INDIAN ASSOCIATION OF EPIDEMIOLOGISTS

Epidemiology International
Volume 8, Issue 3 - 2023, Pg. No. 9-20
Peer Reviewed & Open Access Journal

Research Article

# COVID-19 Epidemiological Trends and Impact Assessment in India's Northeastern States: The First Wave Analysis

Anjali Chauhan[1], Madhuri Devaraju[2], Priscilla C Ngaihte[3], Pritinanda Jethi[4], Sakshi Gaur[5], Surabhi Pandey[6]

[1,2,4,5]Indian Institute of Public Health, New Delhi, India.
[3,6]Public Health Foundation of India, New Delhi, India.
**DOI:** https://doi.org/10.24321/2455.7048.202314

## INFO

**Corresponding Author:**
Anjali Chauhan, Indian Institute of Public Health, New Delhi, India
**E-mail Id:**
anjalichauhan919@gmail.com
**Orcid Id:**
https://orcid.org/0009-0006-0539-0433
**How to cite this article:**
Chauhan A, Devaraju M, Ngaihte P C, Jethi P, Gaur S, Pandey S. COVID-19 Epidemiological Trends and Impact Assessment in India's Northeastern States: The First Wave Analysis. Epidem Int. 2023;8(3):9-20.

Date of Submission: 2023-07-14
Date of Acceptance: 2023-09-11

## ABSTRACT

*Introduction:* The COVID-19 pandemic in India has seen a significant increase in cases since the first reported case in January 2020. The northeastern states have performed relatively well in combating the infection and have remained in the bottom half of the national COVID-19 tally until January 2021.

*Methods:* The data was extracted from an open-source portal since the first reported case of COVID-19 in the northeastern states of India almost a year ago and was analysed using epidemiological indicators to assess the inter-state variability in the spread, factors affecting it, and mitigation strategies adopted by them.

*Results:* Our analysis shows the highest test positivity rate in Nagaland (9.8%) and the lowest in Meghalaya (0.24%). Cases per million (CPM) were highest in Arunachal Pradesh (9642) and deaths per million (DPM) were highest in Sikkim (190). These values were lowest in Mizoram (CPM: 3261, DPM: 6.9), respectively. Such disproportions are seen at both inter- and intra-state levels. For these states, the biweekly rate of rise in cases increased to its peak in July 2020 and then slowly declined from August, approaching zero until January 2021.

*Conclusions:* The overall situation in the northeastern states was better than in the other states of India; however, there was wide inter and intra-state variation, which calls for appropriate measures to tackle future outbreaks. The study highlights the need for robust public health infrastructure and proactive measures to prevent and manage outbreaks effectively.

**Keywords:** COVID-19, SARS-CoV-2, Data Analysis, Cases per Million, Deaths per Million, Test Positivity Rate

## Introduction

A novel coronavirus (SARS-CoV-2) that originated in Wuhan, China, has been linked to the outbreak of severe respiratory infections in humans first reported on December 31, 2019. According to a WHO Situation Report 10, India witnessed its first SARS-CoV-2 case on January 30, 2020 when a Kerala student returned from Wuhan City.[1] The population-based seroepidemiological studies might indicate the extent of SARS-CoV-2 infection in the country and the effect of ongoing public health responses to control the pandemic. The findings of the first round of a national serosurvey conducted during May–June 2020, among the adult population of India (aged above 10 years) indicated that 0.73% (95% CI, 0.35–1.13) of adults in India were exposed to SARS-CoV-2 infection. Notably, this serosurvey found a high infection-to-case ratio (81.6–130.1 infection per reported COVID-19 case), suggesting the need for a further expansion of testing, and a low infection-fatality ratio (0.27–15.04 deaths per 10,000 infections).[2] Seroprevalence among adults increased by about ten times, from 0.7% in May 2020 to 7.1% in August 2020 says the findings of the second round of national serosurvey.[3]

The northeastern (NE) region of India comprising eight states, namely Assam, Manipur, Mizoram, Nagaland, Sikkim, Arunachal Pradesh, Meghalaya, and Tripura represents both geographic and political-administrative divisions of the country. All NE states except Assam have 100% land under hilly terrain and more than 70% of forest cover in the total geographic area except Assam and Sikkim.[4] The first COVID-19 case in Northeast India was detected on March 24, 2020 in Manipur in a 23-year-old student returning from the UK.[5] In Assam, the first case was confirmed on March 31, 2020.[6] Tripura had its first case confirmed on April 5, 2020. The case was a 45-year-old woman who returned from Guwahati.[7] In Meghalaya, the first case was confirmed on April 13, 2020 in a 69-year-old doctor who died later.[8] As of January 20, 2021, India reported 10,611,728 laboratory-confirmed cases and 152,906 deaths, whereas, combined figures from the NE states reported 332,161 laboratory-confirmed cases and 2260 deaths contributing to 3.1% and 1.5% of the country's burden respectively.[9] A study conducted by an Assam-based NGO showed a 23.7% seroprevalence in the state before mid-August 2020.[10] In an independent study, Tripura reported a seroprevalence of 33.98%, placing the state in a comparatively safer position.[11] The Governments of Arunachal Pradesh and Manipur, on the other hand, began the seroprevalence study in July 2020 and December 2020 respectively. Unfortunately, seroprevalence figures from states like Sikkim, Mizoram, Nagaland, and Meghalaya were not visible in the picture. The third round of nationwide serosurvey estimated that a huge proportion (79.5%) of the Indian population remains vulnerable to the infection with only 21.5% seroprevalence found till the first week of January 2021.[12]

Studies and clinical reality show that patients with certain comorbidities (most specifically - diabetes, CVDs, respiratory disorders, hypertension) are more vulnerable to COVID-19 infection consequently leading to poor prognosis.[13] The projected population of 45 years (and above) and 60 years (and above) for India is 25.3% and 10.1% respectively; 23.1% and 8.2% for Assam, 23.7%, and 8.8% for NE states other than Assam respectively (Population projection report for India and States 2011–2036, Census of India, 2011). The prevalence of comorbidities such as type 2 diabetes, and hypertension has been increasing over the years in the NE population.[14] Table 1 reflects the mean of comorbidities prevalence (60 years and above) in Northeast India (except Sikkim) and in India as a whole.[15] It is also evident from Figure 1 that the prevalence of hypertension, CVDs, and obesity for some NE states, especially Sikkim, is increasing at an alarming rate than the prevalence of diabetes.[16]

**Table 1.Mean of Comorbidities Prevalence (60 Years and Above) in Northeast India (except Sikkim) & India[15]**

| Comorbidity | Mean (SD) of Prevalence (%) in Northeastern States (except Sikkim) | All India Prevalence (%) |
|---|---|---|
| Diabetes mellitus | 9.2 (2.2) | 14.2 |
| Hypertension | 24 (5.0) | 25.8 |
| CVDs | 32.4 (8.8) | 34.6 |
| Asthma | 2.8 (1.7) | 5.9 |

