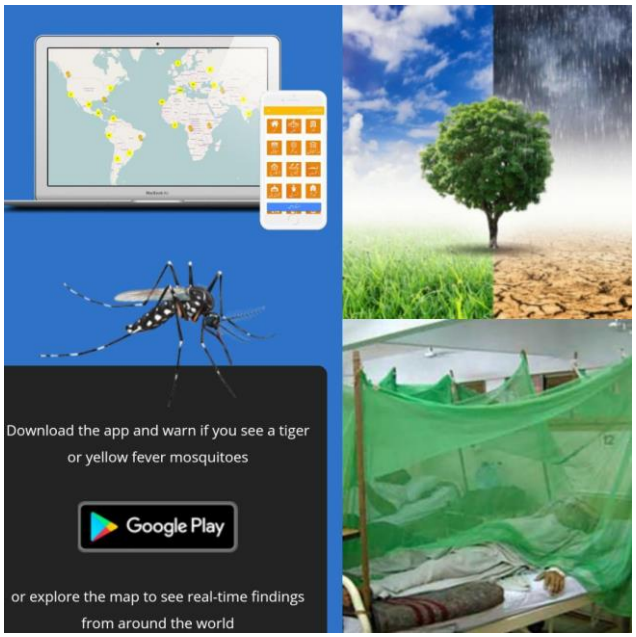

REPORT ON VECTOR BORNE DISEASES AND MOSQUITO ALERT PAKISTAN

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Abstract: The present study provides information regarding geographical distribution of mosquitoes in Pakistan. Original photos were sent from the general public of Pakistan through using Mosquito Alert Pakistan application. Information about culicidae mosquitoes is still very meager. It is important to have an up-to-date list of mosquito species present in country to control vector borne diseases in Pakistan. Mosquito Alert would play a significant role in surveillance and monitoring of Aedes mosquitoes. Mosquito surveillance provides an early warning system for the risk of transmission of mosquito borne diseases in an area. This will help in formulating better vector control strategies in Pakistan.

Introduction

Vectors are the living creatures that can spread diseases from animals to human being or between humans. Many insects are vectors; mosquitoes are the best known disease vector. The vectors swallow pathogens during sucking blood from an infected host. During their later blood meal infected insect transmit pathogen to a new host through bite. Some vectors of different diseases of public health importance are mosquitoes, ticks, flea, flies and sand flies[1].

Vector-borne diseases are caused by viruses, bacteria and parasites that are spread by ticks, mosquitoes, tsetse flies, mites, snails, sand flies, triatomine bugs, black flies and lice. There are more than 700,000 deaths from diseases such as yellow fever, Japanese encephalitis, dengue, schistosomiasis, leishmaniasis, trypanosomiasis, chagas disease, onchocerciasis and malaria occurs globally every year. Around 17% of all infectious diseases are vector-borne diseases. In the world, outbreaks of vector borne diseases have afflicted populations, since 2014, in many countries. In over 128 countries more than 3.9 billion people are at risk. Mosquito borne disease causes estimated 400,000 deaths in the world every year. Leishmaniasis, chagas disease and schistosomiasis have an effect on hundreds of millions of people worldwide[1].

Transmission of vector-borne diseases is determined by different factors i.e. social, unplanned urbanization, environmental, complex demographic, trade and local to global travel. Changes in climate such as changes in temperature and rainfall can affect the pathogen transmission and emergence of vector borne diseases in new areas or region and making transmission season longer or severe.

Situation in Pakistan/ Vector Borne Diseases (VBDs) and their outbreaks in Pakistan

Major vector-borne diseases in Pakistan are dengue, chikungunya, malaria, dengue; Crimean-Congo haemorrhagic fever and leishmaniasis. In Pakistan, malaria is a major cause of illness and death in Pakistan. Every year one million estimated and 300,000 confirmed reported cases, Pakistan has been grouped with Afghanistan, Somalia, Sudan and Yemen due to high burden of malaria in this region. *A. stephensi* and *A. culicifacies* are known primary vectors and *P.vivax and P.falciparum* are the only reported parasite species of malaria in Pakistan. Transmission of malaria has been seasonal. High transmission occurs in districts, located in bordering regions with Baluchistan, Sindh, Islamic Republic of Iran and Afghanistan .Balochistan and Khyber Pakhtunkhwa are the highest malarial endemic provinces. Thatta, Mirpur Khas,

Khairpur, and Tharparkar are the major endemic districts in Sindh. Punjab has been the lowest endemic province with API>1/1000[2].

