REVIEWS

Impact of climate change on the epidemiology of vector-borne diseases in Pakistan

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Abstract

Climate change is a hard reality that has already started affecting air quality, food production, water supply, coastal settlements, and human health. There is increasing evidence about the effect of climate change on vector-borne diseases (VBDs). In this article, we have collected data from published articles, journals, reports, and books on VBDs in Pakistan and review the changing epidemiology of the most important VBDs i.e. Malaria, Dengue fever, Chikungunya, Leishmaniasis, Crimean-Congo hemorrhagic fever (CCHF), West Nile fever and Japanese encephalitis in Pakistan. We have summarized the district-wise VBDs outbreaks and developed maps. There is no proper surveillance of vectors and diseases available in Pakistan. Early warning system for preventing outbreaks are direly needed. No study has been done on the effect of climate change on vector-borne disease in Pakistan. Long-term observational studies and a multidisciplinary effort are needed to monitor climate-change effects on vector-borne diseases in Pakistan. It is essential to establish a vector surveillance system, integrated vector management (IVM), and climate change with the utmost priority for the prevention and control of VBDs in Pakistan.

Key words: Climate change, Epidemiology, Vector-borne diseases, Pakistan

Introduction

Climate change is an increasing global concern. It is the adverse effect of the atmospheric accumulation of greenhouse effect gases as a result of human activity (1). Climate change is affecting every region of the globe, but in Asia and Africa, vulnerability is higher (2). Living organisms and biological processes associated with the transmission of infectious diseases are especially influenced by climatic variables such as humidity, precipitation, and temperature. The effects of climate change increase the density of vectors and transmission potential of many infectious diseases (3, 4).

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. Around 17% of all infectious diseases are vector-borne diseases. Every year there are more than 700,000 deaths globally from diseases such as yellow fever, Japanese encephalitis (JE), dengue fever, schistosomiasis, leishmaniasis, trypanosomiasis, chagas disease, onchocerciasis, and malaria (5, 6). Throughout the world outbreaks of vector-borne diseases have afflicted populations in many countries since 2014. In over 128 countries, more than 3.9 billion people are at risk. Mosquito-borne diseases cause an estimated 400,000 deaths world-wide every year. Leishmaniasis, chagas disease, and schistosomiasis effect hundreds of millions of people (7).

Pakistan is in the northwest of South Asia. It is situated between the latitudes 24-37⁰ north and between the longitudes 62-75⁰ east. It consists of four provinces (Balochistan, Khyber Pakhtunkhwa (KP), Punjab, and Sindh), the independent state of Azad Jammu and Kashmir (AJK), and 132 districts (8). There are four seasons. The onset and duration of seasons varies somewhat according to location. The eastern areas of the southern half mainly receive precipitation from June to September, while the northern and western areas of the southern half of the country get rains from December to March. The northern area includes some of world's highest mountain peaks (K-2) and the largest glaciers (Siachen and Biafo). The temperature in winter in this region drops to as low as -50⁰C and stays around 15⁰C in the warmest months of May to September (9). The mean temperature during summer (March-June) varies from 23-49⁰C (upper plain) and from 42-44⁰C (lower plain), while the mean winter temperature (December-February) in the upper plain 20-23⁰C and 14-20⁰C in the lower plain (10).

The transmission of VBDs is determined by various factors, including social, environmental, and complex demographic factors, as well as factors relating to unplanned urbanization, trade, and both local and global travel. Changes in climate, such as changes in temperature and rainfall, can affect pathogen transmission and give rise to vector-borne diseases in new areas or regions and make the transmission season longer or more severe (11).

Methods

We searched all Web of Science databases for peer reviewed articles published between 1960 to December 2019. Search terms were related to vector-borne disease (dengue, malaria, chikungunya, CCHF, leishmaniasis, West Nile virus, Japanese encephalitis and yellow fever) present or historical occurrence in province (Balochistan, Punjab, Sindh, KP, Azad Jammu and Kahmir and Gilgit Baltistan) and climate change assessment. Only peer reviewed article published in English were included and year wise geographical distribution of vector borne diseases outbreaks in Pakistan were summarized. We did not find any published article related to occurrence of yellow fever therefore excluded it from the study.

