Journal of Zoonotic Diseases
2022: 6 (1): 25-32
doi: 10.22034/JZD.2022.14408
https://jzd.tabrizu.ac.ir/article_14408.html

Original Article

Environmental risk assessment for Zika, Nipah virus and Scrub typhus disease in a district of north India: First step towards one health

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(Received 4 March 2022, Accepted 13 March 2022)

Summary
Various emerging and remerging zoonotic infectious diseases are seen as a threat to manifest in a pandemic. The current study was planned to assess the environmental vulnerability or preparedness for Scrub typhus and disease due to Nipah and Zika virus infection in the Faridabad district. A Cross-sectional study was conducted in 2021 through 2022 in a rural and an urban area in the Faridabad district of Haryana, India. Houses of the study area were the study unit for internal environment risk assessment. The important landmarks which are frequently visited by the residents of the community were the study unit for external environment assessment. A sample size of 192 was calculated by scientific methods, and systematic random sampling was used. A predesigned checklist for the assessment of risk factors in the environment was used. Data were analyzed using Epi info version 7. Twelve external sites were studied in urban and nine in the rural areas. Stagnant water in external sites as a potential source of breeding for the Zika virus vector (Aedes mosquito) was present in 16.7% of rural and 57.1% of urban areas. Potential dwelling sites for bats (the carriers of Nipah virus) were observed in 66.7% and 42.9% of rural and urban sites, respectively. The garbage dump was observed in the internal environment of 58.8% urban and 15.2% of rural households. Rats (one of the hosts of mites) have been reported in more than 80% of urban and rural households. Low lying shrubs (which carry vector mites of Scrub typhus) were present only in rural areas. No cases of all three diseases has been reported in this district. The study reported that the environment was susceptible to Zika virus and Scrub typhus agents. The behavior of the people was more susceptible to Zika virus disease.
Keywords: Risk preparedness, One health, Zoonotic diseases, Emerging diseases

Introduction

India has witnessed an extensive pandemic of Covid 19 disease countrywide. One health Zoonotic disease prioritisation is required now as other emerging and remerging zoonotic infections are posing a threat of outbreak along with the ongoing pandemic. Of these, Zika virus cases were witnessed for the first time in the country from July 2021 onwards from Kerala, Maharashtra, Kanpur, Uttar Pradesh. (WHO, 2021) Nipah virus outbreak started in 2001 in India in the form of clusters. Kerela witnessed subsequent outbreaks in 2018 at Kozhikode district, and in 2019, at Kochi. Recently in September 2021, another outbreak was confirmed in the Kozhikode district of Kerala. (WHO, 2021) Scrub typhus is a zoonotic bacterial disease transmitted by the mites. Scrub typhus is spread along with the Shivalik ranges from Kashmir to Assam, Eastern and the Western Ghats, and the Vindhyachal and Satpura ranges in the central part of India. Scrub typhus outbreaks have been documented in Himachal Pradesh, Sikkim, and Darjeeling in the period of 2003 to 2007. (Chakraborty and Sharma, 2017) However, no case of Zika and Nipah virus has been reported from Haryana, and recently sporadic cases of scrub typhus have been reported from one or two districts of Haryana.

The model for any infectious disease can be explained by the epidemiological triad, which states an agent (pathogen), a host, and environmental factors interact to bring about a disease. (Snieszko, 1974) Environmental determinants of vulnerability to infectious diseases include physical, social, behavioural, cultural, political, and economic factors. District Faridabad has not reported a single case of the above three diseases to date. However, it is susceptible to the agents owing to its high migrant industrial population. The current study was planned to assess the environmental vulnerability or preparedness for the above three diseases as the district Faridabad authorities have issued advisory to spread awareness regarding prevention of Nipah virus and Scrub typhus. Through this survey, we plan to estimate the internal and external environmental risk of the emergence of these three zoonotic diseases followed by an awareness session at a rural and urban slum of Faridabad, Haryana, India.

Materials and methods

In the present study, a Cross-sectional descriptive design was used to achieve the objectives over three months period (Nov-Jan, 2021-22) at Rural (Village Pali, Faridabad) and urban (Prem Nagar and Patel Nagar, Sector 7, Faridabad) catchment area of the Community Medicine department. Faridabad is one of the very populous districts of south Haryana (North India), situated at the border of the Capital state Delhi. Its elevation is 198 meters above sea level, with a hot semi-arid climate in summer and a humid subtropical climate in winter. (Government of Haryana, 2022) No case of the three zoonotic diseases have yet been notified in the district. Houses of the rural and urban catchment areas of the Community Medicine department were the study unit for internal environment risk assessment. The important landmarks which are frequently visited by the residents of the community were the study unit for external environment assessment.