Dengue is another mosquito borne disease has been causing major mortality and illness in different regions of the world. It is estimated that Dengue virus transmission has endemic in about 120 countries and reported 21,000 deaths every year[3, 4]. In Pakistan, dengue is endemic and transmission season has observed in the post monsoon period[5]. Dengue fever was reported first time in 1985[6]. In Baluchistan, 57 deaths and 75 cases of dengue reported from Hub during 1995[7]. During dengue outbreak 1000 cases and 7 deaths were reported from district Haripur in 2003. In the same year 2500 cases and 11deaths were reported from Khushab, Nowshera in 2004. In Karachi, 500 cases and 13 deaths were reported during 2005[8, 9]. In 2006, 55 deaths and 5400 cases of dengue were registered in district Sukkur, Islamabad, Rawalpindi and Karachi[10]. A total 24 deaths and 2700 cases of dengue were reported from Lahore, Haripur, MirpurKhas, Hyderabad, Karachi, Nawabshah, Islamabad, Sukkar and Rawalpindi in 2007[11]. During 2008, 1800 cases of dengue virus were reported from Lahore and 570 in 2009[12, 13]. In 2010, confirmed dengue 5000 cases were registered[14]. Pakistan had experienced the worst dengue outbreak with 300 deaths and more than 20,000 in Lahore during 2011, the disease was also registered in district Rawalpindi, Sargodha and Faisalabad[16].

In KPK, around 6,376 dengue cases were reported from Swat in 2013[17]. In 2014, about 21,580 cases were reported from different areas of Pakistan. In 2015, total of 7,713 cases were reported from Karachi and Rawalpindi[18]. In the same year dengue outbreak was reported from Malakand district, KPK[19]. Dengue cases were reported from province Sindh, KPK and Punjab in 2016[19, 20]. In 2017, a total of 10,893 lab confirmed cases along with 38 deaths had been registered from Peshawar, KPK. In Pakistan, dengue cases have been recorded from Khyber Pakhtunkhwa, Sindh and district Gwadar in Balochistan Province[21].

In Pakistan, chikungunya virus was detected in rodents in 1983[22]. In 2011, during dengue outbreak a few patients of chikungunya were also reported[23]. Around 30,000 cases of chikungunya were identified in Karachi in 2011. More than 4,000 samples were found positive after lab diagnostic tests at the NIH and Armed Forces Institute of Pathology, Pakistan. The National Institute of Health and Armed Forces Institute of Pathology Pakistan had confirmed more than 4000 cases[23]. According to WHO 1018 suspected cases of chikungunya were registered in 2017 from different districts of Karachi[7]. A total of 157 samples were confirmed for chikungunya infection at NIH[24].

In Pakistan, Crimean Congo Haemorrhagic fever (CCHF) was first time reported in 1976 and 14 cases were reported from 1976 to 2010[25]. About sixty two assumed cases were identified during the year 2012, with forty one confirmed and eighteen deaths; in which thirteen deaths were recorded of the laboratory identified cases and five deaths were recorded as assumed CCHF. About twenty three clear-cut cases were reported from Baluchistan, seven from Sindh; six from Khyber Pakhtunkhwa and

five from Punjab province of Pakistan[26]. According to World Health Organization, six and four deaths were documented in September and November of 2013 respectively, out of which 2 were confirmed as CCHF and were from Abbottabad area of Khyber Pakhtunkhwa. All reported victims were from similar family unit of Abbottabad and were slaughter house workers. A total of seventy two suspected, forty eight confirmed cases of CCHF and sixteen deaths were documented in the country in 2013. In 2016, a total of 7 deaths were reported from Rawalpindi and Karachi which all were positive for CCHF. In Baluchistan, 84 CCHF suspected cases were reported and out of these 22 were found positive for CCHF and ten died in 2016 while 51 cases were found positive and out of positive cases 16 died in 2017 and a total of 59 suspected have been submitted for testing, out of which 8 have been found positive for CCHF in 2018.

