

Coronavirus Pandemic

Changing trends of vector-borne diseases after the COVID-19 pandemic in India

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Abstract

Introduction: Although the unprecedented outbreak of coronavirus disease 2019 (COVID-19) and its deep-rooted consequences are visible in many areas, their impact on vector-borne diseases (VBDs) is only poorly understood. Therefore, the temporal trends of major VBDs such as malaria, dengue, chikungunya, Japanese encephalitis, and kala-azar in India were analyzed before and after the COVID-19 pandemic.

Methodology: Data of annually reported VBD cases, such as malaria, dengue, chikungunya, Japanese encephalitis, and kala-azar, in India from 2014 to 2024 were collected and plotted on a bar graph using Microsoft Excel. Trend lines were drawn separately for all VBDs before and after 2020 and the R² value was calculated. The Pearson correlation coefficient (r value) for each trend was calculated using Microsoft Excel to determine the strength of the trend before and after 2020 for each VBD.

Results: The trend line of each VBD; including malaria, dengue, chikungunya, Japanese encephalitis, and kala-azar; showed a different pattern before and after 2020. The r value of the trend indicated that the COVID-19 pandemic has transformed the declining trend of malaria into a strongly increasing trend. The other trends affected by the pandemic were Japanese encephalitis, dengue, chikungunya, and kala-azar.

Conclusions: This study demonstrates a clear influence of the COVID-19 pandemic over the trend of VBDs ranging from mild changes to a total reversal of the trend.

Key words: COVID-19; pandemic; trend; vector; disease; India.

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Introduction

Vector-borne diseases (VBDs), such as malaria, dengue, chikungunya, and Japanese encephalitis, are major contributors to the national disease burden, affecting millions and causing significant morbidity and mortality in India [1]. While some VBDs are endemic to specific regions, others are emerging or re-emerging across the country [2], often following temporal trends influenced by treatment modalities, vector control practices [3], climatic factors [4–6], herd immunity [7], vaccination strategies [8], urbanization [9], socio-economic status [10] etc, under normal circumstances. The sudden and unprecedented outbreak of the coronavirus disease 2019 (COVID-19) pandemic that quickly killed approximately 15 million people and affected 776 million worldwide between late 2019 and 2021 [11], has had lasting consequences. On 5 May 2023, the World Health Organization (WHO) declared that COVID-19 was no longer a public health emergency of international concern [12], effectively ending the period of heightened global response and providing relief to the overburdened healthcare systems. In addition to the acute morbidity associated with COVID-19, a wide range of secondary health

issues, including persistent long-term complications [11], have emerged [13]. For instance, COVID-19 has been reported to be associated with over 50 different complications [14], including neurological [15], rheumatological [16], and psychological conditions such as anxiety and depression [17]. Although long-lasting health effects from severe COVID-19 are well-documented [18], their impact on susceptibility to and severity of vector-borne diseases remains largely unknown. Analyzing the temporal trends of VBDs during the pre-pandemic years (2014–2019), and the post-pandemic years (2021–2024) can help us to elucidate the pandemic's influence on the occurrence of VBDs. The incidence of VBDs was uniformly lower in 2020 than in the preceding years due to the lockdown measures imposed in 2020, which disrupted vector ecology and reduced human exposure to disease vectors [19]. Therefore, 2020 was excluded from the trend analysis. This study aimed to investigate the impact of the COVID-19 pandemic on the temporal trends of major VBDs, such as malaria, dengue, chikungunya, Japanese encephalitis, and kala-azar in India; before and after the pandemic.

Methodology

Data of annually reported cases of VBDs such as malaria, dengue, chikungunya, Japanese encephalitis, and kala-azar in India from 2014 to 2024 were collected from the National Center for Vector-Borne Diseases Control [20] and the National Health Profile of the Central Bureau of Health Intelligence under the Directorate General of Health Services, Ministry of Family Health and Welfare [21]. The data of the reported cases of each disease were plotted on a bar graph using Microsoft Excel (Figure 1). The cases reported before the COVID-19 pandemic year 2020, that is, from 2014 to 2019, are presented in blue bars; and the cases reported after 2020, that is, from 2021 to 2024, are indicated by red bars. The cases for 2020 are indicated by yellow bars. As the confirmed case data for dengue and chikungunya were available only up to October 2024, a monthly average was calculated, and the same was used to calculate the expected cases for the balance months, which was used to calculate the annual case averages for 2024. Separate trendlines were drawn for each VBD before and after 2020.

