













RESEARCH ARTICLE

REVISED **Impact of COVID-19 on non-COVID intensive care unit service utilization, case mix and outcomes: A registry-based analysis from India [version 2; peer review: 2 approved]**

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v2 First published: 18 Jun 2021, 6:159
<https://doi.org/10.12688/wellcomeopenres.16953.1>

Latest published: 10 Nov 2021, 6:159
<https://doi.org/10.12688/wellcomeopenres.16953.2>

Abstract

Background: Coronavirus disease 2019 (COVID-19) has been responsible for over 3.4 million deaths globally and over 25 million cases in India. As part of the response, India imposed a nation-wide lockdown and prioritized COVID-19 care in hospitals and intensive care units (ICUs). Leveraging data from the Indian Registry of

Open Peer Review

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Intensive care, we sought to understand the impact of the COVID-19 pandemic on critical care service utilization, case-mix, and clinical outcomes in non-COVID ICUs.

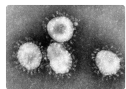
Methods: We included all consecutive patients admitted between 1st October 2019 and 27th September 2020. Data were extracted from the registry database and included patients admitted to the non-COVID or general ICUs at each of the sites. Outcomes included measures of resource-availability, utilisation, case-mix, acuity, and demand for ICU beds. We used a Mann-Whitney test to compare the pre-pandemic period (October 2019 - February 2020) to the pandemic period (March-September 2020). In addition, we also compared the period of intense lockdown (March-May 31st 2020) with the pre-pandemic period.

Results: There were 3424 patient encounters in the pre-pandemic period and 3524 encounters in the pandemic period. Comparing these periods, weekly admissions declined (median [Q1 Q3] 160 [145,168] to 113 [98.5,134]; $p < 0.001$); unit turnover declined (median [Q1 Q3] 12.1 [11.32,13] to 8.58 [7.24,10], $p < 0.001$), and APACHE II score increased (median [Q1 Q3] 19 [19,20] to 21 [20,22]; $p < 0.001$). Unadjusted ICU mortality increased (9.3% to 11.7%, $p = 0.015$) and the length of ICU stay was similar (median [Q1 Q3] 2.11 [2, 2] vs. 2.24 [2, 3] days; $p = 0.151$).

Conclusion: Our registry-based analysis of the impact of COVID-19 on non-COVID critical care demonstrates significant disruptions to healthcare utilization during the pandemic and an increase in the severity of illness.



Keywords

COVID-19, registries, critical care, severity of illness



This article is included in the [Coronavirus \(COVID-19\)](#) collection.

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Competing interests: No competing interests were disclosed.

Grant information: This work is partially supported by the Wellcome Trust and Mahidol Oxford Tropical Research Unit. Authors RH and AB were co-applicants on the Wellcome Innovations grant 215522.

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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How to cite this article: Indian Registry of Intensive care (IRIS), KJ Adhikari N, Beane A *et al.* **Impact of COVID-19 on non-COVID intensive care unit service utilization, case mix and outcomes: A registry-based analysis from India [version 2; peer review: 2 approved]** Wellcome Open Research 2021, 6:159 <https://doi.org/10.12688/wellcomeopenres.16953.2>

First published: 18 Jun 2021, 6:159 <https://doi.org/10.12688/wellcomeopenres.16953.1>

REVISED Amendments from Version 1

Based on reviewer feedback, changes that have been incorporated as part of the revised version:

1. Additional clarification provided for 'unit occupancy' under section 'methods' and sub-section 'variables'.
2. Under the section 'methods', sub-section 'analysis', a sentence added on why interrupted time series was not used.
3. [Figure 1](#) - color of lines changes to 'orange' for clarity
4. All p values reported in the format recommended by the reviewer
5. 'Discussion' section updated to add reasons for possible increase in mortality during the pandemic period and an additional point around the lack of granularity of information on 'case-mix' added to limitations.

Any further responses from the reviewers can be found at the end of the article

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has been responsible for over 3.4 million deaths globally as of 26th May 2021 ([WHO COVID-19 Dashboard](#)). In India, there have been over 25 million cases and approximately 300000 deaths ([WHO COVID-19 Dashboard for India](#)). As part of the early pandemic response in the first wave, India and several other countries imposed nation-wide lockdowns and restrictions to control the spread of the disease ([The Hindu](#), [BBC](#)). Health-services were restructured with prioritization of COVID-19 care ([The Economic Times](#), [The Times of India](#)) including in hospitals and intensive care units (ICUs). The lockdown also disrupted public transport, limiting access to healthcare facilities. In addition, fears of contracting the infection dissuaded patients from seeking care for non-COVID-19 illnesses ([The Wire Science](#), [TOI Plus](#)).

In past smaller epidemics, health systems have struggled to maintain routine services and non-pandemic healthcare and public health services suffered^{1,2}. During the ongoing COVID-19 pandemic, there is limited information on how the outbreak has impacted acute and critical care service provision in India and other low- and middle-income countries (LMICs).

Even in non-pandemic times, India has a limited supply of critical care capacity with bed availability estimated at 2.6 per 100,000 population compared with much higher capacity in most high-income countries, for example 12.9 ICU beds per 100,000 population in Canada³, and other LMICs in the region, for example 11.7 beds per 100,000 population in Mongolia⁴. Other well-described challenges to the delivery of critical care in India include the limited number of beds with capacity for oxygen delivery, ventilators, and importantly, healthcare professionals⁵. All these challenges are further amplified by the disparities in distribution of these resources between urban and rural India⁶ and between the public and private sector.

