haemorrhagic fever in Calcutta. J. Indian Med. Assoc., 45:314-316.

7)Choudhury, D.S., Malhotra, M.S., Shukla, R.P., Ghosh, Sharma, V.P.(1983):Resurgence of malaria in Gadarpur PHC, District Nainital, U.P., Ind. J. Malariol., 20:49-58.

8)Carey, D.E., Meyers R.M. Reuben R. and Rodrigues, F.M.(1966): studies on dengue in vellore, south india. Am. J. Trop. Med Hyg: 15: 580-7

9)Chaturvedi, U.C. and Nagar, R.(2008) :Dengue and Dengue haemorrhagic fever: Indian perspective. J.Biosci. 33(4): 429-441.

10) Clyde, D.(1931) :Report on the control of malaria during Sarda canal construction (1920-1929). Rec.. Mal. Surv. India., 2:49-110.

11) Dar, L., Broor, S. Sengupta S., Xess, I. and Seth, P.(1999): the first major outbreak of dengue haemorrhagic fever in Delhi, India. Emerg infect Dis., 5: 589-90.

12) Dhar, M., Shirazi, N., Ahmad, S.,Srivastava, S. Biswas, D. and Bhat, N.K. (2013): De novo experience of a single outbreak of dengue infection at a tertiary referral centre of Uttarakhand, North India. J. Ind. Academy of Clin. Med. 14(3-4): 225-229.

13)Dhiman, R.C., Pahwa, S., Dhillon, G.P.S. and Das, A.P.(2010): Climate change and threat of vector-borne diseases in India: are we prepared? Parasitol Res., 106: 763-773.

14)Dhiman,R.C.(2014): Emerging vecor –borne zoonoses: eco-epidemiology and public health implications in India. Front. Public. Health., 2: 168. Doi: 10.3389/fpubh.2014.00168.

15)Gubler, D.J.(1997): Dengue/Dengue haemorrhagic fever: its history and resurgence as a global public health problem: in *Dengue and dengue haemorrhagic fever* (eds) D. J. Gubler and G Kuno(Wallingford, Oxon, UK: CAB international press) pp 1-22.

16)Gubler, D.J.(2002): The global emergence/resurgence of arboviral diseases as public health problems. Arch Med Res.,: 33: 330-42.

17)Gupta, N.,Srivastava, S., Jain, A. and Chaturvedi, U.C.(2012): Dengue in India. Indian J. Med. Res. 136, sept: 373-390

18) Gupta, K(2013) Unprecedented growth of Dehradun urban area: a spatio-temporal analysis. International journal of advancement in remote sensing, GIS and Geography. Vol I (2), 47-56.

19)Halstead, S.B.(1990) Global epidemiology of Dengue hemorrhagic fever, S.E. Asai J.trop.med.pubi.hlth,21:636-641.

20)Hehir, P. (1927) *Malaria in India*, oxford, Unites Kingdom: oxford Univ, Press.P366.

21)Integrated Disease Vector Control (2016): IDVC, Annual report (2015-2016)

22)Kumar, R. and Sharma, S.K.(2013): Trends of communicable and non- communicable morbidities in Uttarakhand state: a systemic review. Ind. J.Commu. Health., 25(2):178—187.

23)Mani, S.(2017): Spatio-temporal analysis of Urbanization in Uttarakhand. KIJECBM.JAN-MAR, 4(1)/A32:317-334.

24)Mondal, R., Pemola Devi, N. and Jauhari, R.K.(2014): Occurrence of Aedes mosquitoes (Diptera culicidae) in Urban areas of Doon valley,(Uttarakhand), India.

25)Namachivayam, V., and Umayal, K.(1982): Editors Proceeding of the National conference on Japanese Encephalitis, New Delhi, Indian Council of Medical Research; pp 30-33.

26)Naik, S.R., Rao, P.N., Datta, D.V., Mehta, S.K., Mahajain, R.C., Mehta, S.(1979): Kala-azar in north-western India. A study of 23 patients. Trans. R. Soc.Trop. Med. Hyg.,73;61-5.

27)National Vector Borne Disease Control Programe (2015): Annual report 2015-16. Govt of India, NVBDCP, Delhi, 1-38 page

28)National Vector Borne Disease Control Programe(NVBDCP) (2018): Accelerated plan for elimination of lymphatic filariasis, NVBDCP, Directorate general of Health service, Govt of India.. 1-24.

29)Parashar, D. and Patil, D.(2012): Chikungunya: a disease re-emerged in India after 32 years. In: NIV golden to diamond Jubille. The glorious decade. Arankulle VA, Cecilia D. Edn. : 221-242.

30)Pavani, G. (2014): Zoonotic diseases with special reference to India. Int. J. Appl. Basic Med. Sci., 4: 73-87.

31)Pemola Devi, N. and Jauhari, R.K.(2004a): Mosquito records from Garhwal region (Uttaranchal). J.Exp. Zool. India. 7(2): 237-244.

32)Pemola Devi, N. and Jauhari, R.K.(2004b): Altitudinal distribution of mosquitoes in mountainous area of Garhwal region: Part-I. J. Vect. Borne. Dis., 41(march and June): 17-26.

33)Pemola Devi, N. and Jauhari, R.K.(2006): Relationship between *Anopheles fluviatilis* and *An. stephensi* (Diptera: Culicidae) catches and the prevalence of malaria cases at Kalsi area in Dehradun district(Uttaranchal). Indian J. Med. Res 123 (Feb):151-158.