In general, 3 possible trendline slopes can be obtained: positive slope (the variables have a positive relationship, and they increase or decrease together), negative slope (the variables have a negative relationship, and when one variable increases, the other decreases), neutral/0'slope (the variables have a constant relationship, and one variable stays the same regardless of the direction of the other) [22]. The linear regression was performed to compare the trend of the VBDs before and after the COVID-19 pandemic year

2020, and Pearson correlation coefficient (r value) for each trend was calculated using Microsoft Excel for each VBDs trend. The relative changes in the r value were also calculated and tabulated along with the r^2 value. In addition to linear regression, the unequal t-test was also performed.

Results

The trendline of each VBD; such as malaria, dengue, chikungunya, Japanese encephalitis, and kala-azar; showed a different pattern before and after the COVID-19 pandemic (Figure 1). Their regression values and their relative change after 2020 are summarized in Table 1. Malaria had r value difference of 1.9069 and showed a strong increasing trend after 2020, compared with a strong declining trend before 2020. Next to malaria, Japanese encephalitis, and chikungunya showed an increasing trend with r value change of 0.248 and 0.1 respectively. Surprisingly, with r value change of - 0.1957, the increasing trend of dengue seemed to be toned down after the pandemic. Similarly, with a relative change of 0.0319 in the r value for kala-azar, the disease had a declining trend and the disease was slowed down after the pandemic, which indicates the increasing kala-azar cases after the pandemic. The *p* value for the trend of all the VBDs was *p* > 0.05. However, the unequal t-test shows that trend before and after COVID-19 pandemic was significantly different (malaria t 3.351, df 8, *p* < 0.05; Japanese encephalitis t 3.991, df 8, *p* < 0.05; dengue t 3.769, df 8, *p* < 0.05; chikungunya t 5.153, df- , *p* < 0.05; kala-azar t 4.530, df 8, *p* < 0.05). Figure 2 shows the trend change in the

Figure 1. Temporal trend of cases of vector-borne diseases, malaria, dengue, chikungunya, Japanese encephalitis, and kala-azar before 2020 (2014–2019) and after the 2020 (2021–2024) coronavirus disease 2019 COVID-19 pandemic, marked with blue and red bars respectively. The vector-borne diseases (VBDs) during the 2020 COVID-19 lockdown are shown with yellow bars. The trendline with R^2 value is shown in blue for cases before 2020 and red for those after 2020.