Major vector-borne diseases in Pakistan

Mosquitoes are the best-known disease vector. The vectors usually swallow the pathogen while sucking blood from an infected host. During their later blood meal, the infected insects transmit the pathogen to a new host through bite. Some vectors of different diseases that are significant to public health are mosquitoes, ticks, fleas, flies, and sand flies (7).

The main VBDs in Pakistan are malaria, dengue, chikungunya, leishmaniasis, and West Nile fever.

Table 1. Vector Borne Diseases-their Pathogens and Vectors [12]

Disease	Pathogen	Vector	Transmission
Malaria	*Plasmodium falciparum, vivax, ovale, malariae*	*Anopheles* spp. Mosquitoes	Anthroponotic
Dengue	DEN-1,2,3,4 flaviviruses	*Aedes aegypti*	Anthroponotic
Chikungunya	Chikungunya fever virus, Alphavirus, Togaviridae	*Aedes aegypti* and *Ae. albopictus*	Anthroponotic
Leishmaniasis	Leishmania spp.	*Lutzomyia* & *Phlebotomus* spp. Sandflies	Zoonotic Reservoir: Domestic animals - cow, buffalo, goat, dog
CCHF	Arbo-virus genus Nairovirus (family Bunyaviridae)	*Hyalomma* ticks	Zoonotic

Climate Change and its effects

Evidence of climate change in Pakistan

Pakistan faces a major climate change challenge. The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) for the South Asia region shows that warming is likely to be above the global mean and climate change will impact the glaciers' melting rate and precipitation patterns, particularly affecting the timing and strength of monsoon rainfall. In the last 50 years, the annual mean temperature has increased by roughly 0.5°C and annual precipitation has shown a slight increase in the last 50 years. The annual mean temperature in Pakistan is expected to rise by 3°C to 5°C by the end of this century. Average annual rainfall is not expected to have a significant long-term trend. Under future climate change scenarios, Pakistan is expected to experience increased variability of river flows due to increased variability of precipitation and the melting of glaciers (10).

Effects of temperature on vectors and pathogens

The survival rates of vectors may increase or decrease depending on the species. For many diseases, transmission temperatures lie in the range of 14-18°C at the lower end 35-40°C at the upper end. At higher temperatures (30-32°C) there is a reduction in the extrinsic incubation period (EIP) of the pathogen; adult female mosquitoes digest blood faster and feed more and shorten the development period of the vectors leading to larger production of vector population, thus increasing transmission intensity. Temperatures above 34°C have a negative effect on the survival of vectors and pathogens (13, 14, 15). Moreover, temperature changes also bring changes in the transmission season and geographical distribution of disease vectors and VBDs, for example by rendering previously endemic areas unsuitable and previously non-endemic areas suitable for their existence and reproduction (16).

Effects of precipitation on vectors and pathogens

For vector-borne diseases, higher precipitation has been associated with dengue fever, malaria, scrub typhus, and Japanese encephalitis (17, 18). The survival may increase as increased rain may increase breeding places by increasing water storage and growth environments for vectors and hosts, such as mosquitoes, rodents, mites, and other insects (19, 20, 21). An important study indicated that mosquito density and disease transmission are susceptible to precipitation frequency. Another study showed that precipitation of >350 mm/day can eliminate vectors and is a positive effect (22). There are few direct effects, but humidity affects malarial parasite development (18).

Effects on transmission of VBDs

Dengue, chikungunya, CCHF and leishmaniasis are emerging in countries where they were previously unknown. Human activities in response to climate change strongly influence transmission. Local to international travel, trade, and climatic suitability for the vectors are the main factors responsible for the movement of vector-borne diseases (23, 24, 25). Furthermore, these factors may also introduce new vectors, pathogens, or hosts, causing some diseases to spread in areas where they are currently absent; for example, in Pakistan dengue has been endemic for decades in Karachi, but more recently dengue epidemics have emerged in Punjab in 2011. In 2017, a dengue outbreak occurred in Peshawar, Khyber Pakhtunkhwa. Dengue cases have been recorded from different districts of Sindh, Balochistan, KP, Punjab, and Islamabad. Climate change may affect the survival and reproduction rates of vectors, resulting in changes in the transmission patterns of pathogens and the geographical distribution of diseases.

