

# COVID-19 Transmission due to Mass Mobility Before and After the Largest Festival in Bangladesh: An Epidemiologic Study

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## Abstract

Festivals traditionally result in mass public mobility from large cities to rural or semi-urban areas in low- and middle-income Countries (LMIC), which are inadequately prepared for tackling the consequences of the COVID-19 pandemic. This study aimed to explore the trend of COVID-19 infection in a peripheral region of Bangladesh during one of the largest festivals to develop an evidence-based hypothesis for its influence on the transmission rate of COVID-19. This study conducted a quantitative analysis of secondary data on COVID-19 collected from the Directorate General of Health Services Bangladesh (DGHS) and divisional director's office in the Mymensingh division. To explore the influence of one of the biggest festivals (Eid-ul-Adha) on the trend of COVID-19 infection, we analyzed data from a week before the festival to 2 weeks following the festival. The infection rate (positive cases per million of the population) and the test positivity rate (positive cases among the total number of conducted diagnostic tests) of each day during this period were calculated both for the Mymensingh region and national level. Both the test positivity rate (TPR) and infection rates in the Mymensingh region demonstrated an increasing trend. The mean test positivity rate of the Mymensingh region on the week before the festival was 9.5%. It increased to a mean test positivity rate of 13% in the following week and further rose to a rate of 17% in the next week. The infection rate of Mymensingh also increased more than 2 folds from the day of the festival (2.0–5.3 cases per million) within the next 2 weeks. The TPR and infection rate on the national level remained similar throughout the study period. Mass mobility during Eid-ul-Adha influences the increased transmission of COVID-19 among the peripheral regions of Bangladesh from the central capital city Dhaka. The findings will help policymakers plan and implement travel restrictions during festivals during the pandemic in LMICs.

## Keywords

folklore, COVID-19 pandemic, communicable disease, epidemiology, Bangladesh

### What do we already know about this topic?

Mass mobility helped for spreading COVID-19 in China.

### How does your research contribute to the field?

Festival in Bangladesh has enormously contributed to spreading COVID-19 from the capital city to peripheral regions of the country.

### What are your research's implications towards theory, practice, or policy?

The findings will help policymakers plan and implement travel restrictions during festivals during a pandemic in LMICs.

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## Background

Social gatherings and internal mass mobility are hallmarks of festivals in the low- and middle-income countries (LMIC), particularly in the densely populated countries of the South-Asian region such as India, Bangladesh, Pakistan. These countries also experience a substantial internal migration from rural, semi-urban, and peri-urban areas to major cities due to the latter region's prevailing economic and lifestyle opportunities.<sup>1,2</sup> During festival holidays, mass mobility of internal migrants from major cities primarily to rural areas occurs in these countries, who wishes to observe the occasion with their remaining family members.<sup>3-5</sup> Much anecdotal evidence considered this phenomenon to play a role in increased transmission of COVID-19 in those areas that experience the sudden influx of people during festive seasons.<sup>6,7</sup> Several experts point out Kerala as an example, which used to be a model state in India for implementing COVID-19 containment strategies, has recently joined the list of hardest-hit regions with a sharp rise in the number of COVID-19 cases following a 10-day harvest festival Onam.<sup>8</sup> The Chinese spring festival also witnessed a significant population movement from Wuhan to other provinces, which caused the spread of COVID-19 to the less affected provinces in the country.<sup>9</sup> Additionally, personal protective behaviors such as hand washing, mask-wearing, and social distancing, which effectively reduce COVID 19 transmission,<sup>10-13</sup> are substantially compromised during festivals in densely populated South Asian countries, contributing to the virus's increased transmission.

Bangladesh shares a similar scenario during festivals, which till 30th March 2021, have about 600 000 positive corona cases and among which about 10 000 people died.<sup>14</sup> Dhaka division, which is one of the 8 major administrative zones in Bangladesh, contains more than half (63.9%) of the total positive COVID 19 cases in Bangladesh as of 24th August 2020.<sup>15</sup> Furthermore, from the very beginning of the pandemic, the capital city Dhaka has been the epicenter of the coronavirus infection and currently holds about one-fifth of the total positive cases of the country.<sup>16,17</sup> The city is the economic, political, educational, and cultural center of Bangladesh attracts many internal migrants from peripheral semi-urban and rural areas,<sup>18</sup> and as a result, about half of Dhaka's total population are temporary residents.<sup>19</sup> During 2 major festivals- Eid-ul-Fitr and Eid-ul-Adha, the country experiences a massive rush of outbound people every year from the central Dhaka city to the peripheral regions of Bangladesh, with about two-thirds (63%) of the city's total population traveling to their home towns or villages.<sup>20</sup> Likewise, in 2020, despite the movement restrictions placed by the government, a significant amount of inter-city travel and mass mobility occurred during Eid occasions.<sup>21,22</sup> Since human mobility has already been shown to increase the spread of coronavirus transmission,<sup>23</sup> Bangladesh was predicted to experience a sharp increase in the COVID 19