Multiple factors have been reported from the areas where the outbreaks of the three diseases have already occurred. (Varghese et al., 2016; de Araújo et al., 2018; Montgomery et al., 2008) Among these, the maximum prevalence of environmental risk of 46.7% was taken to calculate the minimum sample size. At 95% confidence interval, 10% absolute precision, and design effect of 2, the minimum sample size of 192 was calculated using Epi info version 7. It was divided between rural and urban area (96 each). There are 800 houses in the selected village and 400 in urban slum areas. Systemic random sampling was utilized for the purpose of selection of study units. The sampling interval for rural was 8; hence every 8^{th} house was selected starting from the center point of the village. The sampling interval for urban slum was 4; hence every 4^{th} house was selected starting from the center point of the slum. A predesigned checklist for environmental assessment based on risk factors for three diseases was used. The factor contributing to the emergence of three diseases in the internal and external environments is the study outcome. For every disease, the presence of internal and external environmental risk factors in more than 50% of the sample is considered as a potential risk for the emergence of any of the diseases. The interns posted at urban and rural health centers were trained for data collection using the checklist. The intern explained the purpose of the study to household members, and after getting informed consent, they observed the internal and external environment for the checklist. Following this, they imparted awareness regarding the mode of transmission and prevention of these three diseases. In case the household denies entry, the intern moved to the next house. In case the house was locked, it was revisited the next day. Even after two visits, if the house was locked, next house was covered. The data collected was entered into the Microsoft Excel spreadsheet and analyzed using

Epi info version 7 (Center for Disease Control, 2021). Data is presented in the form of proportions.

Result

The findings were briefly presented in Table 1, 2, and 3. The external environment was studied for 19 points (12 urban and nine rural). The internal environment was finally assessed for 99 in urban and 101 households in the rural areas. The Potential breeding sites were observed only for Zika virus disease in both urban and rural locations. Stagnant water in external sites was the source of breeding of Zika virus vector in 16.7% of rural and 57.1% of urban areas (Table 1).

Table 1: Zika virus risk assessment

	Rural N (%)	Urban N (%)	Total N (%)
External Environment	**12 (63.2)**	**7 (36.8)**	**19 (100)**
Potential breeding site			
Yes	6 (50)	7 (100)	13 (68.4)
No	6 (50)	-	6 (31.6)
Type of source			
None	6 (50)	1 (14.3)	7 (36.8)
Stagnant water collection on ground	2 (16.7)	4 (57.1)	6 (12.6)
Rain water collection	-	2 (28.6)	2 (10.5)
Bucket	3 (25.0)	-	3 (15.8)
Cesspit	1 (8.3)	-	1 (5.3)
Actual breeding site seen			
Yes (Stagnant water)	-	1 (14.3)	1 (5.3)
No	12 (100)	6 (85.7)	18 (94.7)
Internal Environment	**99 (49.5)**	**101 (50.5)**	**200 (100)**
Bitten by mosquito			
Yes	78 (78.8)	69 (67.6)	147 (73.1)
No	21 (21.2)	33 (32.4)	54 (26.9)
Heard Zika			
Yes	-	11 (10.8)	11(5.5)
No	99 (100)	91 (89.2)	190 (94.5)
Know how Zika spread			
Yes	-	1 (1)	1 (0.5)
No	99 (100)	101 (99)	200 (99.5)
Anyone travelled outside the state			
Yes	-	3 (2.9)	3 (1.5)
No	99 (100)	99 (97.1)	198 (98.5)
Potential mosquito breeding site			
None	29 (29.3)	80 (78.4)	109 (54.2)
Open water collection in artificial containers	70 (70.7)	13 (12.7)	83 (41.3)
Water tank	-	1 (1)	1 (0.5)
Pets' water bowls, plant pots, clogged gutters and flat roofs that may have poor drainage	-	3 (2.9)	3 (1.5)
More than one	-	5 (4.9)	5 (2.5)
Protection from mosquito bite			
None	22 (22.2)	50 (49)	72 (35.8)
Mosquito nets	75 (75.8)	51 (50)	126 (62.7)
Mesh at windows and doors	1 (1)	0	1 (0.5)
Repellants	1 (1)	0	1 (0.5)
All above	0	1 (1)	1 (0.5)

Mosquito bite was common in both urban and rural areas; however none had heard of the Zika virus in the rural areas and only 10% in the urban areas. Seventy percentage (70%) of the rural households had potential mosquito breeding sites (artificial collection of water). Mosquito nets were used by the majority of rural (75.8%) as compared to 50% of urban households (Table 1).