Malaria

In Pakistan, malaria is a major cause of illness and death. Every year there are one million estimated and 300,000 confirmed reported cases. Pakistan has been grouped with Afghanistan, Somalia, Sudan, and Yemen in terms of the 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 in Pakistan. Transmission of malaria is seasonal. High transmission occurs in districts located in bordering regions with Balochistan, Sindh, the Islamic Republic of Iran, and Afghanistan. Balochistan and Khyber Pakhtunkhwa are the most malaria-endemic provinces. Thatta, Mirpur Khas, Khairpur, and Tharparkar are the major endemic districts of Sindh province. Punjab has been the lowest endemic province with API> 1/1000 (26).

Table 2. Year wise geographical distribution of Malaria cases in Pakistan

Year	Cases Reported	Area	Reference
2004	40697	Badin, Hyderabad, Khairpur, Nawabshah, Nosheroferoz, Mirpur Khas, Mithi, Sanghar, Sukkur, Ghotki, Jacobabad, Shikarpur, Larkana, Dadu, Thatta, Karachi	(27)
2005	27845	Badin, Hyderabad, Khairpur, Nawabshah, Nosheroferoz, Mirpur Khas, Mithi, Sanghar, Sukkur, Ghotki, Jacobabad, Shikarpur, Larkana, Dadu, Thatta, Karachi	(27)
2004-06	652	Barkhan, Balochistan	(28)
2004-06	443	Kohlu, Balochistan	(28)
2009	4695	Punjab	(29)
	32403	Sindh	(29)
	25636	KP	(29)
	22056	FATA	(29)
	45435	Balochistan	(29)
	264	AJK	(29)
2010	29046	Punjab	(29)
	69340	Sindh	(29)
	54278	KP	(29)
	32518	FATA	(29)
	66241	Balochistan	(29)
	316	AJK	(29)
2011	19699	Punjab	(29)
	93306	Sindh	(29)
	75384	KP	(29)
	46149	FATA	(29)
	84579	Balochistan	(29)
	475	AJK	(29)
2012	17522	Punjab	(29)
	114651	Sindh	(29)
	63494	KP	(29)
	30948	FATA	(29)

	63733	Balochistan	(29)
	433	AJK	(29)
2013	9295	Punjab	(29)
	70269	Sindh	(29)
	98137	KP	(29)
	34116	FATA	(29)
	69678	Balochistan	(29)
	260	AJK	(29)
2014	4993	Punjab	(29)
	47640	Sindh	(29)
	118512	KP	(29)
	35978	FATA	(29)
	67836	Balochistan	(29)
	190	AJK	(29)
2015	3230	Punjab	(29)
	44728	Sindh	(29)
	65369	KP	(29)
	40494	FATA	(29)
	48021	Balochistan	(29)
	171	AJK	(29)
2016	2868	Punjab	(29)
	63109	Sindh	(29)
	94100	KP	(29)
	88850	FATA	(29)
	74858	Balochistan	(29)
	239	AJK	(29)
2017	81216	Thattha, Mirpur Khas, Khairpur, Sujawal, Umerkot, Sindh	(30)
	106915	DI Khan, Charsadda, Banu, Tank, KP	(30)
	80924	FATA	(30)
	72867	Jaffarabad, Zhob, Musakhel, Sherani, Balochistan	(30)
2018	112224	KP	(31)
	111920	Sindh	(31)
	60896	Balochistan	(31)
	65853	Tribal Districts	(31)
	658	Punjab	(31)