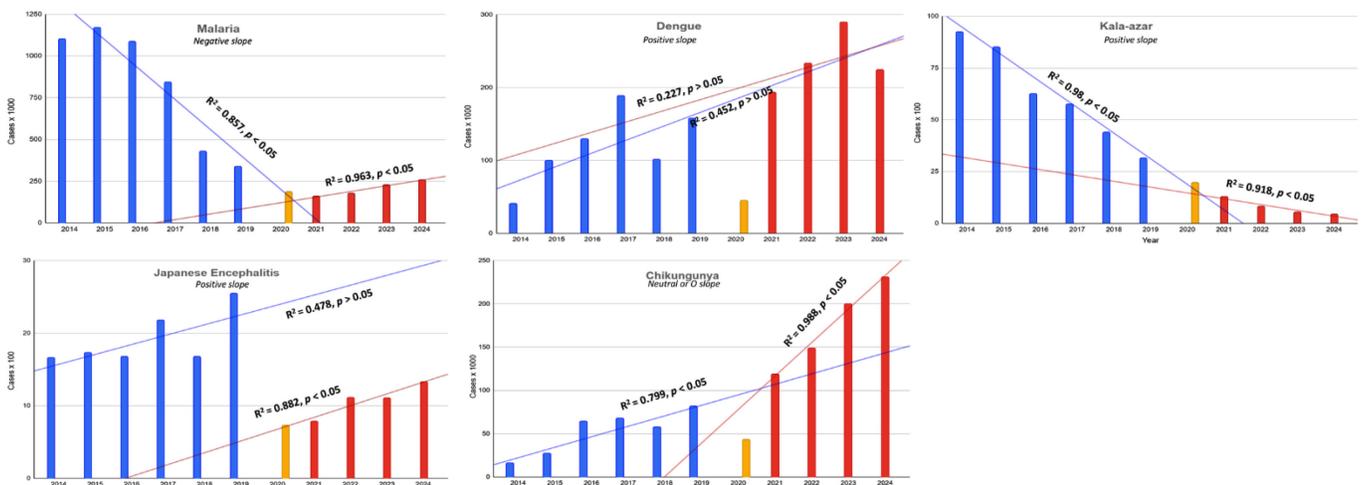


Table 1. The r values, r² values, and p values for the trend of vector-borne diseases (VBDs), such as malaria, Japanese encephalitis, dengue, chikungunya, and kala-azar, before and after the coronavirus disease 2019 (COVID-19) lockdown in 2020, with relative differences. The red color intensity in the cells of the last column shows the degree of changes in the trend of VBDs.

VBDs	Before COVID-19 lockdown (before 2020)					After COVID-19 lockdown (after 2020)					Relative change in r value after 2020
	r value	r ² value	p value	df	Trend	r value	r ² value	p value	df	Trend	
Malaria	-0.9258	0.8571	p < 0.05	5	Declining	0.9811	0.9626	p < 0.05	3	Increasing	1.9069
Japanese encephalitis	0.6914	0.4781	p > 0.05	5	Increasing	0.9394	0.8824	p < 0.05	3	Increasing	0.248
Dengue	0.6724	0.4521	p > 0.05	5	Increasing	0.4767	0.2273	p > 0.05	3	Increasing	-0.1957
Chikungunya	0.8939	0.7991	p < 0.05	5	Increasing	0.9939	0.9879	p < 0.05	3	Increasing	0.1
Kala-azar	-0.9898	0.9796	p < 0.05	5	Declining	-0.958	0.9176	p < 0.05	3	Declining	0.0319

VBDs after the COVID-19 pandemic. The differences in r values for each VBD before and after the COVID-19 pandemic in 2020 shows that there was a tremendous change in the trend of malaria, from a strong declining pattern to a strong increasing trend and an increasing trend of Japanese encephalitis and chikungunya. While, the degree of decline was reduced for kala-azar, the dengue cases declined considerably after the pandemic.

Discussion

This study clearly demonstrates the significant influence of the COVID-19 pandemic on trends of VBDs in India.

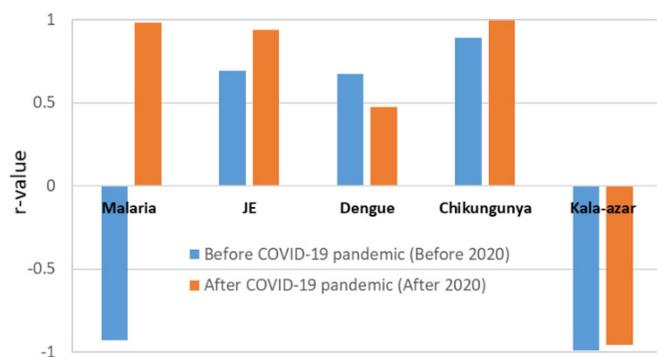
For instance, malaria had been targeted for elimination in India by 2030 [23], and had been showing a consistent decline until the COVID-19 outbreak in 2020. However, this trend reversed post-lockdown, with cases steadily rising over the past four years. This resurgence may be due to several pandemic-related disruptions, including strain on healthcare systems and interruptions in malaria control programs [24]. Our findings align with the report by Moin-Vaziri and Badakhshan, which indicated that the pandemic significantly weakened malaria control efforts, potentially setting back progress to levels seen as early as 2000 [25]. Moreover, changes in susceptibility to malaria among COVID-19-recovered and

asymptomatic individuals warrant further investigation to uncover the underlying mechanisms. If this rising trend continues, India’s malaria elimination timeline may need to be revised, and the overall strategy reconsidered in light of the pandemic’s impact. Interestingly, malaria-infected individuals have been shown to produce anti-GPI antibodies that recognize SARS-CoV-2 glycoproteins, potentially offering protection against severe COVID-19 or resulting in a milder disease course [26].

