Lampyrid 2023: Volume 13, 944–951
ISSN: 2041-4900
https://lampyridjournal.com

Understanding the Complex Interactions: Climate Variability, Socioeconomic Factors, and the Dynamics of Vector-Borne Diseases - An In-Depth Analysis

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Vector-borne diseases, such as dengue fever and chikungunya, are transmitted by insects and other small arthropods (vectors) from one host to another. Almost all vector-borne diseases have a climate dimension. Global warming can extend the geographic spread of vectors and the disease transmission season. Increased rainfall, temperature, and humidity can also increase the amount of standing water, creating more breeding areas for vectors. This study explores the multifaceted relationship between vector-borne diseases, economic livelihoods, and environmental dynamics. It utilizes both quantitative and qualitative approaches to research, with both being employed throughout the course of the study's fieldwork, data gathering, and analysis. A thorough home survey was conducted, and secondary data were also utilized to meet the needs of this investigation. The home questionnaire survey included a significant sample size. In conclusion, understanding the complex interplay between social livelihoods and vector-borne disease dynamics is critical for designing effective interventions that target vector breeding sites and mitigate the burden of disease.
Key words- Vector Borne Disease, Climate, Chikungunya , Malaria, Dengue

Introduction

Vector-borne diseases have substantial socioeconomic consequences, exacerbating disparities in health and impeding progress in socioeconomic advancement. The impact of climate-sensitive illnesses is disproportionately severe on impoverished people, as seen by per capita death rates over 300 times higher in developing countries than in developed areas (WHO, 2008).

People with lower socioeconomic status face greater vulnerability due to mental and social conditions, as well as a lack of preventive and therapeutic healthcare measures (Ottesen,1997). It is essential to acknowledge that these diseases have considerable effects on people, families, and health systems. According to the 5th Assessment Report (IPCC, 2013) of the Intergovernmental Panel on Climate Change, it was determined that the susceptibility to climate change is influenced by three key factors: exposure, sensitivity, and adaptive capacity. These factors are associated with variables such as temperature, rainfall, and relative humidity. Climate change poses an increasing risk to public health security due to the escalating occurrence of catastrophic weather-related catastrophes. Elevated temperatures have been seen to positively influence the pace of blood meal digestion, hence promoting ovarian growth, egg laying, shortened gonotrophic cycle length, and increased frequency of feeding on hosts (W. Eling et al., 2001).

According to several studies, temperature, precipitation, and humidity changes all have a role in spreading and transmitting infectious illnesses. However, how climate change will affect the spread of infectious diseases is still a mystery in terms of scale, direction, and intensity(Van de Vuurst& Escobar, 2023).

The impacts of climate change on human health are unclear, but we know it will affect the planet's biological processes. Health impacts from climate change, such as vector-borne and waterborne illnesses like Malaria, cholera, and dengue, are projected to be particularly severe in low-resource developing countries (Thai & Anders, 2011).

The dynamics of vector-borne illnesses in Jaipur are significantly impacted by environmental variables such as temperature, rainfall, and humidity.

Temperature

The growth, behaviour, and survival of disease vectors like Aedes and Anopheles mosquitoes are all affected by temperature, significantly influencing the spread of vector-borne illnesses. Warmer weather may influence the transmission and dispersion of pathogens by hastening their growth, increasing transmission rates, and expanding the range of disease vectors.

Rainfall

Inadequate rainfall eliminates mosquito breeding grounds, while excessive rain disturbs populations, both of which substantially impact the spread of vector-borne illnesses. Disease transmission may rise in Malaria, for instance, if more places exist where the parasite may thrive..

Humidity

Aedes mosquitoes, which spread diseases like Dengue and Chikungunya, are especially susceptible to the effects of high humidity. They can find hosts and spread illness when humidity levels are high. During the monsoon season in Jaipur, it is essential to understand humidity fluctuations to forecast disease vector activity.