CVDs: Cardiovascular Diseases

**ISSN: 2455-7048**
**DOI: https://doi.org/10.24321/2455.7048.202314**

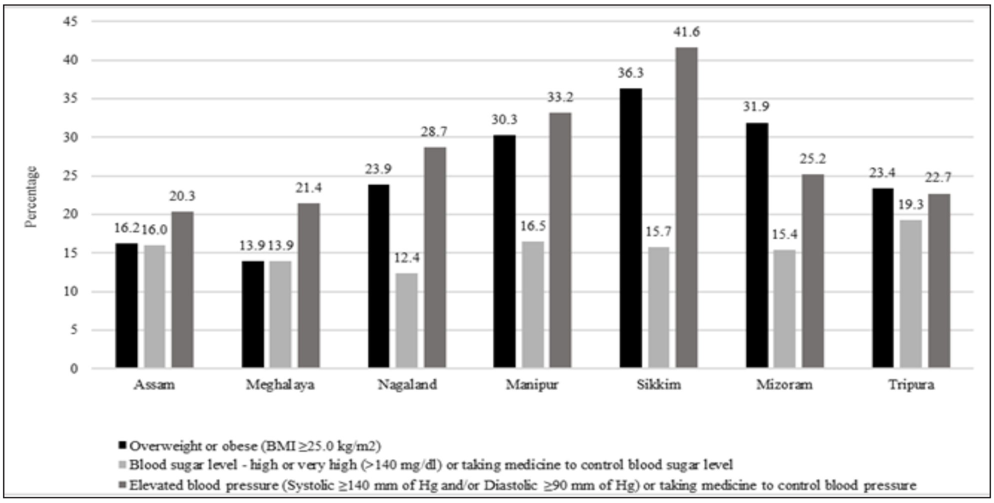



**Figure 1.Prevalence of Comorbidities across Different States in Northeast India[16]**

The community practices in NE states incorporated a combination of traditional as well as newly adopted practices required to deal with the pandemic.[17] Tripura as a state with comparatively better outcomes had strictly obeyed the lockdown rules along with setting up committees to review the state's preparedness from time to time.[17] States such as Manipur and Mizoram followed their traditional method based on trust followed in shops.[17] They ensured social distancing by picking and putting the money into a cash jar for desired items when the shop was unmanned. Most villages of Mizoram built gates to regulate the flow of people and fined local people without masks. In Meghalaya, COVID committees, headed by village headmen and women were framed to generate awareness, distribute self-help journals, and keep an eye on the health of senior citizens in the area, ultimately focusing on behaviour change management. In Assam, a community surveillance program was implemented across all revenue villages and urban wards. Community surveillance programs in Nagaland were headed by village elders where churches were converted into quarantine centres with a provision of a prayer helpline for those feeling anxious, worried, or lonely. A few quarantine centres of Nagaland were named 'COVID-19 Creativity Hub Recreation Centres' as people were offered craft material and stationery for writing and creative work. Village headmen and churches helped to enforce preventive rules in Arunachal Pradesh, as well. However, the knowledge and awareness about sanitation and hygiene are comparatively low in these states.[18]

This study primarily aims to explore the COVID-19 dynamics using certain epidemiological indicators across all NE states of India. We estimated and analysed the inter- and intra-state spread of COVID-19 factors affecting it, and mitigation strategies adopted, state-wise.

## Methodology

The primary objective of this study is to explore the COVID-19 data from the first wave across all eight NE states of India using epidemiological indicators, i.e. Cases per million (CPM), Deaths per million (DPM) and interventional indicators, i.e. test positivity rate (TPR) and biweekly growth rate of cases and deaths. The data was taken from the volunteer-driven Application Programming Interface (API) for COVID-19 statistics and patient tracing in India.[9] It is one of the most detailed, up-to-date, and authentic databases, sourcing data from the Ministry of Health and Family Welfare (MoHFW), State Ministries, and the ICMR daily bulletin. The data was compiled from the first case reported (for every state) until January 20, 2021 using convenience sampling. The population of each state and its districts was extrapolated from the 2011 census.

CPM and DPM are important indicators as the numerator and denominator are relatively less prone to measurement errors.[19] Indicators such as case fatality and doubling time guide us to understand the spread of the COVID-19 pandemic whereas the number of deaths per million people indicates the containment of contagion and case management.[20] Case Fatality Rate indirectly depends on the testing which keeps on changing with time. This variation manipulates the findings accordingly, often giving illusive results. Since the ultimate goal is to contain the spread and not only to salvage the cases who have been diagnosed and admitted to the hospital or being isolated at home, DPM provides us with a combined and beneficial measure of both the containment success as well as the case management success.[20] Test Positivity Rate (TPR) indicates how widespread infection is in the area where the testing is occurring and more importantly whether levels of testing are keeping up with levels of disease transmission. However, a low-test positivity rate (TPR) doesn't suggest a low level of transmission.[21] The biweekly growth rate on any given date measures the percentage change in the number of new confirmed cases over the last 14 days relative to the number in the previous 14 days; depicting a better picture of the disease trend.[22] To estimate the aforesaid epidemiological indicators, we used the below-mentioned formulas:

**Deaths per million (DPM) =** $\frac{Cumulative\ number\ of\ COVID19\ deaths}{Population\ of\ the\ Study\ Area} * 1000000,$

**Cases per million (CPM) =** $\frac{Cumulative\ number\ of\ COVID19\ cases}{Population\ of\ the\ Study\ Area} * 1000$

**Test positivity rate (TPR) =** $\frac{Confirmed\ number\ of\ COVID19\ cases}{Total\ number\ of\ samples\ tested} * 100,$

**Rate of rise in scaled deaths =** $ln\frac{DPM_n}{DPM_{n-1}}$,where is DPM on a cumulative particular day and $DPM_{n-1}$ is DPM on the previous day,

**Rate of rise in cases =** $ln\frac{CPM_n}{CPM_{n-1}}$, where $CPM_n$ is CPM on a particular day and $CPM_{n-1}$ is CPM on the previous day.