In this context, critical care registries, by continually evaluating service provision, case-mix and outcomes, can be used to describe the impact of pandemic on critical care service provision and inform health-capacity strengthening efforts. The Indian Registry of Intensive care (IRIS) prospectively collects information on service utilisation, case mix, and outcomes⁷. Leveraging the registry platform, we sought to understand the impact of the COVID-19 pandemic on critical care service utilization, case-mix, severity of illness and clinical outcomes in non-COVID ICUs.

Methods

Data sources

All data for this analysis was available from IRIS. IRIS, a cloud-based registry established in January 2019, prospectively collects information on service utilisation, case-mix, and outcomes. 13 hospitals (13 ICUs) currently participate in the registry and details of implementation have previously been published⁷.

For this report, we included all consecutive cases admitted between 1st October 2019 and 27th September 2020. Patients admitted before 27th September 2020, but not discharged at time of analysis (2nd November 2020) were excluded. Data was extracted from the registry database and included patients admitted to the non-COVID or general ICUs at each of the sites. In all participating hospitals, COVID-19 patients were managed in designated locations and as such, not included in the registry. No additional variables, other than those already available in the registry, were included in the study design.

Variables

The main exposure was time, defined as the pre-pandemic period (October 2019-February 2020), pandemic period (March-September 2020), and period of intense lockdown (March-May 31st 2020) within the pandemic period. Outcomes of interest included admission rates, unit occupancy, unit turnover, bed availability, use of resources at admission (invasive and non-invasive ventilation, vasoactive medications, renal replacement therapy), number of surgical admissions, route to admission (i.e. from operating room, emergency room, ward etc.) and case mix (diagnosis, APACHE II score⁸).

Unit occupancy was defined in the registry as $(\text{weekly number of admissions} \times \text{mean weekly length of stay}) / (\text{number of beds available} \times 7)$. Unit turnover was defined in the registry as $\text{weekly number of discharges} / (\text{number of beds available} \times 7)$ and bed availability was defined as $(\text{weekly number of admissions} \times \text{mean length of stay}) - (\text{bed capacity} \times 7)$.

Analysis

We used a Mann-Whitney test to compare baseline data from the pre-pandemic period to the pandemic period. In addition, we also compared the period of intense lockdown with the pre-pandemic period. October 2019 was chosen as the reference starting point as most units in the registry were contributing data by then (the registry was established in January 2019). While interrupted time series (ITS) would have been an ideal method for analysing temporal trends, we did not pursue this

approach as the assumptions for ITS (linearity) were not met in our dataset and also due to the inability to control for covariates.

Data is presented as median (Q1, Q3) using weekly recorded numbers. We plotted 2020 data points with a loess smoothing line and standard error bars. Statistical analysis was conducted using RStudio v3.6.1 (R Foundation, Vienna, Austria). Full R code are provided (see *Code availability*)⁹ and raw data are available with restrictions on access (see *Data availability*).

Ethics and consent

This analysis has been approved by the Institutional Ethics Committee (Apollo Main Hospital-C-S-010/02-21) centrally at the study coordinating centre. The consent model for IRIS has been previously described⁷. As this was a secondary analysis of deidentified registry data, no further individual patient-level consent was considered necessary or sought.

Patient and public involvement

Given the nature of this analysis, no patient or public involvement was sought.

Results

A total of 6948 patient encounters from 13 hospitals (13 ICUs) were reported between 1st October 2019 and 27th September 2020, with 3424 encounters in the pre-pandemic period and 3524 encounters in the pandemic period (Figure 1). All variables had <6% missing data. National lockdown commenced in India on the 24th March 2020, and the first phase of unlocking started on 1st June 2020 (Figure 2).

Number of admissions, case-mix and turnover

Weekly admissions declined from a median (Q1, Q3) of 160 (145, 168) admissions from the pre-pandemic period to 113 (98.5, 134.0) for the pandemic period ($p<0.001$) (Table 1). For this same comparison period there was also a significant decline in the unit turnover from a median (Q1, Q3) of 12.1% (11.3, 13.1) to 8.6% (7.2, 10.0) ($p<0.001$) and unit occupancy from a median (Q1, Q3) of 43.2% (35.2, 49.0) to 35.1% (29.0, 40.0) (Table 1).

In terms of case-mix, there were no differences in the proportion of surgical admissions between these periods.

Comparing the pre-pandemic phase to the intense lockdown phase (March-May 2020), the median (Q1, Q3) weekly admissions declined to 98 (93, 157) admissions ($p=0.003$). In addition, for this comparison period, the percentage unit occupancy as well as unit turnover were also significantly lower during the intense lockdown period as compared to the pre-pandemic period (Table 2). The number of beds free per day per week increased from a median (Q1, Q3) of 10.13 (9.3, 11) to 11.92 (11.01, 12) ($p=0.005$) during the intense lockdown phase (Table 2).

For this comparison period, the proportion of surgical admissions increased from a median (Q1, Q3) of 14.6% (12.18, 18) to 17.4% (16.13, 20).

Severity of illness

The median APACHE II score (Q1, Q3) increased significantly from 19 (19, 20) in the pre-pandemic period to 21 (20, 22) during the pandemic period ($p<0.001$) (Table 1). However, the median percentage of patients needing mechanical ventilation at admission was not different (22.01 vs. 22.37; $p=0.852$). There was a decline in the median percentage of patients needing non-invasive ventilation at admission from 14.56 (11.57, 17) to 11.43 (9.41, 13) ($p=0.013$). Need for cardiovascular support at admission was not different between the two periods (17.65% vs. 16.98%; $p=0.648$) (Table 1).