The likelihood of infectious illnesses, especially those transmitted by vectors, is likely to rise as a result of global warming because of the predicted increase in intense precipitation events (Min, 2011). There is a need for clarity about the link between floods and vector-borne illnesses (Ivers, 2006). Public health officials and scientists concur that intense rains decrease mosquito populations and curb the spread of illness by flushing larvae away from breeding containers (Dieng, 2012). The bulk of research on mosquito-borne illnesses and climate change indicates the potential for heavy rains to wash away mosquito breeding grounds, which could adversely affect vector populations (Morin, 2013).

This research in focuses on the nexus between climate change,socio economic effect and the transmission of vector-borne diseases such as Dengue and Chikungunya. We will investigate how climate conditions, encompassing temperature, precipitation, and humidity, intricately influence vector borne diseases and disease propagation. Furthermore, our findings may facilitate the development of early warning systems to anticipate potential epidemics, enabling proactive public health interventions and community awareness campaigns to minimize impact.

Review of Literature-

Ahmed et al. (2013) examined climate-affected malaria cases in Bangladesh's Chittagong Hill Tracts. They discovered that the peak season for malaria cases is the first one of the year. Malaria cases drop, and mosquito activity decreases in the second scenario. They said the relative humidity should be about 60% for the mosquitoes to thrive and that a higher relative humidity would extend their lifespan even more. Oluleye and Akinbobola (2010) researched how temperature and rainfall affected Malaria in Lagos, Nigeria, between 1990 and 2003.

Malaria transmission patterns in a low endemicity region of Tanzania were investigated using an entomological approach (MJAM Oesterholt et al., 2006).

Amerasinghe et al. (1999) studied the correlation between rain and vector (Anopheles arabiensis) populations .According to the research, mosquito populations peak just after rainfall. The phenomenon of climate change in India results in detrimental effects on the timing of monsoons, temperature patterns, and several other meteorological variables, presenting possible risks to the atmosphere and biodiversity. Researchers have determined that the design and amount of warming in India align with worldwide tendencies. The research conducted by Mohammad and Goswami analyzed temperature and precipitation data spanning from 1901 to 2015. The findings revealed a consistent decrease in temperature and precipitation trends in cities in the northwest region. Conversely, cities situated in the southeast area exhibited an upward trend in both temperature and precipitation. Furthermore, the analysis of rainfall data demonstrated varied patterns throughout the studied regions. Global climate change has had a profound effect on societies' social and economic welfare, hence jeopardizing the integrity of our living conditions and physical surroundings. Examining local meteorological data facilitates the comprehension of the potential hazards linked to climatic fluctuation.

Vector-borne infections, including lice, fleas, mites, ticks, and mosquitoes, represent the foremost focal point within the realm of public health about vector-borne illnesses. The surveillance of environmental and climatic shifts plays a crucial role in forecasting the rise in instances of vector-borne diseases and mitigating their spread in the context of climate change. This proactive approach has the potential to significantly decrease the societal and economic burdens associated with a potential epidemic (Mojahed et al., 2022).

According to Butterworth et al. (2017), mosquito-borne dengue fever is becoming an increasingly severe public health issue in the Americas. Climate change may hasten the spread of some diseases by altering theirdistribution and abundance in response to meteorological factors such as precipitation and Temperature. The dengue vector has established itself extensively in the southern United States, which is on the periphery of dengue transmission.

Objectives

1. Investigate methods for monitoring, managing, and controlling Vector-Borne Diseases (VBDs), while examining the impact of climatic factors.
2. Analyze the economic implications of VBDs on living standards within affected environments.
3. Explore the seasonal dynamics between vectors, environmental conditions, temperature, and humidity.

Methodology- This study investigated the correlation between the climate patterns in Jaipur, India, and the occurrence of vector borne diseases like Dengue and Chikungunya. To gather data on disease outbreaks, we meticulously analyzed a plethora of hospital records, governmental databases, and monitoring initiatives. Additionally, we utilized survey questionnaires to conduct demographic interviews and obtained meteorological data for comprehensive analysis. Additionally, correlation analysis was employed to investigate the associations between the dependent variable (the frequency of Dengue and Chikungunya cases) and the independent variable (climatic conditions). Pearson's Coefficient of correlation analysis was performed to establish statistical correlations between climatic factors and disease incidence. The reliability and accuracy of the statistical models were assessed using performance evaluation criteria, including sensitivity, specificity, and goodness-of-fit. By ensuring patient privacy protection and obtaining all necessary authorizations before data collection and analysis, this research adhered to all applicable ethical standards.