## Results

Case counts have the advantage of being the earliest figures of an epidemic. Cases per Million (CPM) enables us to compare case counts of different regions.[20] CPM is limited by breadth, accuracy, reporting, and speed of testing as case counts depend on these factors which vary widely across regions.[22] Figure 2 reflects that Arunachal Pradesh has the highest number of cases per million followed by Sikkim. Figure 3 shows that Nagaland has the highest test positivity rate (TPR) of 9.8% followed by Sikkim (8.3%) Manipur (5.77%) and Tripura (5.5%). Four NE states i.e. Arunachal Pradesh, Assam, Mizoram, and Meghalaya reported TPR below the WHO's threshold of 5%,[21] while the average TPR for India was approximately 5.6%. This indicator reflects the secondary prevention efforts by the local administration. While the mortality rate is the best available measure for comparing COVID-19 epidemics, it may not be perfect—some regions may have unreported deaths.[22] Sikkim has the highest number of deaths per million (DPM) followed by Manipur, as is evident in Figure 4. By comparing CPM and TPRs, we can say that the possible reason behind the high CPM in Arunachal Pradesh is more testing while in the case of Sikkim CPM could have been even higher had testing been at par. This image of under-detection is also mirrored by the highest DPM in Sikkim. Similarly, Manipur also shows a similar picture in comparison to the three indicators. In the case of Nagaland, this comparison reveals an even greater tendency of underreporting and inadequate testing. Overall cases per million, deaths per million, and test positivity rates across the eight NE states until January 20, 2021 are shown in Table 2.[9]

Figure 5 shows the biweekly trend in the rate of rise in cases across the eight states. It was observed that Arunachal Pradesh and Meghalaya saw a higher rise in cases in mid-July 2020 compared to the other states. All the other states witnessed an increase in the biweekly rate of rise from mid-July to mid-August of 2020, after which the rate of rise in cases declined gradually. The biweekly rate of rise in deaths is shown in Figure 6. From the graph, we can see a sudden and the highest rise in death rates in Tripura and Manipur in the last week of July and the second week of August, respectively, which then declined significantly. Assam and Meghalaya saw an early rise in deaths in mid-July, while for Arunachal Pradesh and Sikkim, it was highest in September. Mizoram and Nagaland witnessed the rise in a later phase, in the first half of November.

The state of Mizoram seems to have performed well relatively, with the lowest deaths per million, cases per million, and second-lowest test positivity rate among NE states while Sikkim seems to be on the other end with the highest deaths per million and second-highest cases per million and test positivity rate, and was closely followed by Manipur during COVID-19 first wave. Figures 7–13 illustrate the intra-state/ district-wise variation in CPM and DPM of all the NE states (except Sikkim).

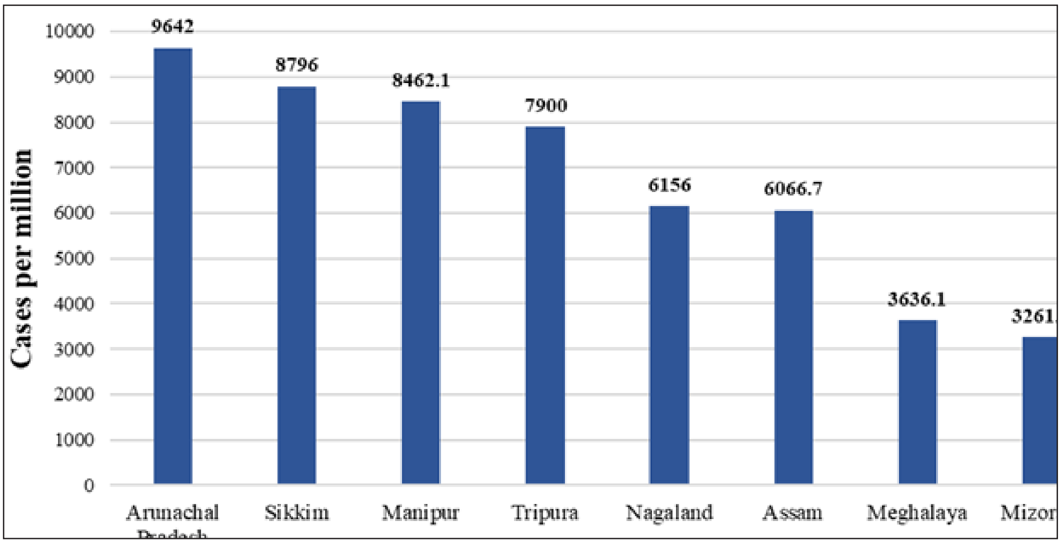



**Figure 2.Cases per Million Population (CPM) in the Northeastern States of India (as of January 20, 2021)**

**ISSN: 2455-7048**
**DOI: https://doi.org/10.24321/2455.7048.202314**

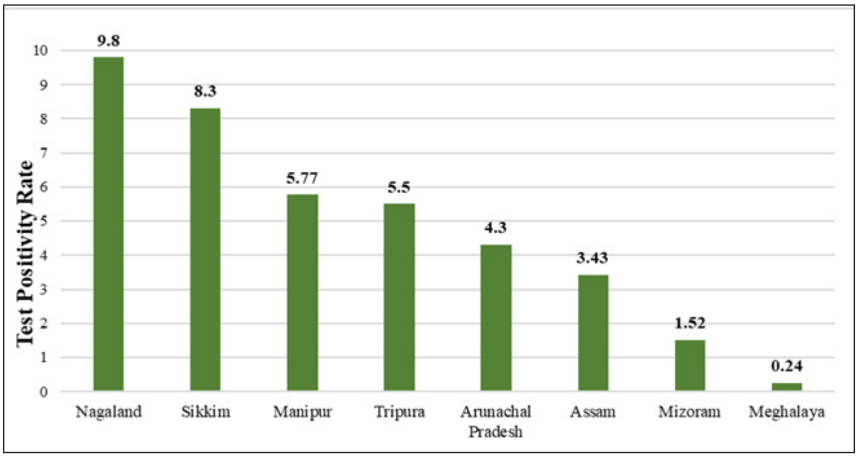



**Figure 3.Test Positivity Rate in the Northeastern States of India (as of January 20, 2021)**

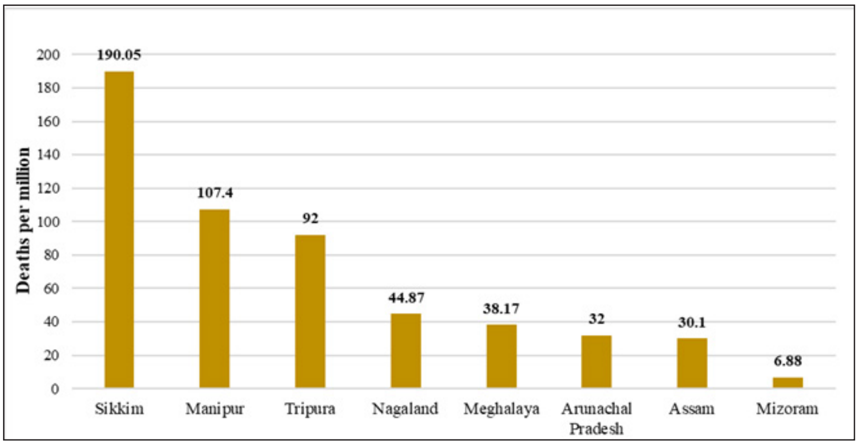



**Figure 4.Deaths per Million Population (DPM) in Northeastern States of India (as of January 20, 2021)**

**Table 2.Test Positivity Rate, Cases per Million, and Deaths per Million across Northeastern States of India[9]**

| States | Test Positivity Rate (%) | Cases per Million Population | Deaths per Million Population |
|---|---|---|---|
| Nagaland | 9.80 | 6156.0 | 44.87 |
| Sikkim | 8.30 | 8796.0 | 190.05 |
| Manipur | 5.77 | 8462.1 | 107.40 |
| Tripura | 5.50 | 7900.0 | 92.00 |
| Arunachal Pradesh | 4.30 | 9642.0 | 32.00 |
| Assam | 3.43 | 6066.7 | 30.10 |
| Mizoram | 1.52 | 3261.6 | 6.88 |
| Meghalaya | 0.24 | 3636.1 | 38.17 |