Comparing the pre-pandemic period to the intense lockdown phase, the median APACHE II was significantly higher (19 vs. 20) ($p<0.001$) (Table 2). The median proportion of patients needing mechanical ventilation was not different between these two periods (Table 2). Similar to the previous comparison period, the median proportion of patients needing non-invasive ventilation was lower during the intense lockdown phase (14.56 vs. 11.58; $p=0.021$).

Outcomes

Table 3 and Figure 3 presents details of the key outcomes in the pandemic and pre-pandemic periods. There was a higher overall unadjusted ICU mortality during the pandemic period as compared to the pre-pandemic period (11.7% vs 9.3%, $p=0.015$). There was no difference in the median length of stay between the two periods.

Discussion

Our registry-based analysis of the impact of COVID-19 on non-COVID critical care services shows a significant reduction in the median number of admissions to the ICUs during the pandemic period as compared to the pre-pandemic period. This reduction was most prominent during the intense lockdown phase. We also noted an increase in the median APACHE II score and a significant decline in the ICU turnover for comparison periods. While the median severity of illness was higher, we did not see an increase in the proportion of patients needing mechanical ventilation or cardio-vascular support at admission. Additionally, the proportion of planned surgical admissions declined over this period but was not statistically significant. Unadjusted ICU mortality was higher during the pandemic period, but the median length of stay was similar.

To our knowledge, our study is the first to demonstrate the collateral impact of the pandemic on non-COVID acute and critical care. In previous epidemics, similar findings have been reported. However, the scale and the extended timeline of the current pandemic means that such disruption is likely of much a larger magnitude than previously witnessed. Lee and colleagues reported a 33% reduction in emergency room visits during the MERS-CoV outbreak in South Korea¹⁰. Similarly, during the SARS outbreak, Huang and colleagues showed a mean reduction of 92.5 ± 8.3 patients in emergency room visits¹¹.

Such disruptions to other components of healthcare delivery have been reported during previous outbreaks and epidemics

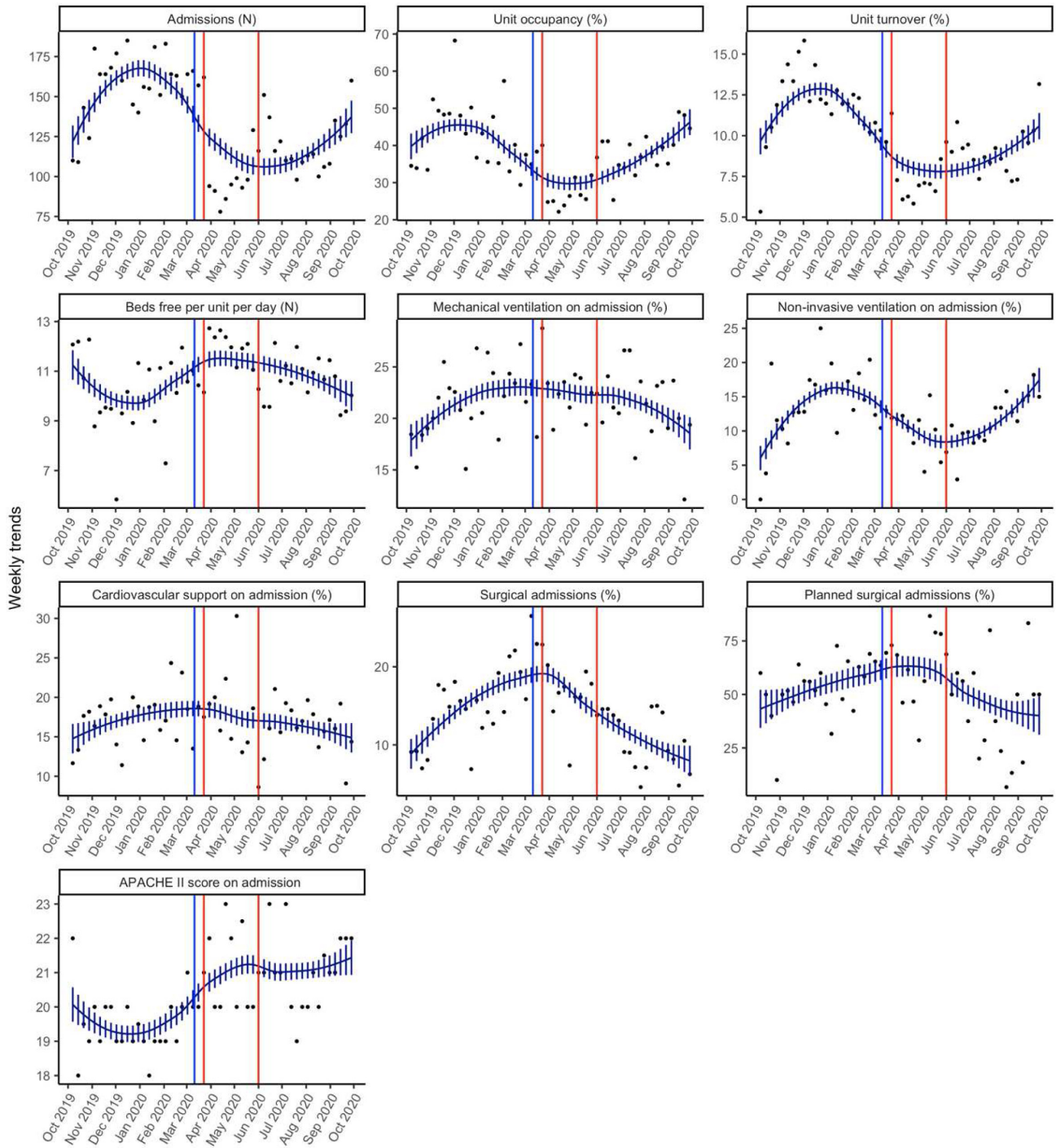
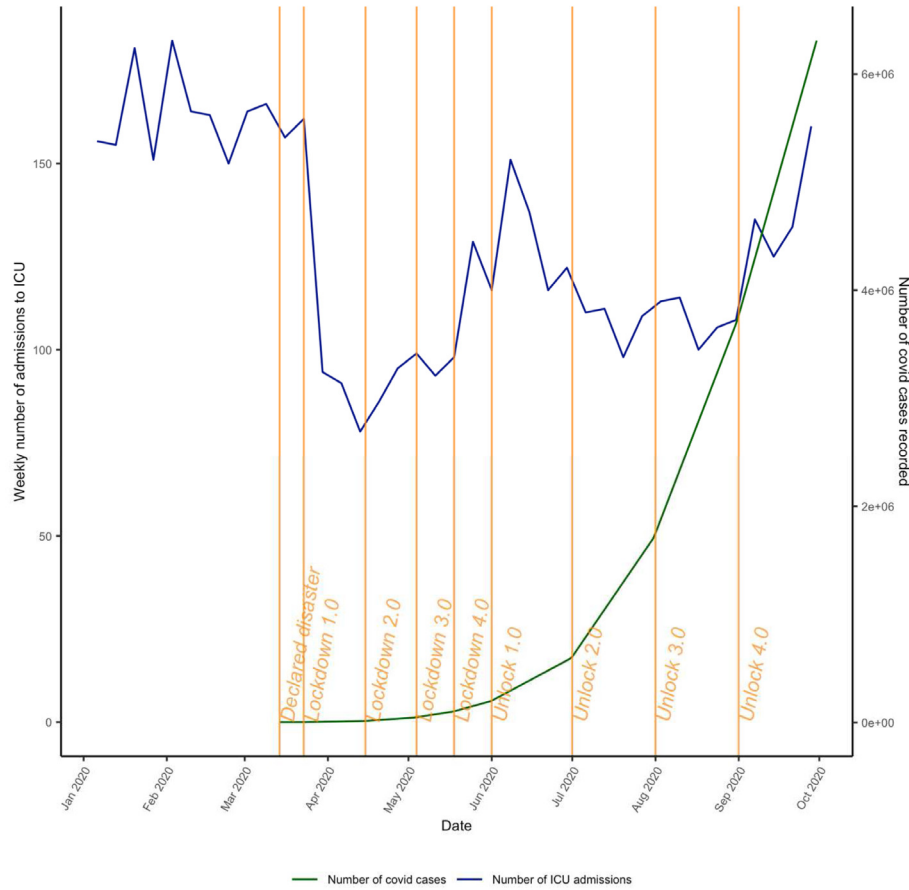