In Pakistan, leishmaniasis was reported from Pakistan in 1960. It is widely spreading all over the country. No definite endemic area has yet been defined[27] however the disease is reported along the entire western border extending north into N.W.F.P. down to South West Baluchistan and Northern area of Sindh, Baluchistan territory. In Punjab, the epidemics have been reported in Multan, Lahore and Dera Ghazi Khan[27, 29]. The areas of Baluchistan which show the highest incidence of this disease are Gambaz Maiwand, Kehan, Loherktak, Tali Tangi, Spin Tangi, Dera Bugti, Sibi, surrounding areas of Kohlu, Loralai, Fort Sandeman, Khuzdar and Lasbella. In Sindh the disease has been reported from Dadu, Larkana and Jacobabad districts. Cutaneous Leishmaniasis also occurs in Northern areas[29], Multan, Quetta, Lasbella and Lahore. In. 1960 Khaplu valley was the hot bed of disease. In 1964 due to control measures taken these villages had no visceral cases of leishmaniasis. In 1974 in Kharmang valley a new foci was discovered. In 1975, two (02) cases were seen in the village of Parkuta. In 1979 the whole of Baluchistan was surveyed and no active case of Kalazar was revealed, but after the 1935 earthquake there was a severe outbreak of cutaneous leishmaniasis in Quetta. Incidence of the disease in Baluchistan is extensive. In 1974 the army personnel who were posted there contracted the disease.

In 1971 another outbreak occurred in non-immune personnel in Uthal area of Lasbella. In Multan there was an epidemic in 1971-72. One explanation offered for these epidemics is the building up of a non-immune population in between the epidemics for the immune response appears to be of utmost importance in resistance to the disease. It takes 15-18 years for the epidemics to recur. In Pakistan the important reservoir for urban areas is the dog and for rural areas, wild rodents e.g. Rhombomysopimus, Merioneshumianae, M. lybicus, M. Persicus, M. crassus and other species are reported[30]. To determine the species of sandfly in Pakistan an entomological survey was undertaken in Baluchistan an endemic area in Pakistan. Three species were found i.e. *P. sergentii* 63.7% and *P. papatasii* 30.5%, *P. sergentomyasquamipleuris* 5.8%; *P. sergentii* was found to be the most important vector in causation of disease[30]. In this issue two cases of visceral leishmaniasis have been reported from Karachi especially one case that never left Karachi[31] so the source of infection and method of transmission have yet to be identified here.

Factors responsible for disease spread

Emergence and re-emergence of dengue are due to multiple factors of environmental, social, economic and political nature including national health care policies. These factors include failures in vector control programs, population growth, fast and unplanned urbanization, an increase in transportation by plane, an increase in the amount of non- biodegradable waste, the inefficiency of public healthcare infrastructure and a lack of funds for its improvement. In general, poverty and inequality stand behind most of these factors in many countries [32, 33].

Climate change is the main worldwide problem. It is considered to be produced basically by the atmospheric accumulation of greenhouse effect gases, as a result of human activity[34]. Many of the organisms and biological processes associated to the transmission of infectious diseases are especially influenced by climatic variables such as humidity, precipitation and temperature. Result of climate change, increases the density of vectors and transmission potential of many infectious diseases [35, 36].