infection rate due to the mass mobility during Eid.<sup>24-26</sup> Furthermore, the concerned festival for this study- "Eid-ul-Adha," is observed by sacrificing animals, resulting in a significant gathering in the community during the sacrificial phase, with a critical safety measure like handwashing frequently ignored. This increases the overall transmission and causes an increase in the shift of transmission from the capital city to peripheral regions or even remote villages, which had a relatively much lower infection rate earlier. Since the COVID-19 strategies in Bangladesh have mainly focused on Dhaka city, the transmission shift can pose a major threat to the country's mitigation strategies. The peripheral regions, primarily rural areas, are not adequately equipped to tackle the COVID-19 infection and its consequences, as there is a low level of awareness, risk communication, isolation centers, and critical care treatment opportunities in these regions. Moreover, practice of preventive behaviors for COVID 19 has also been lower among rural populations than urban residents, which makes them more vulnerable to the infection.<sup>27,28</sup>

Evidence has established the relationship between public movement and the spread of COVID 19 infection. A study in China used aggregated mobile phone data to show the impact of public mobility on COVID 19 transmission,<sup>23</sup> and another study used Facebook mobility data to estimate the probability of spreading the new variants of COVID 19 from UK to other countries.<sup>29</sup> Another study in China investigated the correlation between festival induced population movement from major city Wuhan to other cities with the amplification of COVID 19 outbreak among these regions.<sup>9</sup> While these studies provide some insight, there is still a significant lack of data on the influence of festivals on COVID 19 transmission dynamics, particularly in densely populated LMICs. It is essential to generate evidence and understand the dynamics of transmission in such countries following a festival to bring it to the policymakers' attention so that they can devise appropriate strategies and interventions to control the consequences. Although some anecdotal evidence suggests that festival-induced public mobility may have a potential influence on increasing COVID 19 transmission, to the best of the author's knowledge, this is the first study to attempt to generate empirical evidence on this issue in the context of LMIC, which can fill a knowledge gap and guide policy in this regard. The current study aimed to explore the trend of COVID 19 infection before and after the biggest festival of Bangladesh to assess its influence on the transmission rate of COVID 19 in a peripheral region of the country.

## Methodology

### Study Setting

The concerned peripheral region for this study was the Mymensingh division. Mymensingh is situated 115.5km north of Dhaka city. It has 4 districts, Mymensingh, Sherpur,

Jamalpur, and Netrokona. The total area of the division is 4087sq km, and it has a population of 11.3 million.<sup>30</sup> Mymensingh has 80% of its total households in rural areas and has a predominantly agricultural economy.<sup>31</sup> Till the onset of COVID 19 in Bangladesh, Mymensingh has been reported to have the lowest percentage of cases among the 8 divisions.<sup>32</sup> Traditionally, many people travel from Dhaka city to the Mymensingh division during the festival holidays. Figure 1 presents the map of Bangladesh with a demonstration of the festival-related influx of people from central Dhaka city to peripheral Mymensingh division.

### Study Method and Data Collection

This study conducted a quantitative analysis of secondary data.

The data were collected from the Directorate General of Health Services Bangladesh (DGHS) and divisional director's office in the Mymensingh division.

Bangladesh has 8 divisions as central administrative units, divided into 64 districts (second-level administrative units). At the divisional level, the government of Bangladesh gather daily information on COVID-19, which includes the total number of diagnostic tests, the total number of positive cases, the total number of deaths, the total number of patients recovered, and the age and sex distribution of the patients. Based on this information, the divisional director's offices prepare daily reports on the COVID-19 situation of the divisions. The daily COVID-19 reports of the Mymensingh division were collected from the divisional director of Mymensingh. The COVID-19 data of the national level and Mymensingh were then processed, prepared in an SPSS readable format, and analyzed for this study.

Since the study conducted secondary data analysis, institutional ethical approval was not a requirement. However, permission from appropriate authority was taken while collecting the divisional COVID 19 data of the Mymensingh region, which is not publicly available. The DGHS data that provides daily COVID 19 information on the national level is publicly available at [www.corona.gov.bd](http://www.corona.gov.bd). Completely de-identified data has been used for analysis and presented as the output of this study.