Figure 1. Smoothed weekly trends. The dots are the original data, and the lines and bars are loess predictions and standard errors. The blue line represents March 11th 2020, the date the WHO declared Covid a pandemic. The orange lines indicate the intense lockdown period in India from 23rd March 2020– 1st June 2020.

such as the impact of Ebola on maternal and child health services in Guinea¹² and of SARS on ambulatory and in-patient care¹³. During the current pandemic, concerns have been expressed

about the impact on hematopoietic stem cell transplant¹⁴, on outcomes from cancer surgery¹⁵, on maternal and neonatal care¹⁶, and tuberculosis control programs^{17,18}.



ICU, intensive care unit.

Figure 2. Phases of lockdown in India. ICU, intensive care unit.

Table 1. Comparison of pre and pandemic period. All variables are reported as weekly median (Q1, Q3). A Mann-Whitney test was performed to statistically test the difference between the two time periods.

Variable	Oct 2019 to Feb 2020	Mar to Sep 2020	p-value
Admissions (N)	160 (145, 168)	113 (98.5, 134)	<0.001
Unit occupancy (%)	43.19 (35.23, 49)	35.12 (29.01, 40)	0.003
Unit turnover (%)	12.1 (11.32, 13)	8.58 (7.24, 10)	<0.001
Beds free per unit per day (N)	10.13 (9.3, 11)	11.01 (10.35, 12)	0.034
Mechanical ventilation on admission (%)	22.01 (19.01, 24)	22.37 (19.49, 24)	0.852
Non-invasive ventilation on admission (%)	14.56 (11.57, 17)	11.43 (9.41, 13)	0.013
Cardiovascular support on admission (%)	17.65 (14.57, 19)	16.98 (14.56, 19)	0.648
Surgical admissions (%)	14.59 (12.18, 18)	14.29 (9.05, 16)	0.634
Planned surgical admissions (%)	51.85 (46.43, 60)	56.25 (37.5, 69)	0.751
APACHE II score on admission	19 (19, 20)	21 (20, 22)	<0.001

Table 2. Comparison of pre pandemic and intense lockdown periods. All variables are reported as median (Q1, Q3). A Mann-Whitney test was performed to statistically test the difference between the two time periods.