ISSN: 2455-7048
DOI: https://doi.org/10.24321/2455.7048.202314

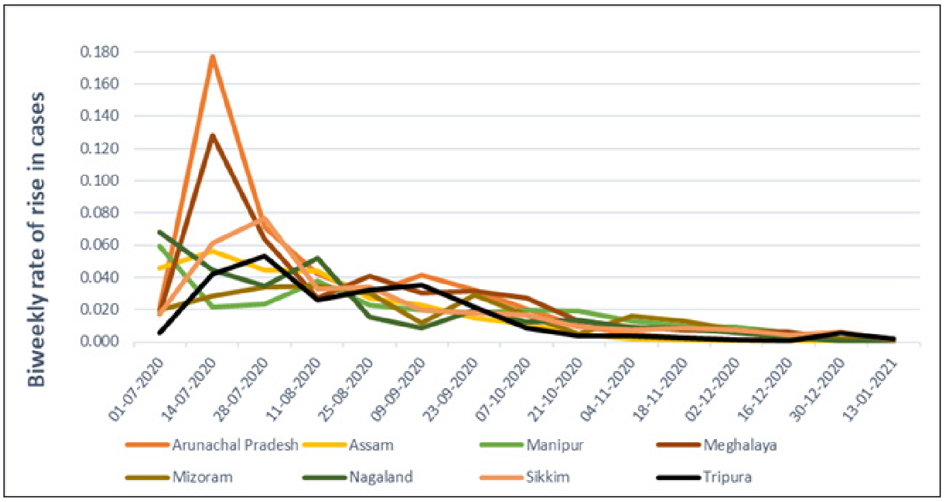



**Figure 5.Biweekly Rate of Rise in Cases across Northeastern States**

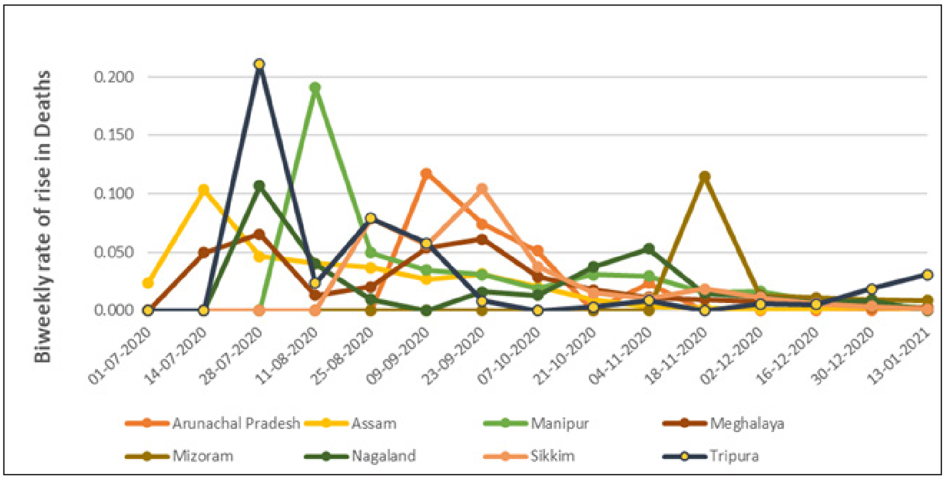



**Figure 6.Biweekly Rate of Rise in Deaths across Northeastern States**

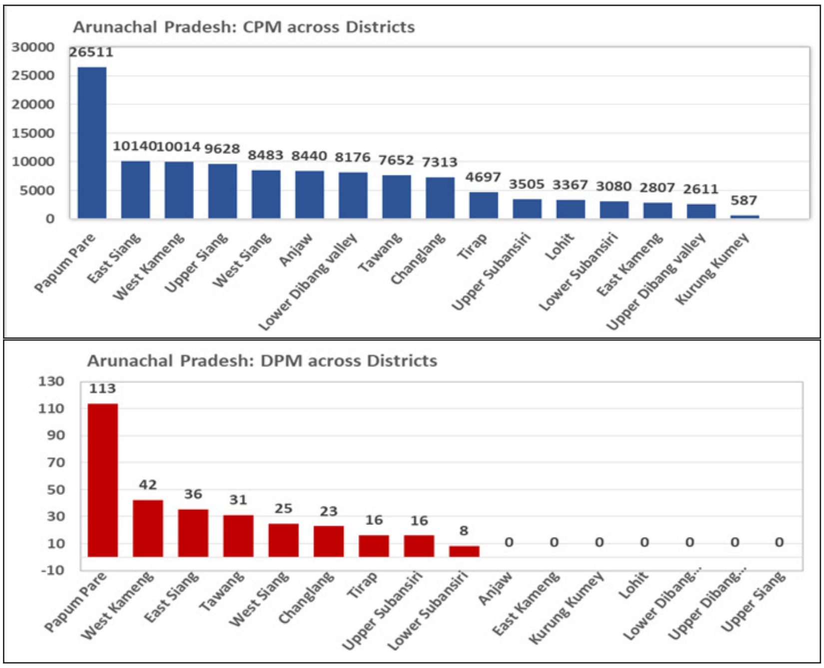



**Figure 7.COVID-19 Cases and Deaths per Million in Arunachal Pradesh**

ISSN: 2455-7048
DOI: https://doi.org/10.24321/2455.7048.202314

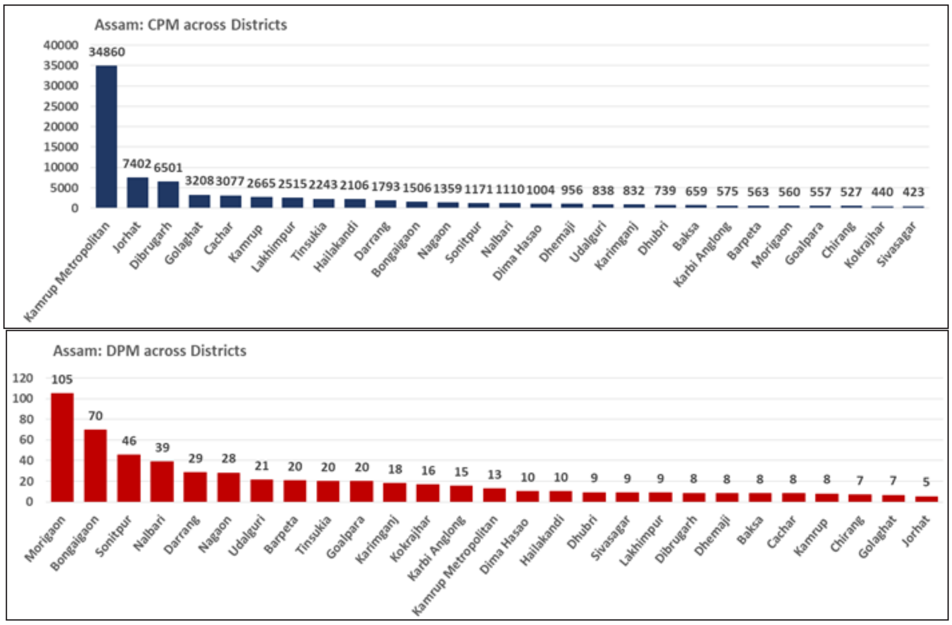



**Figure 8.COVID-19 Cases and Deaths per Million in Assam**

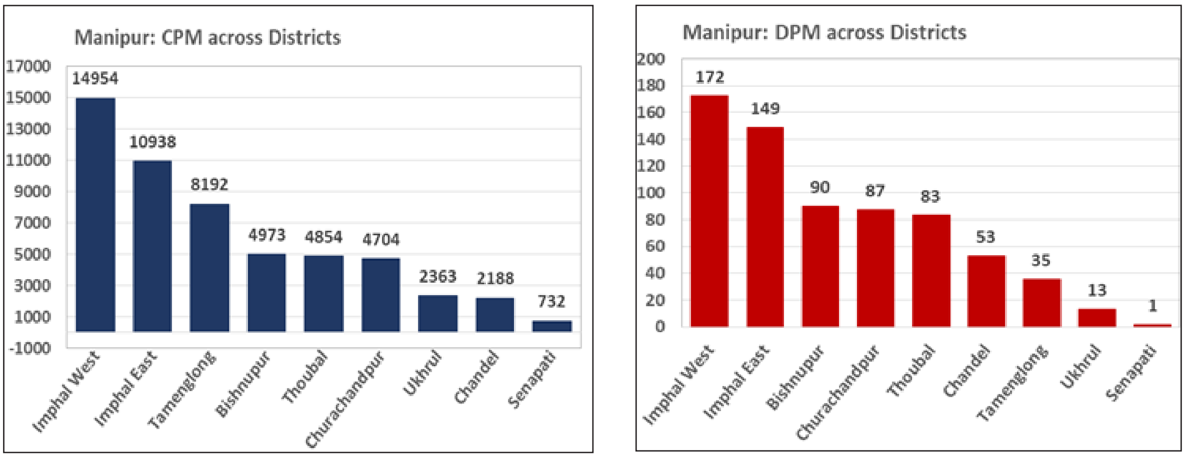



**Figure 9.COVID-19 Cases and Deaths per Million in Manipur**

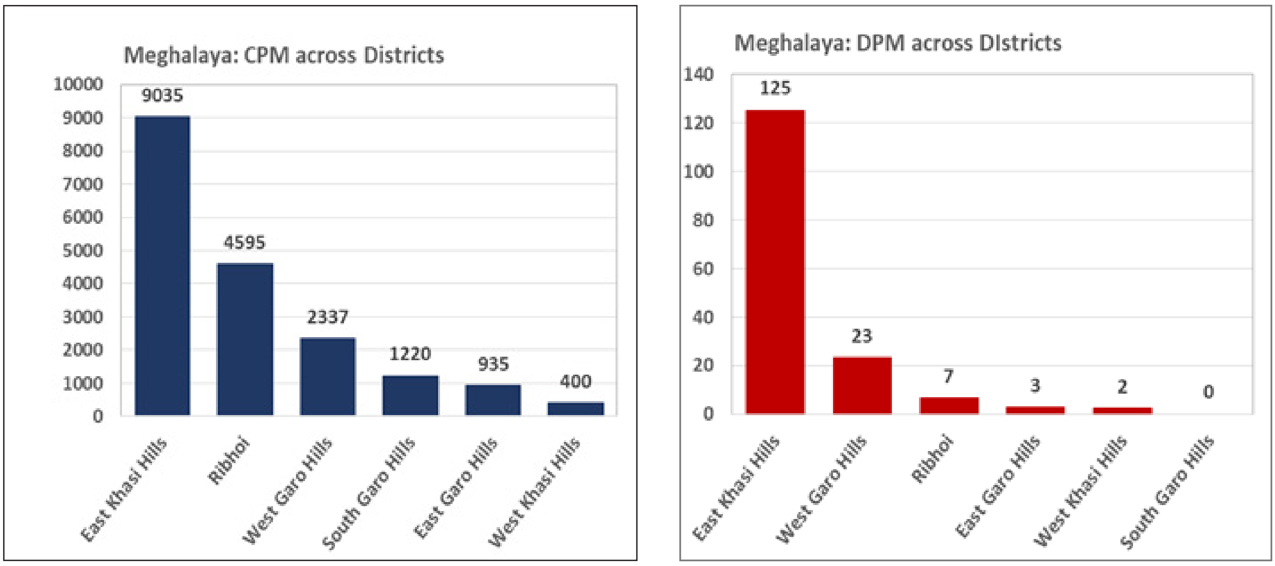



**Figure 10.COVID-19 Cases and Deaths per Million in Meghalaya**

ISSN: 2455-7048
DOI: https://doi.org/10.24321/2455.7048.202311

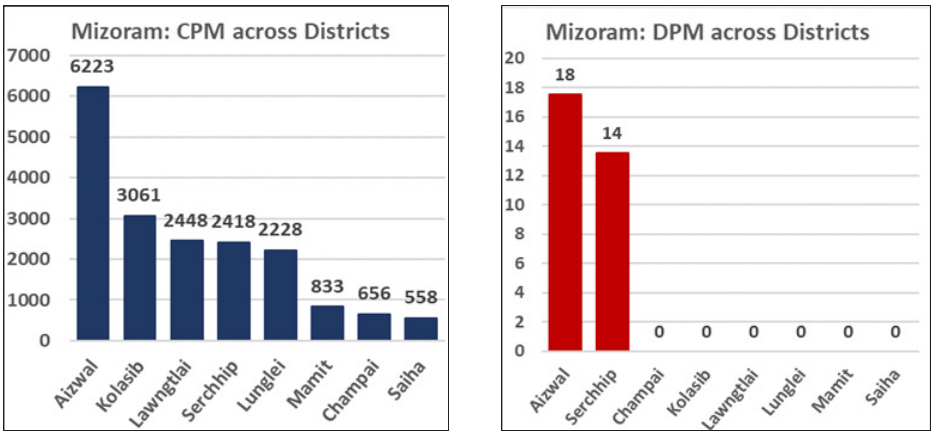



**Figure 11.COVID-19 Cases and Deaths per Million in Mizoram**

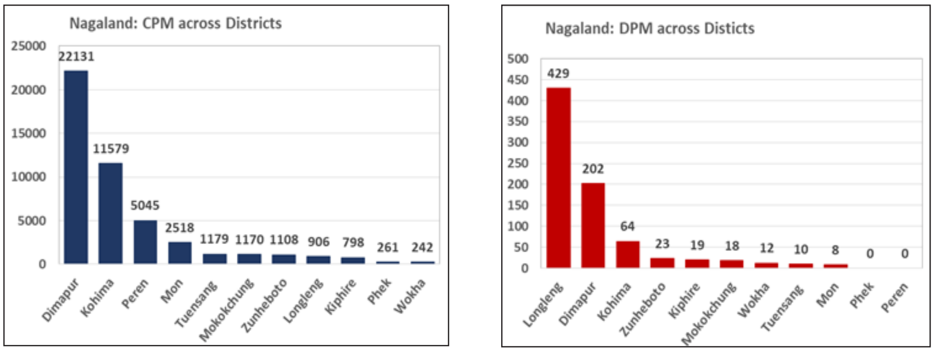



**Figure 12.COVID-19 Cases and Deaths per Million in Nagaland**

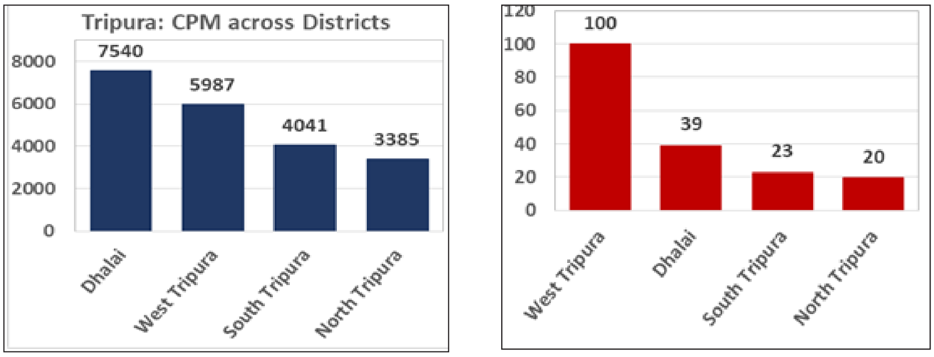



**Figure 13.COVID-19 Cases and Deaths per Million in Tripura**

## Discussion

The analysis of COVID-19 indicators in the NE states of India has unveiled significant variations in testing, positivity rates, and mortality outcomes. Arunachal Pradesh exhibited higher testing rates, reflected in its elevated cases per million (CPM). Conversely, Sikkim, with lower testing rates, experienced substantial under-detection, evident from its high CPM and mortality rates. Manipur displayed a similar trend, suggesting inadequacies in testing infrastructure and surveillance efforts. Mizoram emerged as a commendable outlier, demonstrating a proactive approach with lower cases, deaths per million, and positivity rates.