Potential bat dwellings in the external environment were observed in two-third of rural sites and 42.9% of urban sites; however, the actual presence of bats was not seen by the survey team. Urban and rural dwellers both reported the presence of bats in the vicinity; however, it was higher in the urban areas (44.1%) as compared to 23.1% of rural. Garbage dumping was reported and observed at 58.8% of urban and 15.2% of rural households. None of the study population heard about Nipah virus disease (Table 2).

Table 2: Nipah virus risk assessment

	Rural N (%)	**Urban N (%)**	**Total N (%)**
External Environment	**12 (63.2)**	**7 (36.8)**	**19 (100)**
Indication of presence of bats			
No	12 (100)	7 (100)	19 (100)
Any potential bat dwelling breeding place			
Yes	8 (66.7)	3 (42.9)	11 (57.9)
No	4 (33.3)	4 (57.1)	8 (42.1)
Any pigs in vicinity			
No	12 (100)	7 (100)	19 (100)
Internal Environment	**99 (49.5)**	**101 (50.5)**	**200 (100)**
Overcrowding			
Present	13 (13.1)	15 (14.7)	28 (13.9)
Absent	86 (86.9)	87 (85.3)	173 (86.1)
Seen bats			
Yes	23 (23.2)	45 (44.1)	68 (33.8)
No	76 (76.8)	57 (55.9)	133 (66.2)
Indirect evidence of presence of bats: Unused rooms			
Yes	10 (10.1)	-	10 (5)
No	89 (89.9)	102 (100)	191 (95)
Bitten by bat			
Yes	1 (1)	1 (1)	2 (1)
No	98 (99)	101 (99)	199 (99)
Indirect evidence of presence of bats: Garbage dumping inside house			
Yes	15 (15.2)	60 (58.8)	75 (37.3)
No	84 (84.8)	42 (41.2)	126 (62.7)
Heard about Nipah virus			
None	99 (100)	102 (100)	201 (100)

Potential breeding sites for rodents in the external environments like a garbage dump and that of mites, i.e. low-lying shrubs, were majorly observed in rural sites. These denote scrub typhus agent carrier mite's dwelling places. The presence of rats was reported by 96.3% of rural households, and 86.3% of urban. In rural households 6.1% reported being bitten by the rats (Table 3).

Table 3: Scrub typhus risk assessment

	Rural N (%)	**Urban N (%)**	**Total**
External Environment	**12 (63.2)**	**7 (36.8)**	**19 (100)**
Any dead rodents visible			
No	12 (100)	7 (100)	19 (100)
Any garbage dump			
Yes	12 (100)	0	12 (63.2)
No	0	7 (100)	7 (36.8)
Any low-lying shrubs/ bushes			
Yes	12 (100)	2 (28.6)	14 (73.7)
No	0	5 (71.4)	5 (26.3)
Internal environment	**99 (49.5)**	**101 (50.5)**	**200 (100)**
Seen rats			
Yes	95 (96.0)	88 (87.1)	183 (91.5)
No	4 (4.0)	13 (12.9)	17 (8.5)
Signs of presence of rat			
None	96 (96.9)	66 (65.3)	162 (81.0)
Holes in the walls	2 (2.0)	29 (28.7)	31 (15.5)
Rat droppings	1 (1.1)	2 (2.0)	3 (1.5)
Edges of food containers or objects	0	2 (2.0)	2 (1)
More than one	0	2 (2.0)	2 (1)
Anyone bitten by rodent			
Yes	6 (6.1)	1 (1)	7 (3.5)
No	93 (93.9)	100 (99)	193 (96.5)
Open air defecation			
Yes	1 (1.0)	1 (0.9)	2 (1.0)
No	98 (99.0)	100 (99.1)	198 (99.0)

Discussion

The external environment of both rural and urban slum study areas of Haryana was susceptible to the risk of Zika virus infection. Based on the interview of the study population and observations of the internal environment of the households, the susceptibility for Zika virus was high in both rural and urban areas. However urban population reported a higher proportion of using bed nets. The vector of the Zika virus is Aedes aegypti, which is widely prevalent in this part of the country. Aedes has spread to rural areas due to scarcity of water in Haryana, leading to its storage, use of air coolers, vicinity to the urban National capital region leading to increased transport and practice of bottled water in every household-specific to the current rural study areas (Government of India, 2020) The integrated vector management and vector surveillance in the ongoing national vector-borne disease control program is the key to controlling of emergence and spread of Zika virus disease. Although the virus has just entered the country in July 2021, it has yet not spread to many parts. It is the prevention in the form of environmental modification which will prevent its spread.