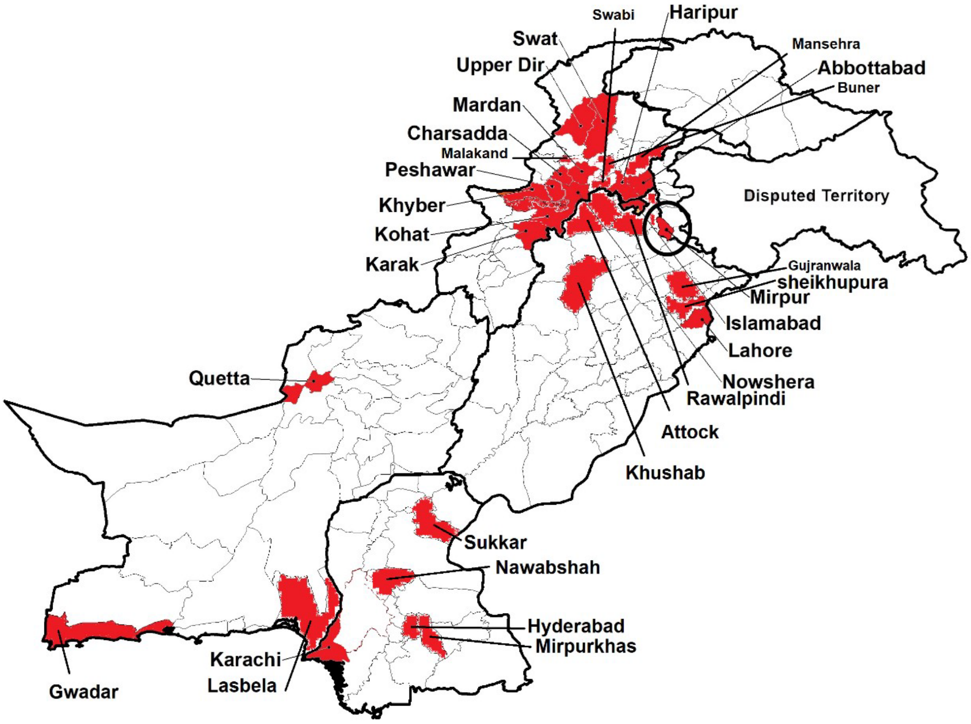
Dengue

Dengue is another mosquito-borne disease, causing mortality and illness in different regions of the world. It is estimated that dengue virus transmission is endemic in about 120 countries and 21,000 deaths are reported every year (32, 33). In Pakistan, dengue is endemic and transmission season has been observed in the post-monsoon period (34). Dengue fever was reported for the first time in 1985 (35). Pakistan experienced the worst dengue outbreaks during 2011, 2017 and 2019 (36, 37). In 2014, a dengue outbreak was reported from the Malakand district, KP [38]. Dengue cases were reported from provinces of Sindh, KP, and Punjab in 2016 (39). The *Aedes* mosquito vector of dengue is highly sensitive to climate conditions and studies suggest that climate change is likely to continue to increase exposure to dengue (16).

Chikungunya

In Pakistan, the chikungunya virus was detected in rodents in 1983 [50]. *Aedes aegypti* and *Aedes albopictus* are the main vectors of chikungunya. In 2011, during a dengue outbreak, a few chikungunya patients were also reported. 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 National Institute of Health (NIH) and Armed Forces Institute of Pathology, Pakistan (51). According to WHO, 1018 suspected cases of chikungunya were registered in 2017 from different districts of Sindh. A total of 157 suspected cases were confirmed for chikungunya infection by the NIH (52). A total 8521 suspected cases of chikungunya were reported from several areas of Pakistan from 2016 to 2018. The most affected provinces were Balochistan and Sindh (53).

Figure 1. Map showing the epidemiology of the Dengue in Pakistan currently and diachronically.



Source: https://wdrfree.com/stock-vector/pakistan-map-with-districts with modification.