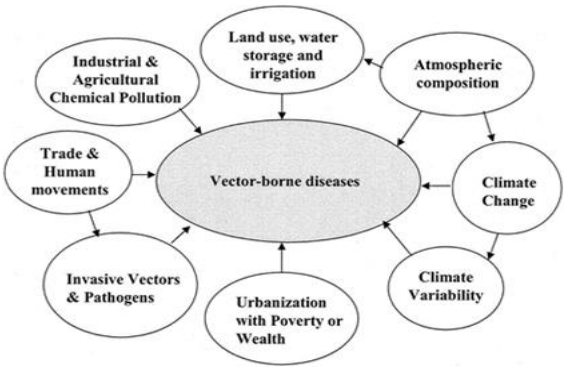


Fig- . Main factors responsible for potential changes in the status of vector borne diseases [36]

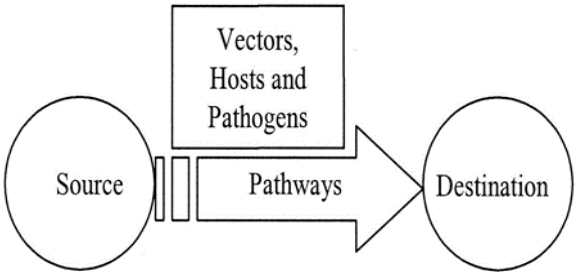
Climate change is the one of the main factor responsible for the spread of vector borne diseases. Rising in temperature can increase in length the breeding season and increase the transmission season. Flooding and increased rainfall create potential breeding sites for vectors and eggs hatch in hotter season.

Socioeconomic factors i.e. Poverty, unplanned urbanization, Shortage of water supply, poor solid waste management constrains on control measures to prevent further spread of mosquito borne disease. The high density of mosquito as well as humans has increased the capacity of mosquito to spread mosquito borne diseases[37, 38]. Local to international travel and trade are the main factors responsible for the spreading of vector borne disease from one region to another region [39, 40].

Movement of vector borne diseases

Local to international travel, trade and climatic suitability for the vectors are the main factors responsible for the movement of vector borne diseases[42, 43]. In Pakistan, dengue has been endemic for decades in, but later on dengue epidemics have emerged in Punjab, in 2011. In 2017, the dengue outbreak with 10,893 confirmed cases and 38 deaths were reported from the Peshawar, Khyber Pakhtunkhwa. Current situation regarding vector borne disease is worst in Pakistan. Dengue cases have been

recorded from different districts of Sindh, Baluchistan, KPK, Punjab province and Islamabad in Pakistan.



Concept of sources, pathways and destination of exotic species translocations[34]

Health facilities and Response

Control of vector borne diseases including dengue is very challenging in Pakistan due to lack of trained vector biologist/ entomologist, quality assurance, absence of vector and epidemiological surveillance system, adequate monitoring and assessment system, and absence of designated vector authority department for dengue vector control interventions. By implementing the steps given below, dengue prevention can be improved in future.

Health care system up-gradation

In Pakistan, poor health care system may be responsible for high mortality rate from vector borne diseases in previous years. The rate of mortality can be decreased by applying timely and proper clinical management. The rate of transmission can be reduced by introducing vector surveillance system at grass root level (union council level). Health Ministry of Pakistan should plan health promotion campaigns for involvement of community to eliminate breeding places of vectors and personal protection measures.

Strengthening of surveillance system

Surveillance is a critical important for prevention and control program of any vector borne disease. The surveillance system provides information required program guidance, risk assessment and program guidance, epidemic response and program assessment. Poor dengue surveillance system of Pakistan is also the reason of unsatisfactory dengue situation. Presence of functional and continuous dengue surveillance at all levels is the primary requirement of dengue in Pakistan and it should be a part of national health care system.

Passive surveillance, active surveillance and event-based surveillance should be the effective component of our surveillance system to determine disease transmission, circulating serotypes and investigating unknown health events, namely fevers of unknown etiology and clustering of cases.

Challenges and knowledge gap on implementation on Integrated vector management (IVM)

Communication, coordination and collaboration between the health and non- health sectors require for prevention and control of vector borne diseases Non availability guidelines/ SoPs for vector bone diseases surveillance, prevention & control at all levels.

Currently, no mechanism is available for coordination at provincial and national level. Line departments may be requested to develop strategies and implement them for safe and clean environment.

While vector control is indicated as a key strategic approach in the control and prevention of VBDs in most countries, there is an absence of a well-articulated overarching policy on vector control. There is very little cross-sector efforts and accountability among the major stakeholders whose actions or inactions contribute to local disease burdens.