The external and internal environment survey yielded a lesser risk of Nipah virus infection susceptibility in both urban and rural areas. However, the knowledge among the population is poor about both Zika and Nipah virus infection. The reemergence of arboviral infections in recent years demands awareness regarding the prevention of risk factors predicting the emergence of these diseases. Awareness about the risk factors and the disease among the community is part of prevention. In an awareness survey conducted among students of Andhra Pradesh by Lasya et al. (Lasya et al., 2020), more than half of the study population were aware of both viral diseases. Transmission of the Nipah virus to humans may occur after direct contact with infected bats, pigs, or humans. The current study area has no reported human case of the Nipah virus to date. Hence to study the presence of environmental risk, the presence of bats and pigs were inquired, which were reported in less than half of the sites (Clayton, 2017). Indirect evidence of the presence of pigs and bats were observed in less than half of the households. The outbreaks of the Nipah virus which, occurred in Kerala, investigated and reported the involvement of Fruit Bats in the transmission of the virus. These bats thrive on ripe fruits and palm sap. The current study area in the state of Haryana does not have the same ecology as Kerala in terms of fruit and palm trees. (Montgomery et al., 2008) It is beyond the scope of this paper to investigate the species of bats in this part of the country and their susceptibility to the viruses. However, active surveillance, early detection of disease in community and livestock, raising awareness of transmission, symptoms are the important steps in prevention and control. (Prarthana, 2018)

Scrub typhus is caused by *Orientia tsutsugamushi* and transmitted to humans through an arthropod vector (Trombiculidae). Scrub typhus reemerged in India after the1960s due to control of the vector by the insecticides. (Chakraborty, 2017) The risk of scrub typhus in the current study was indeterminate as there was only the presence of low-lying shrubs in rural areas and rats in both areas in more than half of the population. Behavioural, geographical factors, unplanned urbanization, displacement of the vectors with increased human travel have been shown to play a role in scrub typhus transmission in India. (George et al., 2018; Chakraborty, 2017) This rickettsia infection needs mites for the transmission of bacteria to humans. The larvae of the mite called chigger rest on low-lying scrubs and grass in groups. They sense carbon dioxide generated by approaching warm-blooded animals and drop off leaves onto their host and attach themselves to the hosts' skin. No toilets inside the house or open-air defaecation in the vicinity of shrubs increase the risk of chigger bite in semi-urban areas (George et al., 2018). The low-lying shrubs were present in the urban slums in the current study however were less dense in comparison to rural shrubs. Rodents were present in almost every household. Hence environmental factors are favourable for the mite-carrying bacteria. Every house in the study areas has its own toilet or shared toilets. Most of the population in the current rural area has left farming due to unyielding land and adapted to other means of earning. The urban slum population was mostly occupied in factories in the area. Hence the behaviour of the population is preventing chigger human interaction. Due to the lack of a uniform surveillance system in states of country, the burden of infection and risk data is inaccurate. (Devasagayam et al., 2021) The changing climate, deforestation, industrialisation, increased movement of people and animals to new geographic areas has affected the health of human beings. The one health issue addressed through this survey is about prevention of zoonotic and vector-borne diseases. Communication, coordination, and collaboration with multiple sectors are the key activities under one health approach for fighting the diseases arising out of human-animal and environment interface. (Centres for Disease Control and Prevention)

The current study is limited by a single village or urban area studied in a cross-section of time. The lack of data on species identification for the vectors of the area limits us from commenting about the specific risks of the emergence of infection.

Conclusion

The current study is one of its kind in assessing the environment for its preparedness for three zoonotic infections which have yet not been reported from the area. The environment was found to be susceptible to the vectors of Zika virus and Scrub typhus agents. The behavior of the population residing recorded in the form of the internal environment is more susceptible for mosquito-borne disease, i.e. Zika virus. This study is will help in understanding the role of primordial and primary prevention in the emergence of zoonotic diseases and the use of evidence in preparedness against future epidemics.

Acknowledgement

The authors thank the efforts of the interns posted in the department who carried out the data collection sincerely as a part of academic activity.

Conflict of Interest

None declared

Ethical approval

The head of the household or available member of the house during the survey was explicitly explained about the purpose of the study by the investigator, and informed written consent was obtained prior to inclusion. Ethical clearance was obtained from the Institute Ethics Committee of the institute. (IEC No. 134X/11/13/2021-IEC/55). In the end, the community members were imparted awareness regarding the mode of transmission and prevention of these three diseases by the interviewers.

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