### Analysis

The concern festival for this study was Eid-ul-Adha, which was observed on 1st August 2020. The outward public movement from Dhaka city for this festival typically starts 1 week before the occasion. Therefore, it was considered that the mass population movement for Eid-ul-Adha started this year from 25th July 2020.

A study focusing on festival time public mobility in Bangladesh reported that 819 884 people traveled from Dhaka City to Mymensingh during the Eid Festival in 2016, which represents 5% of the total population of Dhaka City that year.<sup>20</sup> Based on this study, the expected number of

people traveling from Dhaka city to Mymensingh during Eid-ul-Adha in 2020 would be 5% of the total population of Dhaka city (21 006 000) this year,<sup>33</sup> which was estimated to be 1 050 300 people. Moreover, given the government's travel restrictions, we assumed that only 50% of the expected number of people traveled during Eid-ul-Adha in 2020, which estimates the number of public mobility from Dhaka to Mymensingh to be 572 761 people.

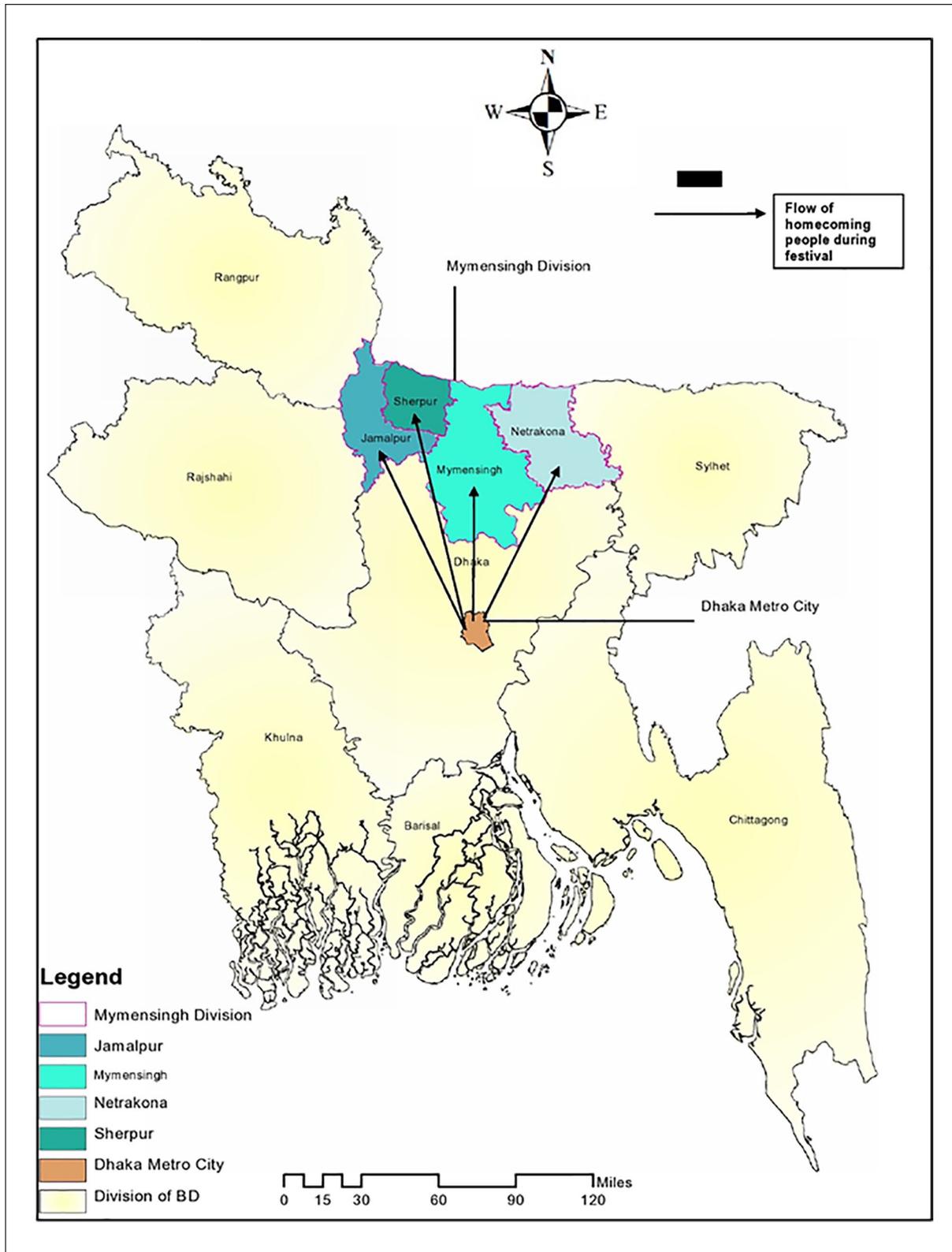
The government holiday for Eid-ul-Adha began on 30th July, 2020 and traditionally, 50% of the total festival-related population movement occurred between the day before the start of the holiday and the day of the festival. The rest 50% of the population movement is assumed to be distributed as follows: 5% on each of the first 2 days and 40% on the next 3 days. Figure 2 demonstrates the timing of estimated public mobility due to Eid-ul-Adha from Dhaka city to Mymensingh during COVID-19 and the conceptual periods of increased transmission and case detection.