Variable	Oct 2019 to Feb 2020	Mar to May 2020	p-value
Admissions (N)	160 (145, 168)	98 (93, 157)	0.003
Unit occupancy (%)	43.19 (35.23, 49)	26.66 (25.02, 35)	<0.001
Unit turnover (%)	12.1 (11.32, 13)	7.1 (6.59, 10)	<0.001
Beds free per unit per day (N)	10.13 (9.3, 11)	11.92 (11.01, 12)	0.005
Mechanical ventilation on admission (%)	22.01 (19.01, 24)	22.48 (21.05, 24)	0.595
Non-invasive ventilation on admission (%)	14.56 (11.57, 17)	11.58 (10.2, 12)	0.021
Cardiovascular support on admission (%)	17.65 (14.57, 19)	18.52 (14.74, 19)	0.736
Surgical admissions (%)	14.59 (12.18, 18)	17.44 (16.13, 20)	0.024
Planned surgical admissions (%)	51.85 (46.43, 60)	65.38 (56.25, 73)	0.029
APACHE II score on admission	19 (19, 20)	20 (20, 22)	<0.001

Table 3. Key outcomes: pre-pandemic and pandemic period. All variables are reported as the weekly median with interquartile range. A Mann-Whitney test was performed to statistically test the difference between the two time periods.

Variable	Oct 2019 to Feb 2020	Mar to Sep 2020	p-value
Dead (%)	9.29 (7.5, 11)	11.68 (9.91, 15)	0.015
Discharged home (%)	6.45 (5.51, 9)	12.23 (8.4, 14)	<0.001
Discharged ward (%)	82.52 (78.82, 84)	73.56 (71.79, 79)	<0.001
Discharged ICU (%)	2.94 (1.88, 4)	3.45 (2.09, 4)	0.709
Transferred to another hospital (%)	1.76 (0.68, 3)	8.7 (4.67, 12)	<0.001
Discharged against medical advice (%)	7.03 (5.29, 9)	9.38 (7.18, 11)	0.014
Discharged other (%)	1.29 (0.75, 2)	1.15 (0, 2)	0.910
Readmitted to ICU (%)	4.27 (2.76, 5)	2.65 (2.17, 4)	0.051
Median length of stay (days)	2.11 (2, 2)	2.24 (2, 3)	0.151

ICU, intensive care unit.

There are several reasons for such disruptions, including the necessary and inevitable prioritization of pandemic healthcare services, obstacles to access of healthcare triggered by lockdown and suspension of public transport, fear of contracting infection whilst trying to access care, among others. Such medical avoidance behaviours have also been described during past outbreaks¹⁹. In India, a nationwide lockdown was imposed on 24th March 2020 with an immediate disruption of public transport and the imposition of a curfew across the country. Additionally, hospitals were explicitly asked to prioritize COVID-19 care by increasing capacity, by redirecting resources (manpower, equipment etc.), and reducing or suspending non-emergency services.

In a recent survey of healthcare worker perceptions on the impact of the pandemic led by our group²⁰, respondents reported a decline in acute care service utilisation and a delay in time-sensitive procedures such as percutaneous coronary angioplasties. In the view of the respondents, fear of contracting infection and lockdown were seen as having contributed the most to such disruptions. The results of the current study provide objective data to complement the perceptions of the survey respondents.

There are several possible reasons for the increase in mortality observed during the pandemic period. This could represent a real effect due to patients presenting late (and sicker) due