34)Pemola Devi, N. and Jauhari, R.K.(2012): Records of potential dengue vector mosquitoes in Doon valley, Uttarakhand, India. Flora and fauna, 18(2): 229-232.

35)Pemola Devi, N. and Jauhari, R.K.(2013): Meteorological variables and malaria cases based on 12 year data analysis in Dehradun (Uttarakhand) India. Euro. J. Exp. Bio., 3(1):28-37.
36)Raina, S. Mahesh, D.M., Kaul, R., Satindera K.S., Gupta, D., Sharma, A. (2009); A new focus of visceral leishmaniasis in sub-Himalayas, India. J. Vect. Borne Dis., 46; 303-306.
37)Saini, P., Joshi, B.D. and Sharma, T.(2013): Malaria infection indistrict Haridwar of Uttarakhand state(India). Report and Opinion: 5(11):45-47.
38)Sarkar, J.K., Chatterjee, S.N., Chakravarty, S.K.(1964) Haemorrhagic fever in Calcutta: some epidemiological observations. Indian j. Med Res: 52:651-659.
39)Sarkar, M., Kumar, K., Sharma, A.K. and Gupta, A.K. (2015): Ento-epidemiological characterization of dengue in Uttarakhand (India). J. Mosq. Res., 5(17):1-10.
40)Sadeura, J.K. (2018): Mosquito diversity from Kempty falls, near Mussorie, Uttarakhand (India). Int. J. Zool. Stud. 3(2):160-162.
41)Satyawali, V.K., Pandey, S.,Rawat, V. and Khalil, M.(2014): Triple co-infection of malaria, Filaria and dengue: a rare entity. J.Lab. Physicians, July-Dec:6(2):136-137.
42)Singh, S., Biswas, A., Wig, N., Aggarwal, P., Sood, R. and Wali, J.P.(1999) A new focus of visceral leishmaniasis in sub Himalayan (Kumaon) region of northern India. J. commun. Dis., 31: 73-77.
43)Singh, R., Singh, S.P. and Ahmad, N. (2013): A study on clinical and laboratory profile of dengue fever in tertiary care centre of Uttarakhand. Int. J. Res. Med. Sci.,2(1):160-163.
44)Singh, R.K., Dhiman, R.C., Dua, V.K. and Joshi, B.C.(2010) Entomological investigation during an outbreak of dengue fever in Lalkuan town, Nainital district of Uttarakhand, India. J. Vect. Borne. Dis., 47: 189-192.
45)Shah, I., Deshpande, G.C.and Tardeja, P.N.(2004): Outreak of dengue in Mumbai and predictive markers for dengue shock syndrome. J. Trop. Pediatr: 50: 301-5.
46)Shukla, R.P. and Sharma S.N. (1999): *Aedes aegypti* survey of West Himalayan foothill town of Haldwani district Nainital, India. Dengue Bull., 23:113-114.
47)Singh, J., Balkrishnan, N.,Bhardwaj, M., Amutha devi, P., George, E.G., Subramani, K., Soundararajan, K.,Appavoo, N.C., Jain, D.C., Ichhpujani, R.L., Bhatia, R. and Sokhey, J.(2000): Silent spread of dengue and dengue haemorrhagic fever to Coimbatore and Erod districts in Tamil Nadu, India, 1998: need for effective surveillance to monitor and control the disease: Epidemiol. Infect., 125: 195-200.
48)Singh, P., Bano, M., Rawat, V., Umesh and Joshi, A.(2017): Clinico epidemiological study of Dengue outbreaks- an overview from Kumaon region of Uttarakhand. JMSCR, 5(4):20962-20971.
49)Sudan, A., Firmal, L and Batola, K.S.(2016): Study of dengue fever cases at a tertiary care hospital in Srinagar, Pauri Garhwal, Uttarakhand, North India. J. Prev., Med., Holistic Health., July-Dec,2(2):46-50.
50) Thapliyal, N. Joshi, U. and Bhadani ,P.(2009): First report of filariasis in a non-endemic hill state of India. .Ind. J. Patho Micro. 52(2) :293-294.
51) Thapliyal, N., Bhadani, P. and Jha, RS.(2011):Filariasis presented as a spermatic cord nodule in a non endemic hilly state of Uttarakhand: a case report of second case in the region. Ind. J. Community Med., 36(2); 161-162.
52)Tiwari, S., Singh, R.K., Tiwari, R. and Dhole, T.N.(2012): Japanese encephalitis: a review of the Indian perspective. BRAZ. J. INFECT. DIS. 16(6): 564-573.
53)The Times of India: Nov 17, 2017
54)Tyagi, M. and Pervez A. (2018): Biodiversity and seasonal prevalence of mosquitoes from terai region of Uttarakhand. J. Bio.. Innov., 7(4): 503-510.
55)Verma, S.K., Ahmad, S., Shirazi, N., Kusum, A., Kaushik, R.M. and Barthwal, S.P. (2007): Sodium stibogluconate-sensitive visceral leishmaniasis in the non-endemic hilly region of Uttarakhand, India. Trans. R. Soc. Trop. Med. Hyg., 101:730-732.
56)WHO (1990): Control of the Leishmaniasis. WHO technical report series, Geneva: 66-94.