Table 3. Year wise geographical distribution of dengue cases in Pakistan

Year	Reported cases	Area	Mortality	Reference
1994	145	Karachi	1	(40)
1995	75	Hub, Baluchistan	57	(41)
2003	1000	Haripur, KP	7	(42)
2004	2500	Khushab, Nowshera	11	(42)
2005	500	Karachi	13	(42)
2006	5400	Karachi, Sukkar, Nawabshah, Rawalpindi, Islamabad	55	(43)
2007	2700	Karachi, Hyderabad, Mirpur Khas, Lahore, Haripur, Rawalpindi, Islamabad	24	(44)
2008	1800	Lahore	30	(44, 45)
2009	570	Lahore	13	(44, 35)
2010	11024	Lahore, Sheikhupura, Gujranwala	40	(46)
2011	20685	Lahore	350	(41)
2012	712	Swat	48	(47)
2013	2180	Swat	72	(47)
2014	2999	Throughout the country	15	(47)
2015	9899	Punjab, Sindh, KP	6	(47)
2017	111979	Peshawar, KP	65	(41, 48)
	142	Abbottabad, KP	4	(48)
	143	Buner, KP	-	(48)
	64	Haripur, KP	-	(48)
	240	Malakand, KP	-	(48)

	72	Mansehra, KP	-	(48)
	369	Mardan, KP	1	(48)
	199	Nowshehra	-	(48)
	133	Swabi, KP	-	(48)
	2884	Sindh	-	(49)
	579	Punjab	-	(49)
	86	Balochistan	-	(49)
	06	AJK	-	(49)
	120	ICT	-	(49)
	406	Tribal districts-KP	-	(49)
2018	332	KP	-	(49)
	175	Tribal districts-KP	-	(49)
	2088	Sindh	-	(49)
	69	Balochistan	-	(49)
	539	Punjab	-	(49)
2019	13,294	Islamabad	22	(37)
	10,119	Punjab	23	(37)
	16,685	Sindh	46	(37)
	7,082	Khyber Pakhtunkhwa	0	(37)
	794	KP Tribal districts	0	(37)
	3,474	Balochistan	3	(37)
	1690	AJK	1	(37)

Table 4. Year wise geographical distribution of Chikungunya cases in Pakistan.

Year	**Reported cases**	**Areas**	**Reference**
2016-18	4714	Karachi	(54)
	2866	Balochistan	(54)
	785	Tharparkar, Sindh	(54)
	136	Khyber Pakhtunkhwa	(54)
	18	Punjab	(54)
	1	Azad Kashmir	(54)
2018	776	Sindh, Punjab, Khyber Pakhtunkhwa, Balochistan	(53)