Disease outbreaks are influenced by a multitude of factors within a community. Table 3 shows that revenue generation is limited in the NE states, apart from the state of Sikkim, which enjoys larger revenue generation than the rest due to its lucrative tourism industry. This partly explains the relatively poor performance of Sikkim during the first wave. The proportion of Gross State Domestic Product (GSDP) for all NE states combined is 16.2%, whereas that of Maharashtra is 83.8%. However, the proportion of cases per million (CPM) for NE states combined is 28%, while for Maharashtra, it is 71.8%. This suggests that even though revenue generation in NE states lags by a factor of 5 when compared to Maharashtra, one of the most industrialised states of India, the CPM for all the NE states lags only by a factor of 2.5.

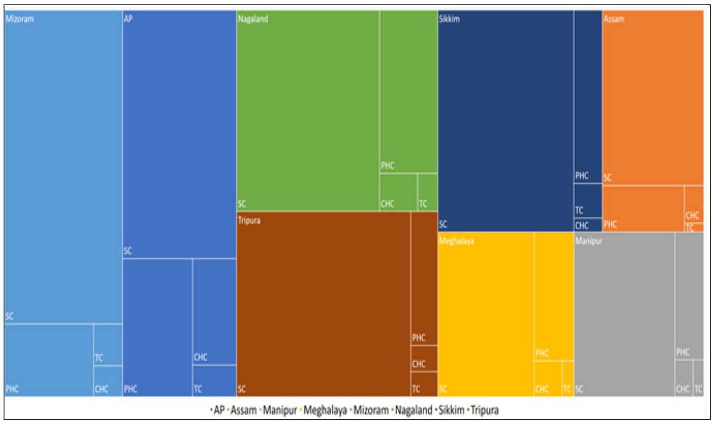
Economic growth can be helpful in the management of public health when growth is reflected in the health infrastructure and health-related human resources. Mizoram presents a relatively better picture in both areas i.e., healthcare infrastructure and healthcare workforce which is in line with our observations regarding the first wave of the pandemic in NE states (Figures 14 and 15). However, the same does not seem to be true in the case of states like Sikkim, which have suffered a harsher first wave comparatively. This indicates the contribution of other factors like difficult terrain and steeper economic shock. Having been India's first organic state, cleanest state,[23] and a contender to become India's first BPL-free state (with an 8% population below the poverty line currently) could not help Sikkim perform better when it comes to COVID management. With the highest per capita NSDP among NE states, coincidentally Sikkim also has the highest prevalence of comorbidities such as hypertension (41.6%), overweight/ obesity (36.3%), and asthma and stands third in total cholesterol among the NE states. On the other hand, Mizoram fares much better in the health infrastructure index[24] with better health facilities available per thousand populations, functional sub-centres, and CHCs.

The strength of our study is the inter and intra-state analysis of the COVID-19 dynamics across all eight NE states of India, which is one of its kind. The epidemiological indicators namely Cases per million, Deaths per million, and Test Positivity Rate used here are not only impactful but also conclusive when compared to indicators like Case Fatality Rate. This study attempts to look into the persistent comorbidities in the population where CPM and DPM were found to be alarming. The study also compares the epidemiological indicators and revenue figures of northeast India with an industrialised state like Maharashtra to estimate the opportunity to invest in health infrastructure. However, the study encounters a few limitations. Since this is a secondary analysis of publicly reported data from the first wave of COVID-19, we have not taken into account the under-reporting in our analysis and interpretation.