Diseases transmitted by *Aedes* mosquitoes—dengue and chikungunya—showed different post-2020 trends. Among the five VBDs examined, only dengue showed a continued decline after the pandemic. This decline might be partially explained by antigenic cross-reactivity between the dengue virus and SARS-CoV-2, potentially conferring some level of protective immunity in COVID-19-recovered individuals [27]. Chikungunya, on the other hand, showed a slightly increasing pattern. While there are documented similarities in long-term symptoms between COVID-19 and chikungunya—such as general malaise, mental health issues, impaired quality of life, and social consequences [28]—there is currently no direct evidence linking the two infections or suggesting mutual influence.

In contrast, kala-azar (visceral leishmaniasis) continued its declining trend post-2020, although at a slower pace than before the pandemic. Notably, SARS-CoV-2 infection has been reported to reactivate previously asymptomatic leishmaniasis cases [29], which could explain a potential uptick in the incidence and may delay India’s elimination goal for kala-azar [30]. No direct correlation with COVID-19 has been established for Japanese encephalitis. Some studies suggest a reduced incidence of COVID-19 in Japanese encephalitis-vaccinated regions [31,32], while others report a higher COVID-19 incidence in the same areas [33], presenting conflicting evidence. Overall, while the impact of the COVID-19 pandemic on VBDs has varied by disease, the concurrent occurrence of COVID-19 and VBD outbreaks poses potentially severe public

Figure 2. The change in r values for malaria, dengue, chikungunya, Japanese encephalitis (JE), and kala-azar before and after the 2020 coronavirus disease 2019 (COVID-19) lockdown shows the changing trend of vector-borne diseases (VBDs) after the COVID-19 pandemic.



health challenges [34]. The tendency of diverting away from the field of VBDs has increased after the COVID-19 pandemic, which created a vacuum in the vector control workforce, diversion of research, and fund allocations to other areas; all this may have played a role in the VBDs trend change after the pandemic [35]. In general, the trend shifts in the VBDs after the pandemic can be attributed to the public health measures implemented to control the spread of COVID-19, which inadvertently disrupted routine vector surveillance and control programs, including regular household surveys. SARS-CoV-2 infection had been shown to cause long-term modifications in both humoral and cell-mediated immunity [13] which might have potentially increased either susceptibility or resistance to VBDs in recovered individuals. Therefore, changes in population-level susceptibility to VBDs following the pandemic might also have contributed to these alterations in the trend. As the significance limit for $df = 5$ is $r = 0.754492$, and for $df = 3$ is $r = 0.878339$ [36], the trend of Japanese encephalitis before the COVID-19 pandemic, and the trend of dengue before and after the COVID-19 pandemic may not be statistically significant.

There are some possible limitations in this study. This study is based on data from passive surveillance systems in government hospitals and health facilities, where the cases reported would be several times less than the actual number of cases. Underreporting is a major issue in India, and the true burden of disease may be several times higher than the reported figures. However, the number of cases reported each year during the study period was assumed to be fairly a stable proportion of the actual number of cases. Furthermore, although attempt was made to correlate VBD trends with the COVID-19 pandemic, it is important to recognize that other contributing factors may also be influencing these trends.

Conclusions

The COVID-19 pandemic, which spanned two years, had a clear impact on the trends of vector-borne diseases (VBDs), particularly on malaria, followed by Japanese encephalitis, dengue, chikungunya, and kala-azar. Although the peak of the pandemic lasted for a relatively short period, its lasting consequences have irreversibly altered the trends of these diseases. As malaria and kala-azar are slated for elimination from India, the trend change should not derail the progress. The lacunae in the control program of these diseases after the COVID-19 pandemic needs to be addressed. Vaccination for Japanese encephalitis needs to be

extended to risky areas, and routine surveillance and control activities need to be strengthened for dengue and chikungunya.

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Ethics approval and consent to participate

The present study has been waived from ethical approval by the Institutional Human Ethics Committee (IHEC) with registration No. ECR 681/Inst/Py/2014/RR-21 as per the ICMR National Ethics Guidelines as “anonymized, de-identified, publicly available aggregate data”.

Data availability

The data that was generated and analyzed in this study is available upon reasonable request. For data requests, please contact correspondent.

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Conflict of interest

No conflict of interest is declared.

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