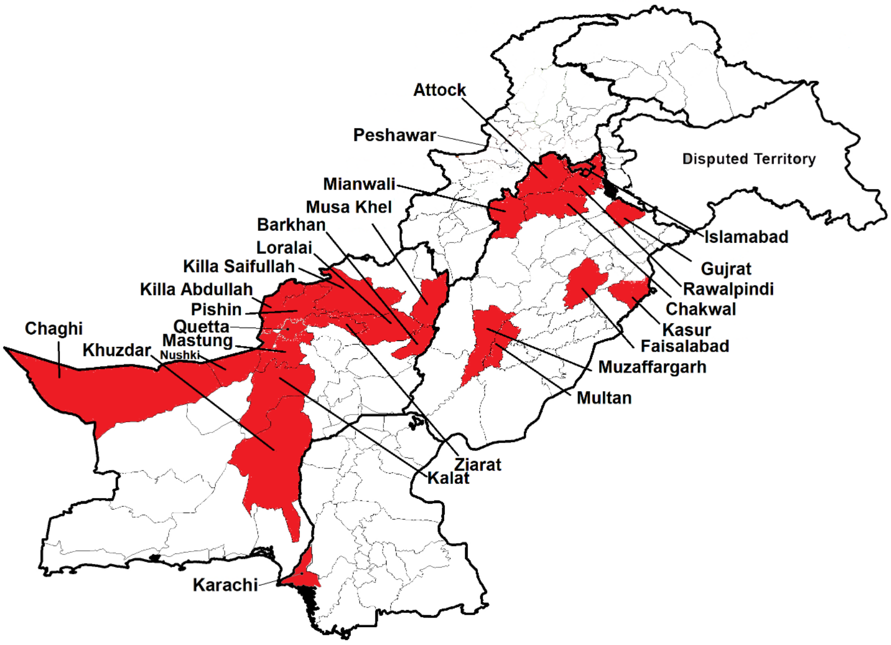
Crimean-Congo haemorrhagic fever

In Pakistan, Crimean-Congo hemorrhagic fever (CCHF) was reported for the first time in 1976 and 14 cases were reported from 1976 to 2010 (55). About sixty-two assumed cases were identified during the year 2012, with forty-one confirmed and eighteen deaths; whereby thirteen deaths were laboratory-identified cases and five deaths were recorded as assumed CCHF. About twenty-three clear-cut cases were reported from Balochistan, seven from Sindh; six from Khyber Pakhtunkhwa and five from the Punjab province of Pakistan (56). In 2017, lab-confirmed CCHF cases were reported from the districts of Attock, Chakwal, Faisalabad, Gujrat, Kasur, Mianwali, Multan, Muzaffarghar, and Rawalpindi of Punjab. In the same year CCHF cases were repo reported from the provinces of Balochistan, Khyber Pakhtunkhwa, Karachi, and ICT (57). During 2018, confirmed CCHF cases reported from throughout the country (53).

Leishmaniasis

In Pakistan, leishmaniasis was first reported in 1960. It is widely spreading all over the country. No definite endemic area has yet been defined (59). However, the disease is reported along the entire western border extending north into North-West Frontier (N.W.F) down to southwest Balochistan and the northern area of Sindh. In Punjab, the epidemics have been reported in Multan, Lahore, and Dera Ghazi Khan (59, 60). The areas of Balochistan that showed the highest incidence of this disease are Gambaz, Maiwand, Kehan, Loherktak, Tali, Tangi, Spin, Dera Bugti, Sibi, Kohlu, Loralai, Fort Sandman, Khuzdar, and Lasbela. In Sindh, the disease had been reported from the Dadu, Larkana, and Jacobabad districts. Cutaneous leishmaniasis also occurred in northern areas (60), including Multan, Quetta, Lasbela, and Lahore. In 1960, Khaplu valley was the hotbed of the disease. In 1974, a new focal point was discovered in the Kharmang valley. In 1975, two cases were seen in the village of Parkuta. In 1979, the whole of Balochistan was surveyed and no cases of visceral leishmaniasis were found. There was a severe outbreak of cutaneous leishmaniasis in Quetta after the earthquake in 1935. Incidents of the disease in Balochistan are extensive. In 1974, the army personnel who were posted there contracted the disease (61). In 1971 another outbreak occurred in non-immune personnel in Uthal area of Lasbela. In Multan there was an epidemic in 1971-72. In Pakistan, the main reservoirs are dogs and rodents for urban and rural areas, respectively. To determine the species of sand fly in Pakistan, an entomological survey was undertaken in Balochistan. Three species were found: *P. sergentii*, *P. Papatasii*, and *P. sergento myasquamipleur*. *P. sergentii* was found to be the important vector in the causation of the disease (62). Two cases of visceral leishmaniasis were reported from Karachi (62, 63). Cutaneous leishmaniasis is common in Pakistan and outbreaks have occurred from 1996 to 2018 in different areas.

Figure 2. Map showing the epidemiology of the CCHF in Pakistan currently and diachronically.