**Table 3.Comparison of Income Aggregates for 2019–2020 (Base Year: 2011–12) in Million INR with Cases Per Million**

| State | Per Capita NSDP | GSDP | CPM |
|---|---|---|---|
| Arunachal Pradesh | 0.105 | 1785 | 9642 |
| Assam | 0.063 | 24879 | 6067 |
| Manipur | 0.053 | 2067 | 8462 |
| Meghalaya | 0.066 | 2669 | 3636 |
| Mizoram | 0.148 | 1880 | 3261 |
| Nagaland | 0.075 | 1933 | 6156 |
| Sikkim | 0.256 | 2002 | 8796 |
| Tripura | 0.089 | 4058 | 7900 |
| Northeast states combined | - | 41273 | 6053.08 |
| Maharashtra (reference state) | 0.152 | 213406 | 15372.19 |

NSDP: Net State Domestic Product, GSDP: Gross State Domestic Product, CPM: Cases Per Million




*SC: Sub-Centres, PHC: Primary Health Centres, CHC: Community Health Centres, TC: Tertiary Centres, AP: Arunachal Pradesh

**Figure 14.Treemap Showing Health Infrastructure in Northeastern States per 10000 Populations**

ISSN: 2455-7048
DOI: https://doi.org/10.24321/2455.7048.202314

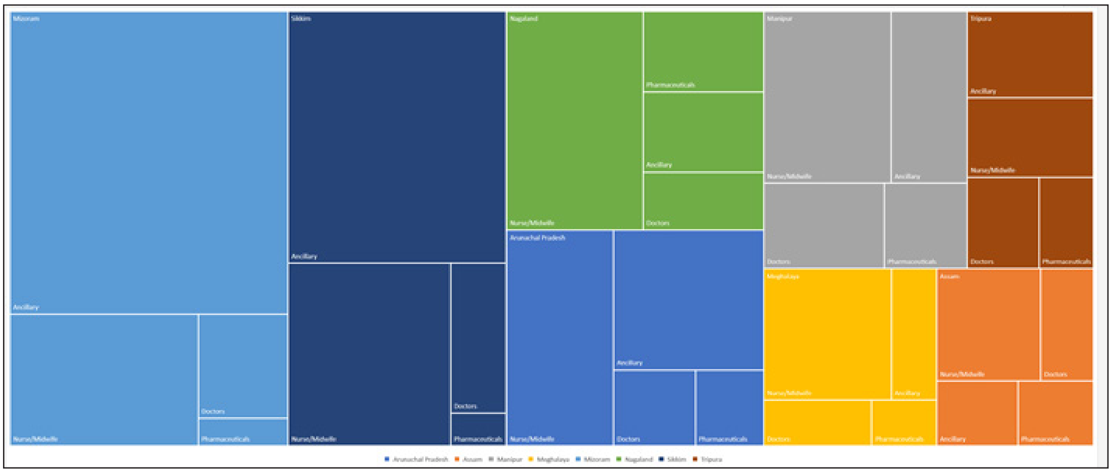


**Figure 15.Treemap Showing Health Workforce in Northeastern States per 100,000 Populations**

## Conclusion

The study concludes that a systemic focus on public health infrastructure, along with preparedness and timely intervention to minimise comorbidities, could help in handling the pandemic more effectively. Keeping the specific geography of northeast India in mind, the health infrastructure and workforce should also be accessibility and availability-based rather than solely population-based. With a notable history of successful public health communication in India through large-scale campaigns for diseases like polio and smallpox, we should use impactful and scientifically evidence-based communication techniques to educate and motivate people to ensure COVID-appropriate behaviour and lifestyle modifications to minimise co-morbidities. Hence, it is recommended that the testing capacities in states like Sikkim and Manipur shall be improved in case detection and mitigate underreporting. Implementation of comprehensive surveillance systems to ensure accurate tracking of cases and enhancement of control measures is the need of the hour. Strengthening public health communication to promote awareness of the significance of testing, reporting, and adherence to preventive measures might secretly work wonders. Lastly, fostering collaboration between states to share best practices and optimise resource allocation for a coordinated response will evolve the mitigation landscape. By addressing these recommendations and leveraging the insights gleaned from this analysis, the NE states can safeguard public health and curb outbreaks within the region.

## Acknowledgements

We are grateful to Prof Srinath Reddy for his guidance and valuable suggestions. We are also thankful to Dr Anuj Mubayi for his constructive comments, which strengthened the manuscript.

**Source of Funding:** None

**Conflict of Interest:** None

## References

1. World Health Organization [Internet]. Coronavirus disease (COVID-19) situation update report 10; [cited 2021 Jul 10]. Available from: https://www.who.int/publications/m/item/situation-report---10
2. Murhekar MV, Bhatnagar T, Selvaraju S, Rade K, Saravanakumar V, Thangaraj JW, Kumar MS, Shah N, Sabarinathan R, Turuk A, Anand PK, Asthana S, Balachandar R, Bangar SD, Bansal AK, Bhat J, Chakraborty D, Rangaraju C, Chopra V, Das D, Deb AK, Devi KR, Dwivedi GR, Khan SM, Haq I, Kumar MS, Laxmaiah A, Madhuka, Mahapatra A, Mitra A, Nirmala AR, Pagdhune A, Qurieshi MA, Ramarao T, Sahay S, Sharma YK, Shrinivasa MB, Shukla VK, Singh PK, Viramgami A, Wilson VC, Yadav R, Kumar CP, Luke HE, Ranganathan UD, Babu S, Sekar K, Yadav PD, Sapkal GN, Das A, Das P, Dutta S, Hemalatha R, Kumar A, Narain K, Narasimhaiah S, Panda S, Pati S, Patil S, Sarkar K, Singh S, Kant R, Tripathy S, Toteja GS, Babu GR, Kant S, Muliyil JP, Pandey RM, Sarkar S, Singh SK, Zodpey S, Gangakhedkar RR, Reddy DC, Bhargava B. Prevalence of SARS-CoV-2 infection in India: findings from the national serosurvey, May-June 2020. Indian J Med Res. 2020;152(1&2):48-60. [PubMed] [Google Scholar]
3. Murhekar MV, Bhatnagar T, Selvaraju S, Saravanakumar V, Thangaraj JW, Shah N, Kumar MS, Rade K, Sabarinathan R, Asthana S, Balachandar R, Bangar SD, Bansal AK, Bhat J, Chopra V, Das D, Deb AK, Devi KR, Dwivedi GR, Khan SM, Kumar CP, Kumar MS, Laxmaiah A, Madhukar M, Mahapatra A, Mohanty SS, Rangaraju C, Turuk A, Baradwaj DK, Chahal AS, Debnath F, Haq I, Kalliath A, Kanungo S, Kshatri JS, Lakshmi GG, Mitra A, Nirmala AR, Prasad GV, Qurieshi MA, Sahay S,