The lack of knowledge and experience of mainstreaming management issues in IVM is a major challenge. Responsibilities must be allocated for all concerned stakeholders in overall system at all levels i.e. national, provincial, district and community. There is a need to design a comprehensive cost-benefit analysis model for evaluating IVM against other vector control approaches and showcase IVM if it has to be widely accepted through evidence-based decision making process. The lack of a comprehensive policy on vector control prevents appropriate placement and cross-sectoral mobilization of resources for vector control within the Ministry of Health. With the exception of malaria, there is virtually no vector control policy or effort linked to other vector-borne diseases. Compounded by the lack of national capacity for entomological and eco-epidemiological evaluations of other VBD, it becomes difficult to convince decision makers to allocate resources for VBD they consider less of apriority.

Operational Research

Major causes of dengue and other vector borne diseases are poor surveillance system, inadequate funding, and unawareness of the community and climate change. Vector lab/insectary is not available in the provinces. Enhanced research on vectors and insecticide resistance is very necessary to control the vector borne diseases. Insecticide resistance is the one of the cause of failure in control of vector borne diseases. Furthermore, lack of collaboration between departments involved in vector control and research institutes.

Data availability and limitations

Currently, data regarding epidemiological and entomological is not available in Pakistan at provincial and national level. The implementation of vector and disease surveillance data is important to control future epidemics in the country. The surveillance system has been operational in Punjab, since 2013 and receiving data from all levels of health facilities.

Mosquito Alert Pakistan

The National Institute of Health (NIH) has launched its first-ever android based application named “Mosquito Alert Pakistan” in Pakistan. The main purpose of this App is to collect information on disease vector (Aedes, Anopheles and culex) mosquitoes to assist research, surveillance and control and to promote awareness raising. *Aedes aeypti* and *albopictus* are the primary vectors chikungunya, dengue, yellow fever and zika. Anopheles mosquitoes transmit Malaria. Culex mosquitoes spread West Nile fever, Lymphatic filariasis and Japanese encephalitis.

Through this Mosquito Alert app, anyone can send photo of mosquitoes and their breeding places. These photos are part of a common database and used for surveillance, monitoring and control of mosquito. This information system is key for generating a participatory alert system to improve the management of mosquito' species, minimize the risk of disease transmission and raise awareness among general public. Medical Entomologists may study the distribution and dynamics of expansion of these invasive species and make it possible to have valuable information for decision making.

Results and discussion

Mosquito Alert Pakistan application has been launched on 11th January, 2019. Total 23 pictures have been received from the general public of Pakistan. It was a positive response from the people during off season of mosquitoes. It was observed that environmental factor i.e. temperature and humidity affecting hatching percentages of populations of mosquitoes. High density of mosquito was found during the rainy season due to high relative humidity (up to 75%) and high temperature (28–36 °C), while low density of mosquito was observed during the winter in Pakistan. High density of mosquito found during August, September and October.

Four pictures were received from Islamabad, 6 from Punjab, 8 from Sindh, 3 from KPK and 1 from Baluchistan (Table 1). Aedes mosquitoes were received from two localities of Islamabad while 1 picture of Anopheles mosquito was received from Loralai, Balochistan. Culex mosquitoes were reported from Karachi, Jamshoro, Miani, Hasilpur and Kalu Khan. Five pictures received from Karachi were not clear. In 9 pictures did not see any mosquito.