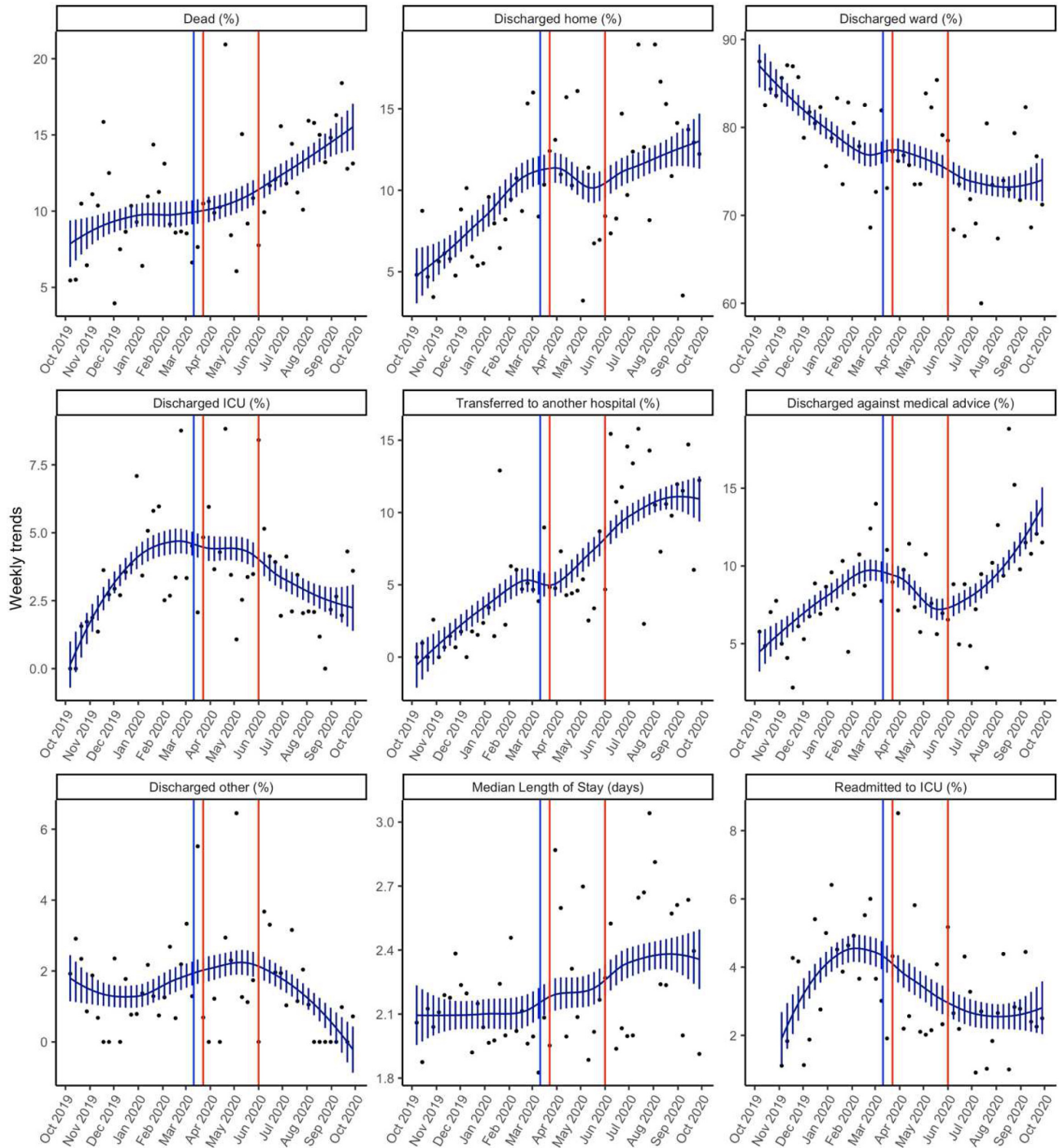


Figure 3. Smoothed weekly trends of outcomes. The dots are the original data, and the lines and bars are loess predictions and standard errors. The blue line represents March 11th 2020, the date the WHO declared COVID-19 as a pandemic. The brown lines indicate the intense lockdown period in India from 23rd March 2020– 1st June 2020.

to the fear of contracting COVID-19 when they come in contact with the healthcare system or due to pandemic imposed restrictions on access to healthcare facilities. Alternately, this could be a chance finding reflecting secular trends. We tried

to limit this by extending the time periods of the analyses but cannot be confident that we have fully excluded such effects. This observed increase also be due to lack of adjustment for potential confounders.

Strengths and limitations

Our study has several important strengths. We compared the service utilisation during the pandemic and the intense lockdown phase with an extended pre-pandemic period to overcome any limitations arising from secular trends. Missingness for our dataset was less than 6% for all variables and the reported changes are therefore not due to systematic differences in data availability for the pre and pandemic periods. In addition, our study, to the best of our knowledge, is the first to provide objective data on disruptions to acute and critical care.

Our report has several limitations. Our network includes only a fraction of ICUs within India and may not be epidemiologically representative of the impact of the pandemic on critical care service utilisation across the country or wider region. The impact on ICU service utilisation described may be due to other agents external to the registry's surveillance and are not described here. In addition, we did not include data from COVID ICUs nor did we compare the service utilization between the COVID and non-COVID areas. Mortality in our cohort is low (9.3 and 11.7%) as compared to other registries (for example 31% for the year 2019 in the Linking Of Global Intensive Care or LOGIC initiative) and this may be explained by a combination of reasons including the mix of ICUs represented in IRIS and the overall small number of ICUs currently participating. In addition, the registry collects information on broad diagnostic categories and does not have granular information on case-mix; as such, we were unable to describe changes in the case-mix during the pre and pandemic periods. We are also unable to comment on the effect of the pandemic on population-level health indicators. Nonetheless, we think this report provides valuable insights into the impact of public health decision and policy making during the pandemic and the impact of the pandemic on healthcare resource utilisation.

Conclusion

Our registry-based analysis of the impact of COVID-19 on non-COVID critical care demonstrates significant disruptions

to healthcare utilization during the pandemic and an increase in the severity of illness. Our findings are likely to inform future healthcare planning during pandemics to minimise disruptions to other aspects of healthcare delivery.

Data availability

Underlying data

Pooled data from IRIS are available from the IRIS Dashboard at <https://nicst.com/picu-iris-public/>. The IRIS collaboration supports and welcomes data sharing. Our agreement with participating sites in the registry is only for the sharing of deidentified data between them and the registry coordinating centre for the purposes of audit, quality improvement and specific research questions. We are not allowed to post data on a repository or any other public database. However, raw data will be made available to qualified researchers who provide a detailed and methodologically sound proposal with specific aims that are clearly outlined. Such proposals will be screened by the IRIS Steering committee for approval.

Data sharing will be for the purposes of medical research and under the auspices of the consent under which the data were originally gathered. To gain access, qualified researchers will need to sign a data sharing and access agreement and will need to confirm that data will only be used for the agreed upon purpose for which data access was granted. Researchers can contact the corresponding author through electronic mail (bharath@icuconsultants.com) for such access; alternatively, IRIS can be contacted at info@irisuregistry.org and joinus@irisuregistry.org.

Code availability

Analysis code available from: <https://github.com/NICST-PROTECT/ICU-service-utilisation-public/tree/v1.0.1>

Archived analysis code at time of publication: <https://doi.org/10.5281/zenodo.4939947>⁹

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Open Peer Review

Current Peer Review Status:  

Version 2

Reviewer Report 07 December 2021

<https://doi.org/10.21956/wellcomeopenres.19216.r47013>

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 **Kate Tatham** 

Division of Anaesthetics, Pain Medicine & Intensive Care, Department of Surgery & Cancer, Faculty of Medicine, Imperial College London, London, UK

I approve this article.