The infection rate of COVID 19 in the Mymensingh region in the week starting from 25th July (1 week before Eid-ul-Adha) was considered the baseline. From the start of the holidays, when most of the festivals related to public mobility occurred, until 1 week after the Eid-ul-adha (7th August) was considered the time of increased transmission. Furthermore, 2 weeks following the festival (2nd-14th August) was considered the increased case detection period. The COVID-19 situation of the Mymensingh region was determined in terms of the number of positive cases, positive cases per millions population, and the positivity ratio among the total number of conducted diagnostic tests. For diagnostic tests, the data only considered the results of Reverse Transcription *Polymerase Chain Reaction* (RT-PCR) tests for COVID 19.

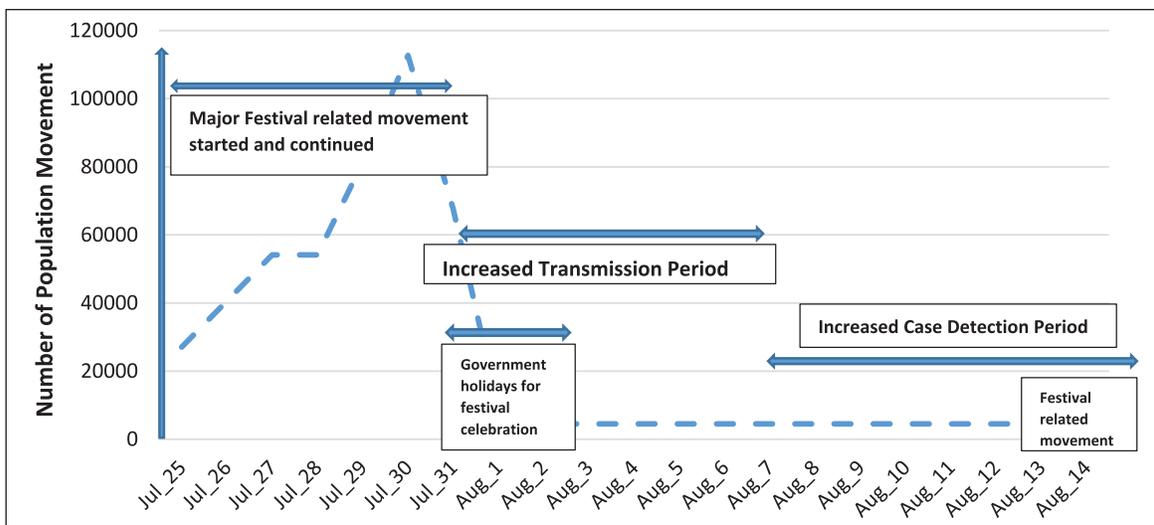
We conducted a descriptive analysis to explore the influence of Eid-ul-Adha, the trend of COVID-19 infection from the baseline (the week before Eid-ul-Adha) to 2 weeks after the festival. The infection rate (positive cases per million of the population) and the test positivity rate (positive cases among a total number of conducted diagnostic tests) of each day during this period were calculated both for the Mymensingh region and national level. Comparative analysis of the infection trends of the Mymensingh region and national level was done, and the result was demonstrated as line graphs. Following evaluation of the normal distribution of test positivity rates over a week, the weekly mean test positivity rates were calculated and compared using the One-way Anova test. An additional analysis of the test positivity rates of the national and Mymensingh region in 2 weeks beyond the concerned study period was done to explore whether the festival has a long-term influence on the COVID-19 transmission.