Table 1: Picture received from different localities of Provinces, Pakistan

Sr.no	Date	Place	Total	State	City	Mosquito	Type
1	15-1-2019	other	9	Islamabad	Islamabad	Yes	Aedes
2	16-1-2019	office	1	Sindh	Jamshoro	Yes	Culex
3	16-1-2019	Other	Not sure	Punjab	Miani	Yes	Culex
4	16-1-2019	Office	Not sure	Islamabad	Islamabad	No	N/A
5	16-1-2019	other	30	Sindh	Karachi	Yes	Culex
6	17-1-2019	Home	30	Sindh	Karachi	yes	Other
7	17-1-2019	Home	30	Sindh	Karachi	Yes	Other
8	17-1-2019	home	Not sure	Sindh	Karachi	No	N/A
9	17-1-2019	Other	Not sure	Punjab	Dera Ghazi Khan	No	N/A
10	17-1-2019	other	1	Islamabad	Islamabad	yes	Aedes
11	17-1-2019	Home	Not sure	Sindh	Karachi	Yes	Other
12	18-1-2019	Home	Not sure	KPK	KalpaniKalay	No	N/A
13	18-1-2019	Other	30	Sindh	Karachi	Yes	Others
14	18-1-2019	Other	2	Punjab	Hasilpur	yes	culex
15	18-1-2019	other	Not sure	Punjab	Sangla Hill	Not sure	N/A
16	19-1-2019	Other	Not sure	Punjab	Sargodha	No	N/A
17	20-1-2019	Home	Not sure	Balochistan	Loralai	No	N/A
18	20-1-2019	Other	1	Sindh	Karachi	Yes	Other
19	21-1-2019	Office	Not sure	Islamabad	Islamabad	No	N/A
20	23-1-2019	Office	Not sure	Punjab	Manga Mandi	Yes	Culex
21	23-1-2019	Home	Not sure	KPK	Kalu khan	No	N/A
22	24-1-2019	Other	Not sure	Balochistan	Loralai	Yes	Anopheles
23	26-1-2019	Hotel	Not sure	Punjab	Rawalpindi	No	N/A

Figure 1: Map showing geographically distribution of mosquitoes in Pakistan

Figure 2: Number of Mosquitoes reported by date wise

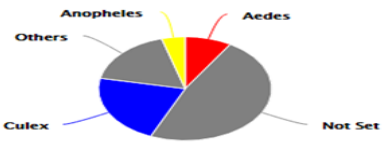


Figure 3: Different type of mosquitoes reported by the general public

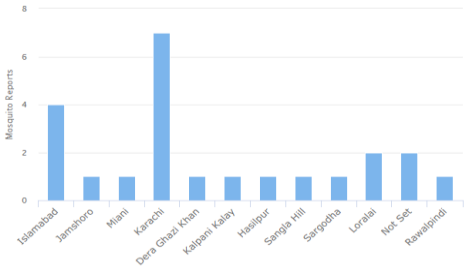


Figure 4: Mosquitoes reported from different cities of Pakistan

Figure 5: Mosquito reported from the provinces of Pakistan

Conclusion

There is no available information on the geographical distribution status of mosquito at local level in Pakistan. Further collections of mosquitoes would be helpful in improving our knowledge of the species that are present in the country. Mosquito fauna of province Baluchistan is unknown. It is important to have an up-to-date list of mosquito species present in country to control vector borne diseases in Pakistan. Mosquito Alert App can play important role in surveillance and monitoring of mosquito. Vector surveillance system should introduce at union council level, in all provinces. Future research priorities should include further collection of culicines from all provinces.

Recommendations

i. Establishment of vector lab/ insectary at Provincial and district level.
ii. Operational/ Enhanced research should be conducted in all provinces and regions.
iii. There should be coordination, communication and collaboration between departments involved in vector control and researcher should share the available information on vectors in Pakistan.
iv. Monitoring system for insecticide resistance should be established at NIH, Islamabad.
v. Promotion of Mosquito Alert Pakistan should be started in spring season i.e. March- April.
vi. GIS mapping of vector and disease should be done at all level to control further epidemics of vector borne diseases in Pakistan.
vii. Entomological and Epidemiological data should be collected systematically and sharing of data should be done at all levels e.g. national, provincial and districts
viii. There should be coordination, communication and collaborate between Ministry of climate change, metrological and other relevant stakeholders.
ix. Guideline/ SOPs should be developed for vector surveillance, prevention and control of VBDs and disseminated to all stakeholders.
x. Capacity building of Medical Entomologists on vector surveillance, Integrated Vector Management (IVM) and application of insecticide.
xi. Public education should be strengthened in all provinces by involving the community for prevention and control vector borne diseases.

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