Minor comment- please state that normality testing was performed and that the data were non-parametric and hence Mann-Whitney U was utilised.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Intensive Care

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 12 November 2021

<https://doi.org/10.21956/wellcomeopenres.19216.r47014>

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 **Saptharishi Lalgudi Ganesan** 

¹ Department of Paediatrics, Schulich School of Medicine and Dentistry, Western University, London, ON, Canada

² Children's Hospital of Western Ontario, London Health Sciences Center, London, ON, Canada

³ Brain & Mind Institute, Western University, London, ON, Canada

I would like to thank the authors for considering my suggestions and providing clear responses to each comment. I have no further comments to make. The reviewer suggestions have been incorporated wherever feasible.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Critical Care, Global Health, Clinical epidemiology, Neurocritical Care, Child Health

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 14 October 2021

<https://doi.org/10.21956/wellcomeopenres.18709.r45550>

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Kate Tatham 

Division of Anaesthetics, Pain Medicine & Intensive Care, Department of Surgery & Cancer, Faculty of Medicine, Imperial College London, London, UK

Thank you for asking me to review this manuscript analysing non-COVID ICU utilisation before and during the peak COVID pandemic in India. It demonstrates a significant disruption in healthcare utilisation during this time.

Overall the study is well designed and well written and acknowledges its strengths and limitations.

Major comments are:

- Could you comment on how the time periods were assigned. Would it be better to compare equal time periods (currently 5 months versus 7 months)?
- Can you elaborate on how the unit occupancy equation definition was decided on? Did it include mean length of stay **and** no. of beds **or** no. of beds **or** divided by number of beds? Perhaps inserting a formal equation might make this easier to interpret?
- Can you comment on why you think mortality went up? It would be interesting to know the adjusted mortality (eg for APACHE?).
- Did transfer of medical staff and equipment to COVID ICUs take place and thus limit ability to admit to non-COVID ICUs?

Minor points:

- In the equation stated under variables in the methods, consider using the multiplication sign 'x' or even '*'.
- Was Mann-Whitney U used as normality tests indicated non-parametric data?
- What does the red line signify on Figure 1. It's quite hard to tell the difference in colour compared to the brown line.
- The axes numbering on Fig2 are almost too small to read.

I would recommend following this general rule (taken from here: <https://www.nejm.org/author-center/new-manuscripts>) *In general, P values larger than 0.01 should be reported to two decimal places, those between 0.01 and 0.001 to three decimal places; P values smaller than 0.001 should be reported as $P < 0.001$.*

Results: Outcomes - typo 'morality' instead of mortality I think.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Intensive Care

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 05 Nov 2021

IRIS India, Apollo Main Hospital, Chennai, India

We would like to thank the reviewers for their important and insightful feedback. The feedback has helped improve the manuscript and we are grateful for this. We address their comments below. Reviewer comments are presented in italics.

Comment:

Thank you for asking me to review this manuscript analysing non-COVID ICU utilisation before and during the peak COVID pandemic in India. It demonstrates a significant disruption in healthcare utilisation during this time.

Overall the study is well designed and well written and acknowledges its strengths and limitations.

Response: Thank you.

Major comments are:

Could you comment on how the time periods were assigned. Would it be better to compare equal time periods (currently 5 months versus 7 months)?

Response:

Thank you- the choice of the time periods was based on the following reasons:

All 13 units in the registry were fully onboarded and collecting data only by October 2019- hence the decision to use this as the start of the pre-pandemic period. While the first case of COVID-19 was reported in India on January 30th2020, the surge in cases only started in the 3rd week of March with the imposition of the lockdown on 24th March 2020. The first wave of the pandemic continued up until September/October 2020. Hence this was chosen as the 'pandemic period'. We acknowledge that these separations can be artificial, but had to pick a time point for the purposes of the analysis. However, we don't think that the slightly unequal time periods (5 vs. 7 months) had a material impact on the magnitude or direction of the results, especially because the results are reported per week within each period, and not by period.

*Can you elaborate on how the unit occupancy equation definition was decided on? Did it include mean length of stay **and** no. of beds **or** no. of beds **or** divided by number of beds? Perhaps inserting a formal equation might make this easier to interpret?*

Response:

Thank you. We have clarified (Page number 13, Section- 'Methods', sub-section 'Variables' , Paragraph 2):

"Unit occupancy was defined in the registry as (weekly number of admissions × mean weekly length of stay)/(number of beds available × 7). Unit turnover was defined in the registry as (weekly number of discharges/(number of beds available × 7) and bed availability was defined as (weekly number of admissions × mean length of stay)-(bed capacity × 7)".

Can you comment on why you think mortality went up? It would be interesting to know the adjusted mortality (eg for APACHE?).

Response: Thank you. Our hypotheses:

- This represents a real change due to patients presenting late (and sicker) either due to the fear of contracting COVID-19 when they come in contact with the healthcare

system or due to pandemic imposed restrictions on access to healthcare facilities (a combination of lockdown and re-prioritization of healthcare beds and services for COVID-19). We have provided some references that support these theories in the 'Discussion' section.

- This represents a chance finding and may be a reflection of secular trends. We tried to limit this by extending the time periods of the analysis, but cannot be certain that we have fully excluded such effects.
- We have not performed an adjusted analysis as we are not confident that all information on confounders is available and/or are measured.

We have now added a paragraph in the 'Discussion' section on these possible hypotheses.

Did transfer of medical staff and equipment to COVID ICUs take place and thus limit ability to admit to non-COVID ICUs?

Response: Thank you- this is an interesting hypothesis, and we don't have data to either confirm or refute this. At all participating sites, designated areas of the hospital were assigned for COVID-19 care. While hospitals did indeed increase their manpower and infrastructure capacity (by either procuring new equipment, hiring new personnel or redirecting resources from areas such as operating rooms and non- COVID wards), we don't have data to substantiate whether this limited their capacity to admit non-COVID patients. It would indeed be interesting to explore in a future piece of work.