Sangwan RK, Sekar K, Shukla VK, Singh PK, Singh P, Singh R, Varma DS, Viramgami A, Panda S, Reddy DC, Bhargava B; ICMR Serosurveillance Group. SARS-CoV-2 antibody seroprevalence in India, August–September, 2020: findings from the second nationwide household serosurvey. Lancet Glob Health. 2021 Mar;9(3):e257-66. [PubMed] [Google Scholar]
4. India State of Forest Report. Delhi: Forest Survey of India; 2019. p. 13-273.
5. Choudhary R. Coronavirus: first coronavirus case in North-East in Northeast, full lockdown in almost all of India [Internet]. NDTV; 2020 [cited 2021 Apr 14]. Available from: https://www.ndtv.com/india-news/first-coronavirus-case-in-north-east-woman-who-returned-from-uk-tests-positive-in-manipur-2199615
6. Nath HK. Assam's 1st Covid-19 patient visited Nizamuddin, 130 quarantined [Internet]. India News; 2020 [cited 2021 Apr 14]. Available from: https://www.indiatoday.in/india/story/coronavirus-assam-covid-19-patient-travelled-to-nizamuddin-1662092-2020-04-01
7. Barman PD. Tripura reports first case of Covid-19, becomes 5th state in Northeast to be affected [Internet]. Hindustan Times; 2020 [cited 2023 Apr 13]. Available from: https://www.hindustantimes.com/india-news/tripura-reports-first-case-of-covid-19-becomes-4th-state-in-northeast-to-be-affected/story-mqU9OUxOob5ygpytm9mPbO.html
8. Nath HK. Coronavirus in India: Meghalaya's first case leads to 8 fresh infections in state [Internet]. India Today; 2020 [cited 2021 Apr 14]. Available from: https://www.indiatoday.in/india/story/coronavirus-india-meghalaya-first-case-leads-fresh-infections-state-1667944-2020-04-17
9. COVID19-India API [Internet]. API; 2020 [cited 2021 Apr 14]. Available from: https://api.covid19india.org/
10. Singh B. Assam's sero-survey found 23.7 per cent seroprevalence in the state [Internet]. The Economic Times; 2020 [cited 2021 Apr 14]. Available from: https://economictimes.indiatimes.com/news/politics-and-nation/assams-sero-survey-found-23-7-per-cent-seroprevalence-in-the-state/articleshow/78606153.cms
11. Deb D. 33.98% of Tripura has COVID-19 antibody in them, shows sero survey [Internet]. The Indian Express; 2020 [cited 2021 Apr 14]. Available from: https://indianexpress.com/article/north-east-india/tripura/33-98-of-tripura-has-covid-19-antibody-in-them-shows-sero-survey-7049100/
12. Scroll Staff. 21.5% of India's population has past exposure to coronavirus, shows ICMR's third sero survey [Internet]. Scroll.in; 2021 [cited 2021 Apr 13]. Available from: https://scroll.in/latest/985948/21-5-of-indias-population-has-past-exposure-to-coronavirus-shows-icmrs-third-sero-survey
13. Gold MS, Sehayek D, Gabrielli S, Zhang X, McCusker C, Ben-Shoshan M. COVID-19 and comorbidities: a systematic review and meta-analysis. Postgrad Med. 2020 Nov;132(8):749-55. [PubMed] [Google Scholar]
14. Beliya K, Devi KB, Singh HS, Singh J. Prevalence of type 2 diabetes in northeast India: a review. Int J Curr Res. 2018;10(9):73370-5.
15. International Institute for Population Sciences (IIPS) [Internet]. Longitudinal Ageing Study in India (LASI) – wave 1 : publications; [cited 2023 Apr 13]. Available from: https://www.iipsindia.ac.in/content/lasi-publications
16. National Family Health Survey, India [Internet]. Key findings for NFHS-5; [cited 2023 Apr 13]. Available from: https://rchiips.org/nfhs/factsheet_nfhs-5.shtml
17. Katiyar P. How local communities in northeast are at the forefront of fight against coronavirus [Internet]. The Economic Times; 2020 [cited 2021 Apr 14]. Available from: https://economictimes.indiatimes.com/news/politics-and-nation/how-local-communities-in-northeast-are-at-the-forefront-of-fight-against-coronavirus/articleshow/77038858.cms?from=mdr
18. Centre for Microfinance & Livelihood [Internet]. WASH; 2015 [cited 2021 Apr 14]. Available from: http://cmlnortheast.com/wash/
19. Chandna H. Cases, fatality rate or deaths per million, India in control of Covid: Niti Aayog expert [Internet]. The Print; 2020 [cited 2021 Mar 7]. Available from: https://theprint.in/health/cases-fatality-rate-or-deaths-per-million-india-in-control-of-covid-niti-aayog-expert/437237/
20. Ethiraj G [Internet]. 'Deaths per million key indicator of COVID containment & case management'. India Spend; 2020 [cited 2021 Apr 14]. Available from: https://www.indiaspend.com/deaths-per-million-key-indicator-of-covid-containment-case-management/
21. Dowdy D, D'Souza G [Internet]. COVID-19 testing: understanding the "percent positive". Johns Hopkins Bloomberg School of Public Health; 2020 [cited 2021 Mar 7]. Available from: https://www.jhsph.edu/covid-19/articles/covid-19-testing-understanding-the-percent-positive.html
22. Elvery JA. Getting to accuracy: measuring COVID-19 by mortality rates and percentage changes [Internet]. Cleveland FED District Data Brief; 2020 Apr 8 [cited 2021 Apr 13]. Available from: https://www.clevelandfed.org/newsroom-and-events/publications/cfed-district-data-briefs/cfddb-20200408-getting-to-accuracy [Google Scholar]
23. Sharma SN. How Sikkim became the cleanest state, and is working towards becoming poverty-free in four years [Internet]. The Economic Times; 2016 [cited 2021 May

ISSN: 2455-7048
DOI: https://doi.org/10.24321/2455.7048.202314

8]. Available from: https://economictimes.indiatimes.com/news/politics-and-nation/how-sikkim-became-the-cleanest-state-and-is-working-towards-becoming-poverty-free-in-four-years/articleshow/54499474.cms

24. Lyngdoh LM. Inter-state variations in rural healthcare infrastructure in North-East India. NEHU J. 2015;13(2):31-48. [Google Scholar]

**ISSN: 2455-7048**
**DOI: https://doi.org/10.24321/2455.7048.202314**