### Results

About 572 761 people were considered to travel from Dhaka city to the Mymensingh region this year during the Eid-ul-adha

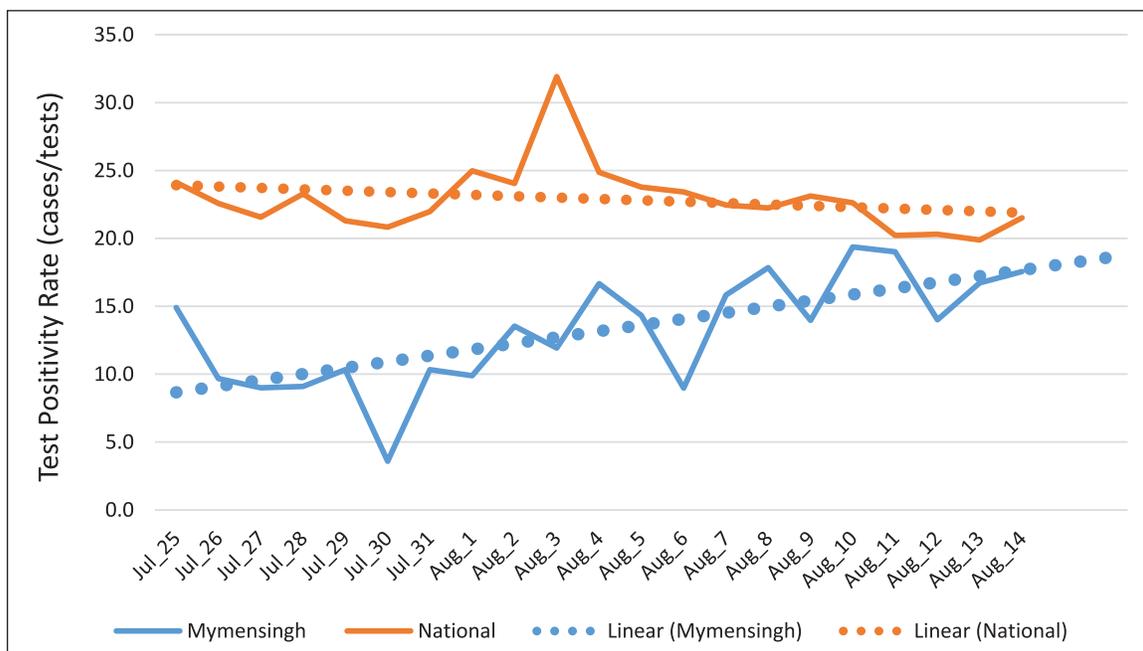


**Figure 1.** The map of Bangladesh indicating the flow of people from central Dhaka city to the peripheral Mymensingh division during the festival seasons.



**Figure 2.** The conceptual framework for timing of festival (Eid-ul-adha) related public mobility from Dhaka city to Mymensingh region and its hypothetical influence on COVID 19 transmission.

Note. In Figure 2, the 'X' axis presents the number of people moved from Dhaka to Mymensingh and the 'Y' axis presents the daily dates during the study period (25 July – 14 Aug 2020). The line (—) demonstrates the trend of festival related public mobility during this period.



**Figure 3.** Test positivity rate of COVID 19 by the peripheral region (Mymensingh) and national perspective during the study period.

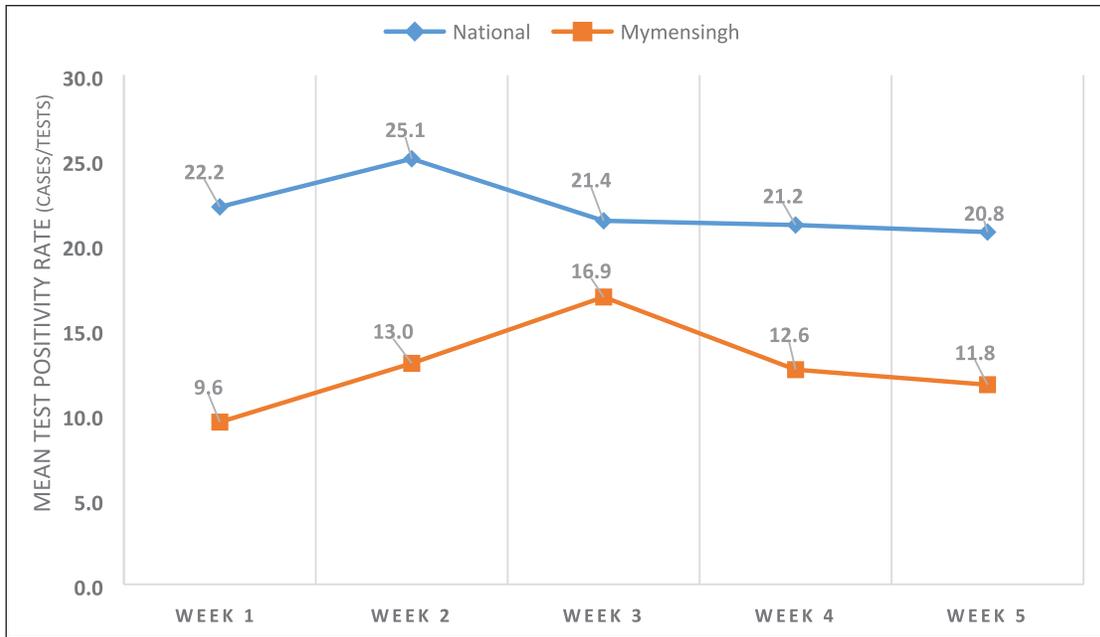
festival observed on 1st August. Comparative results of the test positivity rates and the infection rates of COVID 19 at the Mymensingh region and national level during our selected study period (1 week before festival [25<sup>th</sup> July] to 2 weeks after the festival [14th August]) is discussed in this section.