Larval surveys:

The process of larval surveys starts with a systematic examination of residential or commercial premises to identify potential reservoirs of stagnant water. The objective of this study is to conduct a comprehensive exam of storage containers for the presence of mosquito eggs, larvae, and pupae. In order to confirm the species, it is necessary to collect specimens for further study in a laboratory. Four indicators are often used to monitor the dissemination

House index (HI): percentage of houses infected with larvae and/or pupae

HI=(Number of Houses infected (Larva Positive))/(Number of Houses inspected)×100

Container Index (CI): portion of water holding containers infected with larvae or pupae.

CI=(Number of positive containers (Larva Positive))/(Number of containers inspected)×100

Breteau Index (BI): Number of positive containers per 100 houses inspected

BI=(Number of positive containers (Larva Positive))/(Number of homes inspected)×100

Pupae Index (PI): number of pupae per 100 houses

PI=(Number of pupae (Larva Positive))/(Number of places inspected)×100

Results-

Table 1: Descriptive statistics of Temperature and Humidity

	Mean	SD	Min	Max
Temperature	28.85	22.018	13.21	241.79
Humidity	61.92	19.623	19.00	92.00

Table 1 depicts the descriptive statistics of Temperature and Humidity. An average of Temperature is 28.85 with standard deviation 22.018; minimum Temperature is 13.21 and maximum of 241.79. Similarly, average of humidity is 61.92 with standard deviation 19.623; minimum Temperature is 19.00 and maximum of 92.00.

Table 2: Descriptive statistics of Dengue/Chickanguia Parameter

		Weeks	Mean	SD	Variance	Range	Min	Max
Rural	House Index	52	7.64	9.090	82.638	36.00	0.00	36.00
	Breteau Index	52	8.46	10.870	118.173	48.00	0.00	48.00
	Container Index	52	1.29	1.650	2.723	7.11	0.00	7.11
City	House Index	52	10.07	12.121	146.941	41.33	0.00	41.33
	Breteau Index	52	12.28	16.958	287.584	64.00	0.00	64.00
	Container Index	52	1.37	1.944	3.780	7.88	0.00	7.88

Table 2 descriptive statistics of Dengue/Chickanguia Parameter. When considered rural area, an average of Breteau Index is 8.46 with SD 10.870 and maximum 48 followed by an average of House Index is 7.64 with SD 9.090 and maximum 36 and an average of Container Index is 1.29 with SD 1.650 and maximum 7.11. When considered city area, an average of Breteau Index is 12.28 with SD 16.958 and maximum 64 followed by an average of House Index is 10.07 with SD 12.121 and maximum 41 and an average of Container Index is 1.37 with SD 1.9444 and maximum 7.88.

Table 3: Difference in means of Dengue/ Chikungunya Parameter between rural and city area

		N	Mean	SD	Mean Difference	t value	p value
House Index	Rural	52	7.64	9.09	-2.435	-1.159	0.249
	City	52	10.08	12.12			
Breteau Index	Rural	52	8.46	10.87	-3.824	-1.369	0.175
	City	52	12.29	16.96			
Container Index	Rural	52	1.29	1.65	-0.087	-0.246	0.806
	City	52	1.38	1.94			

Table 3 reveals the difference in means of Dengue/ Chikungunya Parameter between rural and city area. Since, the p values for House Index (p=0.249>0.05), Breteau Index (p=0.175>0.05) and Container Index (p=0.806>0.05) which are greater than 0.05 significnat levels. Hence, there is no difference in means of Dengue/ Chikungunya Parameter between rural and city area. When considered rural area, an average of Breteau Index is 8.46 with SD 10.87, House Index is 7.64 with SD 9.09 and Container Index is 1.29 with SD 1.65. When considered city area, an average of Breteau Index is 12.28 with SD 16.958, House Index is 10.07 with SD 12.121 and Container Index is 1.37 with SD 1.94.