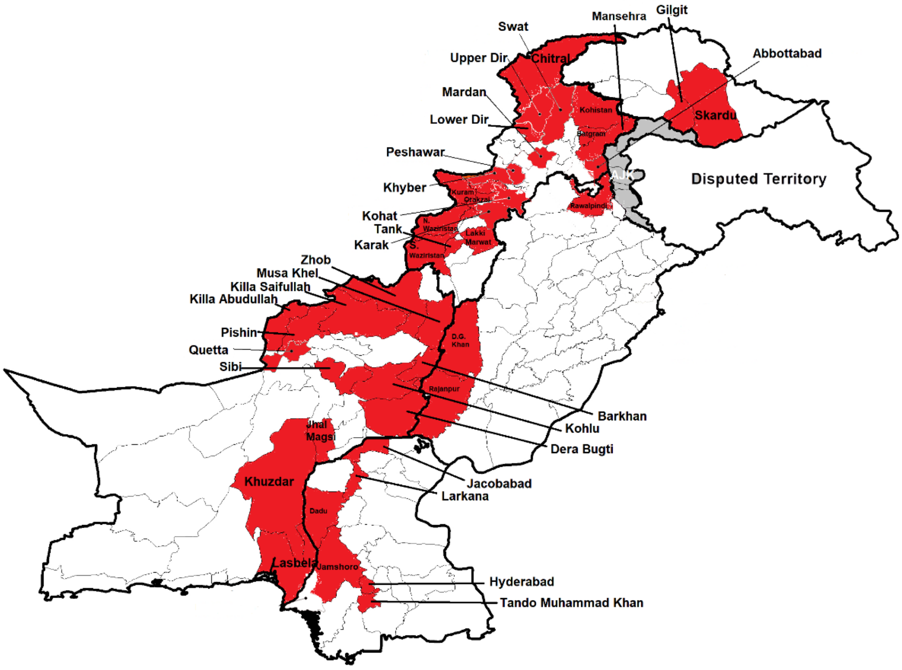


Source: https://wdrfree.com/stock-vector/pakistan-map-with-districts with modification.

Table 5. Year wise geographical distribution of CCHF cases in Pakistan.

Year	Reported cases	Areas	Mortality	Reference
2000-02	191	Balochistan, Khyber Pakhtunkhwa, Punjab, Sindh	59	(58)
2003-06	328	Kalat, Noshki, Balochistan, Khyber Pakhtunkhwa, Punjab, Sindh	42	(58)
2009-10	29	Balochistan, Khyber Pakhtunkhwa, Punjab, Sindh	3	(58)
2011-12	61	Balochistan, Sindh, Khyber Pakhtunkhwa, Punjab	17	(58)
2013-14	134	Quetta, Qillah Abdullah, Zhob Balochistan, Sindh, Khyber Pakhtunkhwa, Punjab	27	(58)
2015-16	131	Qilla Saifullah, Loralai, Chaghi, Balochistan, Sindh, Khyber Pakhtunkhwa, Punjab	44	(58)
2017	23	Pishin, Ziarat, Mastung, Harnai, Musa, Khel, Balochistan	-	(57)
	16	Attock, Chakwal Faisalabad, Gujrat, Kasur, Mianwali, Multan, Muzaffarghar Rawalpindi (Punjab)	-	(57)
	7	Peshawar, Karak (KP)	-	(57)
	4	Karachi, Sindh	-	(57)
	1	Islamabad	-	(57)
2018	63	Throughout the country	11	(53)

Figure 3. Map showing the epidemiology of the cutaneous leishmaniasis in Pakistan currently and diachronically.



Source: https://wdrfree.com/stock-vector/pakistan-map-with-districts with modification.

Table 6: Year wise geographical distribution of cutaneous leishmaniasis in Pakistan

Year	Reported cases	Area	Reference
1996-2001	8007	Bela, Chaman, Dera Bugti, Dulki, Kohlu, Lasbela, Quetta and Sibi	(64)
2002	5,000	Kurram Agency	(65)
2007-08	355	Skardu	(66)
	349	Gilgit	(66)
	370	Chitral	(66)
	387	Dir upper	(66)
	395	Dir lower	(66)
	405	Swat	(66)
	446	Kohistan	(66)
	412	Batgram	(66)
	472	Mansehra	(66)
	484	Abbottabad	(66)
	800	AJK	(66)
	458	Rawalpindi	(66)
	343	D.G. Khan	(66)
	344	Rajanpur	(66)
	325	Jacobabad	(66)
	428	Larkana	(66)
	471	Dadu	(66)
	531	Lasbela	(66)
	485	Khuzdar	(66)
	517	Jhal Maghsi	(66)
	511	Dera Bughti	(66)
	514	Barkhan	(66)

	461	Musa Khel	(66)
	427	Zhob	(66)
	430	Qilla Saifullah	(66)
	415	Qilla Abdullah	(66)
	397	Pashin	(66)
	496	Quetta	(66)
2009	1210	Larkana, Dadu and Jacobabad	(67)
2013-2015	474	North and South Waziristan	(68)
2017	94	Dadu, Hyderabad, Jamshoro, Sindh	(69)
2018	2802	Bajaur	(70)
	5373	Mohamad	(70)
	9378	Khyber	(70)
	225	Kuram	(70)
	163	Orakzai	(70)
	443	North Waziristan	(70)
	354	South Waziristan	(70)
	270	Peshawar	(70)
	28	Lakki	(70)
	20	Kohat	(70)
	4	Tank	(70)