**Test Positivity Rate**

Figure 3 shows the number of positive cases among the number of conducted diagnostic tests for COVID 19 between

25th July to 14th August 2020 of the Mymensingh region and the whole country.

The test positivity rate (TPR) of the Mymensingh region shows an increasing trend. With a test positivity rate of 9.9% on 1st August (The festival day), it increased by 77.8% in the next 2 weeks following the festival and was calculated to be 17.6 % on 14th August. The test positivity rates remained within 10% in the week before the festival and took a sharp rise to 17% in the next 2 weeks. On the other hand, the test positivity rate on the national level stayed almost similar



**Figure 4.** Mean test positivity rates of COVID 19 in the national and the peripheral region Mymensingh from 1 week before festival to 4 weeks after festival.

**Table 1.** Comparison of Weekly Mean Test Positivity Rates of COVID 19 in the Peripheral Region Mymensingh (Before Festival, 1 Week After Festival, and 2 Weeks After Festival).

Time	Mean test positivity rate	P value
Week before festival (25th – 31st July)	9.6	<.01
Week 1 after festival (1st –7th August)	13	
Week 2 after festival (8th – 14th August)	16.9	

throughout the study period, with a slight decline in the last 2 weeks.

The mean test positivity rates are shown in Figure 4 for the week before the festival and 4 weeks after the festival.

The mean test positivity rate of the Mymensingh region on the week before the festival was 9.5%. It increased to a mean test positivity rate of 13% in the week following Eid-ul-Adha and further rose to a mean test positivity rate of 17% in the next week. On the other hand, the national mean test positivity rate of COVID 19 on the week before the festival was 22.2%, the mean was 25% on the week following Eid-ul-Adha, and it was again 21.4% in the last week.

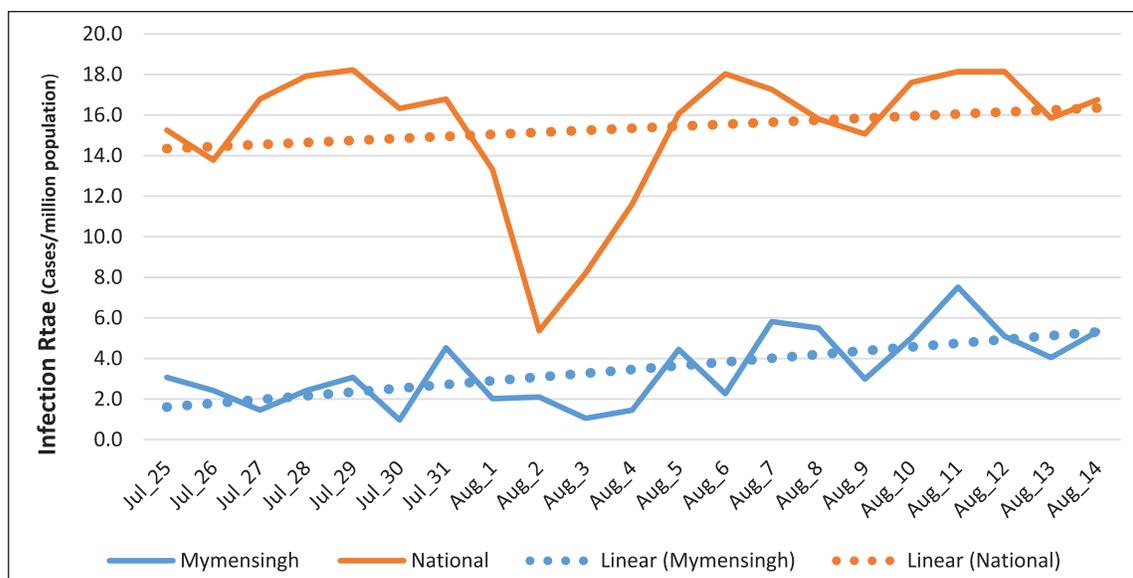
In the fourth and fifth week in Figure 4, the mean TPR on a national level remains steady and almost similar. On the other hand, although the TPR declined from its peak in Mymensingh, it was still 22% higher from the baseline week, in the fourth week following the festival. Table 1 presents the comparison of weekly mean TPR in the Mymensingh region during the study period.