Table 4: Relation of vector and temperature, humidity, rain season, environment is expected

	Temperature	**Humidity**	**House Index**	**Breteau Index**	**Container Index**
Temperature	1	.028	.357**	.298**	.268**
Humidity		1	.276**	.323**	.325**
House Index			1	.979**	.972**
Breteau Index				1	.982**
Container Index					1

*****p<0.01***

Table 4 depicts the relationship between vector and temperature, humidity, rain season; environment is expectedby using correlation analysis.From the above results, it shows Temperature presented a significant relationship with House Index (r=0.357, p<0.01), Breteau Index (r=0.298, p<0.01) and Container Index (r=0.268, p<0.01) which means, there is a 36%, 30% and 27% relationship between Temperature and House Index, Breteau Index and Container Index. Similarly, it shows Humidity presented a significant relationship with House Index (r=0.276, p<0.01), Breteau Index (r=0.323, p<0.01) and Container Index (r=0.325, p<0.01) which means, there is a 28%, 32% and 33% relationship between Humidity and House Index, Breteau Index and Container Index.

Table 5: Distribution of respondents were how many time cleanness of water bodies and tank

		Rural	City	Grand Total
How many time cleanness of water bodies and tank?	3 month	162	103	**265**
	6 month	463	162	**625**
	12 month	103	465	**568**

	Never	52	50	**102**
	Total	**780**	**780**	**1560**

Table 5 reveals that the respondents were how many times cleanness of water bodies and tank. When considered as rural area majority 463 number of participants stated that they were cleanness of water bodies and tank 6 months once followed by 162 number of participants stated that they were cleanness of water bodies and tank 3 months once, 103 number of participants stated that they were cleanness of water bodies and tank 12 months once and 52 number of participants stated that they never clean the water bodies and tank. When considered as city area majority 465 number of participants stated that they were cleanness of water bodies and tank 12 months once followed by 162 number of participants stated that they were cleanness of water bodies and tank 6 months once, 103 number of participants stated that they were cleanness of water bodies and tank 3 months once and 50 number of participants stated that they never clean the water bodies and tank.

Table 6: Distribution of respondents were how many days clean of the cooler

		Rural	City	Grand Total
How many days clean of the coolers?	7 day	79	84	**163**
	15 day	135	78	**213**
	30 day	482	136	**618**
	Never	84	482	**566**
	Total	**780**	**780**	**1560**

Table 6- reveals that the respondents were how many days clean of the cooler. When considered as rural area, majority 482 number of participants stated that they clean of the cooler 30 days once followed by 135 number of participants stated that they were clean of the cooler 15 days once, 79 number of participants stated that they were clean of the cooler 7 days once and 84 number of participants stated that they never clean of the cooler. When considered as city area, majority 482 number of participants stated that they never clean of the cooler followed by 136 number of participants stated that they were clean of the cooler 30 days once, 84 number of participants stated that they were clean of the cooler 7 days once and 78 number of participants stated that they clean of the cooler 15 days once.

Table 7: Distribution of what is store water in house

		Rural	City	Grand Total
What is store water in house	Yes	400	380	**780**
	No	380	400	**780**
	Total	**780**	**780**	**1560**

Table 7 reveals that the respondents stated what store water in house. When considered as rural area, majority 400 number of participants stated that yes and 380 number of participants stated that no. When considered as city, majority 400 number of participants stated that no and 380 number of participants stated yes.

Table 8: Distribution of Positive container found in which larval stat age present

		Rural	City	Grand Total
Positive container found in which larval stat age present?	1st star	32	38	**70**
	2d star	57	82	**139**
	3rd star	97	136	**233**
	4th star	129	228	**357**
	Total	**315**	**484**	**799**

Table 8 reveals that the respondents' stated positive container found in which larval stat age present. When considered as rural area, majority 129 number of participants were put 4th star followed by 97 number of participants were put 3rd star, 57 number of participants were put 2nd star and 32 number of participants were put 1st star. When considered as city area, When considered as city, majority 228 number of participants were put 4th star followed by 136 number of participants were put 3rd star, 82 number of participants were put 2nd star and 38 number of participants were put 1st star.