Minor points:

In the equation stated under variables in the methods, consider using the multiplication sign 'x' or even ''.*

Response: Done

Was Mann-Whitney U used as normality tests indicated non-parametric data?

Response: Yes- we have stated this under section 'methods', sub-section 'analysis'

What does the red line signify on Figure 1. It's quite hard to tell the difference in colour compared to the brown line.

Response: The red/brown lines represent the period of intense lockdown in India. We apologize that it is not clear. We have now changed this to orange for clarity.

The axes numbering on Fig2 are almost too small to read.

Response: We have now rectified this.

I would recommend following this general rule (taken from here: <https://www.nejm.org/author-center/new-manuscripts>) In general, P values larger than 0.01 should be reported to two decimal places, those between 0.01 and 0.001 to three decimal places; P values smaller than 0.001 should be reported as $P < 0.001$.

Response: Thank you- we have now made the changes.

Results: Outcomes - typo 'morality' instead of mortality I think.

Response: We have changed this- thank you.

Competing Interests: None

Reviewer Report 06 July 2021

<https://doi.org/10.21956/wellcomeopenres.18709.r44617>

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? **Saptharishi Lalgudi Ganesan** 

¹ Department of Paediatrics, Schulich School of Medicine and Dentistry, Western University, London, ON, Canada

² Children's Hospital of Western Ontario, London Health Sciences Center, London, ON, Canada

³ Brain & Mind Institute, Western University, London, ON, Canada

The pandemic has disrupted the healthcare system in a multitude of ways and caused a lot of collateral impact. The authors explore the utility of critical care registries in evaluating service delivery, change in case mix or outcomes and describing the impact of the pandemic on critical care service provision overall. Using a 13 ICU registry, the authors have explored ICU occupancy during 3 time periods: pre-pandemic, pandemic with intense lockdown and the remainder of the pandemic.

This study captures the impact of COVID-19 on non-COVID critical care services well showing a significant reduction in the median number of admissions to the ICUs during the pandemic period as compared to the pre-pandemic period with the reduction being most prominent during the intense lockdown phase. While the median severity of illness was higher, the ICUs did not see an increase in the proportion of patients needing mechanical ventilation or cardio-vascular support at admission. Unadjusted ICU mortality was higher during the pandemic period, but the median length of stay was similar.

The authors must be congratulated for taking this on as such studies provide valuable information regarding the collateral impact of the pandemic on critical care services and allow policy makers/leaders to plan resource allocation. The methods utilized for the purpose are appropriate. I would, however, encourage the authors to consider employing an interrupted time series approach to gain a deeper understanding of the data trends.

As acknowledged in the limitations, having data regarding COVID and non-COVID critical care would have been valuable. In its current form, there is little information on the actual diagnoses that patients were admitted with. It would be helpful to evaluate differences if any in the case mix in a more granular manner. Also, given the scale, severity and impact of the second COVID wave in India, it would be helpful to have that time period included in this or the subsequent manuscript. We may be surprised by what we find and the results could be completely different given that healthcare services in most regions were completely overwhelmed or bursting at the seams based

on media reports.

Overall, this work is important and efforts should be made to gather and analyze health care utilization data in all regions of India and other parts of the world so that we can be better prepared for future pandemics. As everyone now recognizes, when it comes to pandemics, it is not a matter of 'if' but 'when'.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Critical Care, Global Health, Clinical epidemiology, Neurocritical Care, Child Health

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Author Response 05 Nov 2021

IRIS India, Apollo Main Hospital, Chennai, India

We would like to thank the reviewers for their important and insightful feedback. The feedback has helped improve the manuscript and we are grateful for this. We address their comments below. Reviewer comments are presented in italics.

Comment: *The pandemic has disrupted the healthcare system in a multitude of ways and caused a lot of collateral impact. The authors explore the utility of critical care registries in evaluating service delivery, change in case mix or outcomes and describing the impact of the pandemic on critical care service provision overall. Using a 13 ICU registry, the authors have explored ICU occupancy during 3 time periods: pre-pandemic, pandemic with intense lockdown*

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Response: Thank you! Regarding the suggestion for use of interrupted time series (ITS), we agree in principle that this approach would add rigour. We did not employ this technique as the assumptions required for ITS (linearity etc.) are not met in our dataset. For future analyses and as the registry grows, we will certainly consider this approach. Thank you. We have now added a sentence under the 'analysis' sub-section of the 'methods' to explain why an ITS approach was not taken.

Comment: *As acknowledged in the limitations, having data regarding COVID and non-COVID critical care would have been valuable. In its current form, there is little information on the actual diagnoses that patients were admitted with. It would be helpful to evaluate differences if any in the case mix in a more granular manner. Also, given the scale, severity and impact of the second COVID wave in India, it would be helpful to have that time period included in this or the subsequent manuscript. We may be surprised by what we find and the results could be completely different given that healthcare services in most regions were completely overwhelmed or bursting at the seams based on media reports.*

Response: We agree that additional granular information on case-mix would provide crucial insights. However, the registry is currently set up to capture broad diagnostic categories and hence we were unable to provide this information. We will also consider the suggestion of the reviewer to include data from the 'second' wave in India in a future manuscript. We have now added this to the section on 'limitations'.

Comment: *Overall, this work is important and efforts should be made to gather and analyze health care utilization data in all regions of India and other parts of the world so that we can be better prepared for future pandemics. As everyone now recognizes, when it comes to pandemics, it is not a matter of 'if' but 'when'.*

Response: Thank you once again for the feedback.

Competing Interests: None