The data in Table 1 indicates that there was a statistically significant increase in the TPR of COVID 19 in the Mymensingh region in the weeks following the festival compared to the week before the festival.

### Infection Rate

The number of positive cases of COVID 19 in per-million population from 25th July to 14th August in Mymensingh and the whole country is shown in Figure 5.

The COVID 19 infection rate in Mymensingh increased gradually over the study period. The infection rate of this region on the day of Eid-ul-Adha (1st August) was 2.0 cases per million, which increased more than two-fold in the following 2 weeks and was calculated to be 5.3 cases per million on 14th August. The mean infection rates in the Mymensingh region also showed an increasing trend over the 3 weeks of the study period. The festival related movement occurred in the week starting from 25th July, and it had a mean infection rate of 2.5 cases per million. It slightly increased to a mean infection rate of 2.7 cases/per million in the week following Eid-ul-Adha and got doubled to reach a mean infection rate of 5 cases per million in the last week. On the contrary, the mean national infection rate was 16.4 cases per million in the week before the festival, it got down to a mean infection rate of 12.8 cases per million in the week starting from the festival day, and then again became a mean infection rate of 16.7 cases/per-million in the last week of the study period.



**Figure 5.** Infection rate per million populations by the peripheral region (Mymensingh) and national perspective during the study period.

## Discussion

To the best of the author's knowledge, this is the first study that tried to explore the potential influence of festivals on the transmission of COVID-19 in a densely populated limited resource setting like Bangladesh. This study compared the national COVID-19 situation with the Mymensingh region before and after Eid-ul-Adha. It generated a hypothesis regarding the festival (Eid-ul-Adha) induced increased transmission of COVID-19 with a shift from capital city Dhaka to a peripheral region of Bangladesh. The COVID-19 situation in the Mymensingh region measured in terms of infection rate and test positivity rate before and after Eid-ul-Adha met the assumptions of the conceptual framework of this study.

The test positivity rate of COVID 19 in the Mymensingh region increased substantially in the 2 weeks following Eid-ul-Adha. This duration was also considered as the period for increase case detection in the conceptual framework. Furthermore, as per evidence, all the festival-related public mobility occurred in the week before Eid-ul-Adha. During this week, the mean test positivity rate was 9.5%, while the TPR of each day remained within 10% over the weeks. The onset of symptoms of COVID 19 takes an average of 5-6 days following the contraction of the virus.<sup>34,35</sup> Our study indicates that TPR has increased significantly during the next 2 weeks following Eid-ul-Adha, with a mean of 13% and 17% at 1 week and 2 weeks after the festival, respectively. While the Mymensingh region experienced a rise in TPR in the weeks following Eid-ul-Adha, the national TPR remained steady and almost similar over the study period.

The hypothesis can explain this phenomenon as demonstrated in the conceptual framework. Due to the mass mobility of people from the central capital city Dhaka to the

peripheral region Mymensingh throughout the week before Eid-ul-Adha, it causes a shift of COVID 19 transmission between the regions. The rush of outbound people from Dhaka city and the gatherings for performing Eid-ul-Adha activities causes increased transmission among the people from 1 week before the festival to 1 day after the festival. Due to the nature of the festival, males are more involved in the process, which also have lower handwashing practices than females,<sup>36</sup> and the practice of mask-wearing is also lower in rural areas in general,<sup>28</sup> which further contributes to the spread of infection.<sup>10,37</sup> Following this period, the symptoms of COVID 19 began to appear, resulting in a sudden increase in the case of detection and test positivity rate in the Mymensingh region over the next 2 weeks of the festival. Since the national TPR remained almost unchanged, it favors the hypothesis of shifting transmission between regions rather than overall increase across the country. The trend in infection rates over the study period also support the hypothesis. It has a 2-fold increase during the final week of the study. This week was also among the period for 'increase case detection, which is a result of increasing transmission of COVID-19 due to the mass mobility resulted from the earlier weeks. Along a similar line with TPR, the national infection rates of COVID-19 also remained similar throughout the study period. The national TPR continued to be steady in the additional 2 weeks' analysis. In these weeks, the TPR in Mymensingh indicated the month-long increased transmissibility of COVID-19 in this region following the festival induced mobility. This could be alarming for the rural and semi-urban areas in LMIC, which are underprepared to tackle COVID-19 and lack the practice of preventive measures like maintaining physical distancing and wearing