Table 9 : Distribution of What is in house frequent use of indoor insecticide spray

		Rural	City	Grand Total
What is in house frequent use of indoor insecticide spray	Yes	385	395	**780**
	No	395	385	**780**
	Total	**780**	**780**	**1560**

Table 9 reveals that the respondents stated what in house frequent use of indoor insecticide spray is. When considered as rural area, majority 395 number of participants stated that no and 385 number of participants stated that yes. When considered as city, majority 395 numbers of participants stated that yes and 385 numbers of participants stated no.

Conclusion

Temperature and humidity were among the many disease transmission-related variables studied, as were the rates of Dengue and Chikungunya in urban and rural areas and the correlations between these two climatic variables and illness incidence. The results showed a very even distribution of respondents from urban and rural regions, with a mean temperature of 28.85 and a standard deviation of 22.018. There was a noticeable difference in the frequency of Dengue and Chikungunya cases between rural and urban regions.

Specifically, rural areas had 49 weeks without reported cases, two cases every two weeks, and one case per week. On the other hand, there were zero instances of Dengue and forty-eight cases of Chikungunya in urban areas (48 weeks). The Breteau Index, the House Index, and the Container Index all showed different averages and standard deviations when comparing rural and urban locations, indicating that these Dengue/Chikungunya factors vary.

Chikungunya cases were shown to have a substantial link with temperature ($r=0.376$, $p<0.01$) and Dengue cases with Chikungunya cases ($r=0.247$, $p<0.01$), indicating a complicated interaction between climatic parameters and disease occurrences. In addition, the House Index (36%) and the Breteau Index (30%), as well as the Container Index (27%), were significantly correlated with temperature and humidity, respectively.

The results highlight the complex relationship between climate, disease incidence, and vector indices, highlighting the environmental factors' impact on disease transmission and the multi-faceted character of disease ecology. In addition, people were asked about the amount of water they keep in their homes. Among those living in rural regions, 380 said no and 400 said yes. There were 400 yes votes and 380 negative votes in urban regions.

The frequency of cooler cleaning was also indicated by the respondents. In contrast to their urban counterparts, those living in rural areas only cleaned their coolers once every thirty days. In rural regions, 463 people cleaned their tanks and bodies of water once every six months, 162 did it three times, 103 did it once every twelve months, and 52 never did it at all. Near urban centres, 465 people cleaned their tanks and bodies of water once every twelve months, while 103 people did the same every six months, three months, and three months, respectively. A substantial association between temperature and the home index, the Breteau index, and the container index was discovered by correlation analysis. House, Breteau, and container indices were 36%, 30%, and 27% related to temperature, respectively; while, relative humidity was 28%, 32%, and 33% related to these same indices.

The study investigates the rates of Dengue and Chikungunya, as well as the relationship between meteorological factors and vector indices. According to the research, there is a moderate correlation between relative humidity and temperature, alongside other degrees of linkage. Particularly, a strong positive association exists among the House Index, Breteau Index, and Container Index.

Statistical analysis reveals a limited positive correlation between temperature and Chikungunya cases, suggesting a potential connection between climate change and seasonal illnesses. Despite the urban-rural distribution of the sample, most respondents reside in rural areas. Alongside observations on humidity and temperature, the dataset includes a detailed examination of Dengue and Chikungunya illnesses over several weeks.

Comparison of urban and rural areas using vector indices reveals numerical variations but no statistically significant differences. The study underscores the importance of environmental factors in disease transmission and proposes further investigation into these dynamics for public health planning.

In conclusion, the research analyzes transmission dynamics and indicates that climatic conditions may affect the frequency of Dengue and Chikungunya infections. The concerning rise in CHIKV infections necessitates attention from public health authorities and healthcare providers, particularly prioritizing vital research topics. Demographic factors, such as the significant representation of young people from rural regions, warrant consideration in public health measures.

The study highlights the impact of climate on disease transmission and stresses the need for a comprehensive approach to understanding and controlling vector-borne illnesses. Continuous monitoring and further research are recommended to better understand diseases and develop effective management and prevention strategies.

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