West Nile fever

West Nile (WN) fever is a mosquito-borne disease. The West Nile virus had been isolated from humans and mosquitoes. During 1961-65, 5 strains of West Nile virus were isolated from *culex tritaeniorhynchus* and *culex pseudovishni* collected from Lahore and surrounding areas of Punjab (71, 72). During 1963-1964, two strains of West Nile virus were isolated from *culex pipiens* collected from Rawalpindi (73). In 1965, five human cases of West Nile virus were reported from Lahore and Rawalpindi (72). Sugamata et al. conducted a study in Karachi from 1983 to 1985 and isolated West Nile virus from a human blood sample (74). Another study showed isolated West Nile virus from Pakistani military personnel in 1996 (75). West Nile virus was also isolated from human samples collected from 2015 to 2016 (76). West Nile virus has been found in blood donors from Rawalpindi and Lahore in 2016 and 2017 respectively (76, 77, 78).

Japanese encephalitis

Japanese encephalitis is a mosquito-borne disease. The mosquitoes belonging to the genus *Culex* transmit Japanese encephalitis (79). In Pakistan, JE was confirmed in the early 1980s JE was isolated from a single specimen from Karachi in 1992 (80). No national Japanese encephalitis epidemiology is available due to the lack of a surveillance system.

Discussion

Due to the location and climatic condition Pakistan is a major hotspot of many vector-borne diseases. Malaria, dengue, CCHF and leishmaniasis are endemic and experiencing expansion of VBD's in Pakistan. This literature review shows that malaria is endemic in all provinces except Punjab (31). The first dengue outbreak was recorded in Karachi but after 2000, the dengue outbreaks have been reported from Punjab, KP, Balochistan, ICT and AJK and other districts of Sindh (37,38,39,40,41,42,43,44,47). CCHF is highly endemic in the province Balochistan and cases were reported from Punjab (Attock, Chakwal Faisalabad, Gujrat, Kasur, Mianwali, Multan, Muzaffarghar Rawalpindi, KP (Peshawar, Karak), Sindh (Karachi) and Islamabad (53, 57, 48). Leishmaniasis is highly endemic in Balochistan and KP. Cases of leishmaniasis were also reported from northern region (Gilgit Baltistan and AJK), Sindh and Punjab province (64,65,66,67,68,69,70).

No studies have been done on the effect of climate change on the disease vectors (mosquitoes, ticks and rodents) in Pakistan. However, Dhmial et al (2021) conducted a study in 2020 and found that climate change is affecting the Hindu Kush Himalayan region (Nepal, Bhutan, Pakistan, Myanmar, Afghanistan, India, China and Bangladesh) due to changes in temperature, precipitation patterns and an increase in the frequency and intensity of extreme events. It was also found that the geographic range of VBDs expanded into previously non-endemic areas of mountains in the HKH region.

Maya N. et al (2015) conducted a study on impact of climate change on VBDs and found that the Mediterranean region (Egypt, Spain, Turkey, Italy, Malta and Israel) is vulnerable to climatic changes. As a result, it is expected that VBDs will be influenced by climate change in the Mediterranean region.

Conclusion

Climate change in Pakistan has affected the VBDs in both directions. Dengue, chikungunya, CCHF and leishmaniasis have been on the rise. There is no proper surveillance of vectors and diseases available in Pakistan. Early warning system for preventing outbreaks are needed. No study has been done on the effect of climate change on disease vectors in Pakistan. Long-term observational studies needed to monitor climate-change effects on vector borne diseases in Pakistan. A multidisciplinary effort is needed to handle the situation before the vector borne diseases becomes an epidemic in non endemic areas. More and more awareness should be created for the masses about the human activities that are causing global warming. To conclude, along with integrated vector management (IVM) for prevention and control of vector-borne diseases. It is essential to address issues related to climate change with the utmost priority.

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