masks by the general population. Furthermore, despite travel restrictions, there was considerable public mobility in Bangladesh during Eid-ul-Adha, indicating a lack of legal implication and the need for policy reform.

Several studies support the hypothesis of this study. A German study that conducted a causal analysis for transmission of COVID-19 found that public mobility due to recreational purposes led to an increase in new cases of COVID-19.<sup>38</sup> Another research in Bangladesh that studied the movement of 40 positive COVID-19 patients in April 2020, found a 13 times increase in the number of new COVID cases following their unrestricted mobility.<sup>39</sup> Furthermore, a study in China found a strong correlation between festival-related public mobility and COVID-19 transmission.<sup>9</sup> The study revealed a significant association between a high proportion of travelers from Wuhan to other cities due to the spring festival and a high proportion of new COVID-19 cases in those cities. Another recent study from Bangladesh provided insight into the first 7 months of the pandemic in the country. In their evaluation, it was observed that there was increased human mobility during the Eid festivals and also during those months, there was a sharp rise in the number of confirmed cases in the peripheral region of Bangladesh.<sup>40</sup>

### Limitations and Strength of the Study

The daily data concerning COVID-19 in Dhaka city could not be collected, which could have provided a better picture of the shift of transmission from this capital city to the peripheral regions. Besides, the aggregated mobility data from Dhaka city to peripheral regions during the selected study period could not be obtained and analyzed. Due to these data limitations, the analysis could not measure a statistically significant correlation between festival-related mobility and the COVID-19 transmission for this study.

However, this study developed an evidence-based conceptual framework that supports the hypothesis of the role of the festivals in increasing COVID 19 transmission. Being the first study of its kind in a limited resource setting, it can guide future methodologically robust research and mitigation strategies in Bangladesh and other similar contexts.

### Conclusion and Policy Implications

Although the study could not produce a statistically significant correlation and the increase in case numbers can be confounded by other factors, this sets out the base for further research on this issue. The festival in discussion in this study was Eid-ul-Adha, but the generated hypothesis is equally applicable to the other Eid occasion- Eid-ul-Fitr and any significant festivals associated with sizeable public mobility. The hypothesis of this study can be further tested by future studies of the sound methodology using aggregated mobility data, both in Bangladesh and in a similar context, that experience a rush of public movement during religious or cultural festivals and use a fragmented approach to tackle COVID-19.

Future research should look into the ways festivals spread infection and identify areas where a targeted approach should be taken. Finally, the study hypothesizes that festivals and their associated mobility influence the increased transmission of COVID-19 among the peripheral regions from the central capital city Dhaka. It has vast policy level implications since all the COVID-19 mitigation measures have been Dhaka-based till now, with the capital city having 90% of the total COVID dedicated hospitals of the country.<sup>41</sup> As central Dhaka city has been the hotspot for COVID-19 and the peripheral regions was going low on infection; this festival-related shift can overburden the limited healthcare resources available in the peripheral regions Mymensingh. The finding demands strong strategy and legislation to implement the travel restrictions during festivals in the coming waves of COVID-19 in resource-constrained settings like Bangladesh. It also emphasizes the importance of reinforcing personal protective behavior practice, particularly in rural areas, which could significantly reduce festival-induced transmission.

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### Authors’ Contributions

KD and AKMFR conceived the design and planning. FNR conducted the data analysis. KD supervised and verified the data analysis methods. FNR and AOI prepared the manuscript in consultation with KD and AKMFR. All authors provided their critical feedback and approved the final manuscript.

### Availability of Data and Materials

The DGHS data is publicly available at [www.corona.gov.bd](http://www.corona.gov.bd). The data collected from divisional director’s office in Mymensingh will be available from the corresponding author on reasonable request.

### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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### Ethics Approval and Consent to Participate

The study used secondary data collected from Directorate General of Health Services (DGHS), Bangladesh and Divisional Director’s office, Mymensingh with permission from respected authorities. Completely de-identified data was analyzed and presented in this study.

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## Supplemental Material

Supplemental material for this article is available online.

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