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Impact of the COVID-19 pandemic on healthcare utilisation and hospital finances in selected private sector hospitals in India: an interrupted time-series study

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Abstract

Background: COVID-19 disrupted healthcare delivery and hospital finances globally. In India, where private hospitals provide a substantial share of care, evidence on changes in service utilisation and financial performance remains limited.

Methods: We conducted a multicentre interrupted time-series study using monthly hospital-level service, outcome, and financial data from 14 private sector hospitals in India from January 2018 to July 2021. Data were analysed across three periods: pre-pandemic baseline (January 2018 to March 2020), Pandemic Period 1 (April 2020 to February 2021), and Wave 2 (March to July 2021). Outcomes included service utilisation, patient outcomes, and hospital financial indicators.

Findings: In April 2020, outpatient visits declined by 48% compared with the expected pre-pandemic trend (p<0·001), inpatient admissions by 40% (p<0·001), surgeries by 47% (p<0·001), and hospital income by 38% (p=0·020). Expenditure and concessions declined by 28% and 35%, respectively. During Pandemic Period 1, outpatient visits and surgeries showed significant monthly recovery trends of 3% and 4%, respectively. In March 2021, emergency visits increased by 24%, inpatient admissions by 21%, ICU admissions by 98%, and pharmacy income by 63%. Routine service disruption was greater among non-COVID-19 care centres.

Interpretation: COVID-19 caused major disruption in routine and elective services, followed by partial recovery. The second wave increased acute and critical care demand. Strengthening service continuity and financial resilience is essential for future public health emergencies.

Funding: This study received no specific funding.

Background

The COVID-19 pandemic had profound health and economic repercussions worldwide. [1] It caused widespread infection through multiple waves, resulting in high rates of illness and death, straining hospital systems, community centres and exposing deficiencies. [2, 3] During such a health crisis, it is crucial for a healthcare system to continue delivering routine, essential services while also meeting the demands posed by the pandemic. In India, the private sector accounts for a substantial share of healthcare utilisation, with national survey data indicating that nearly 60% of people seek healthcare outside government facilities. [4] Amid lockdown measures, which caused extensive job losses, especially in the informal sector, access to healthcare was also disrupted.[5] This situation created multiple challenges by hindering access for patients and communities, potentially leading to adverse health outcomes and financial losses for private hospitals.[6]

The COVID-19 pandemic unfolded in a series of significant events and phases. In December 2019, the novel coronavirus was first identified in Wuhan, China. [7, 8] As cases spread globally, the World Health Organization (WHO) declared COVID-19 a Public Health Emergency of International Concern on January 30, 2020, and subsequently characterized it as a pandemic on March 11, 2020. [7] India implemented a nationwide lockdown on March 24, 2020, to curb the spread of the virus. [6, 9]

The lockdown was a government-imposed restriction on movement and activities to control the spread of COVID-19. [6, 9] During lockdowns, people were required to stay at home except for essential purposes such as buying groceries or seeking medical care. These measures significantly reduced social interactions and economic activities, leading to widespread disruptions in daily life and business operations.

The concept of "waves" in the pandemic context has many potential definitions, but it refers to periods of increased infection rates followed by declines. [10] Although in a large country like India, the disease did not spread uniformly, the first wave was considered to be from June to September 2020, followed by a period of declining cases. [11] The country began a phased unlocking process in June 2020. [12] However, a more severe second wave hit India from March to May 2021, overwhelming healthcare systems. [1[1, 1]3] A third wave, driven by the Omicron variant, occurred from December 2021 to February 2022, though with less severity due to increased vaccination rates.(11 Many experts consider COVID-19 has transitioned to an endemic phase, where the virus continues to circulate but with more predictable and manageable patterns.[14]

Studies from various countries have evaluated the impact of the pandemic on health system resilience and service utilisation.[15–18] However, evidence from India's private sector remains limited, particularly studies combining monthly service utilisation, patient outcome, and financial indicators across multiple pandemic phases.[1[6, 19],20] Therefore, we aimed to investigate the pandemic's impact on healthcare service utilisation and the financial implications for private hospitals in India. We hypothesised that there would be a decline in both service usage and revenue.

This study aimed to assess the impact of the COVID-19 pandemic on healthcare utilisation, patient outcomes, and hospital finances in selected private sector hospitals in India. Specifically, we examined changes across the pre-pandemic baseline (PP), Pandemic Period 1 (P1), and Wave 2 (W2), and assessed whether trends differed between hospitals that provided COVID-19 care and those that did not.

Methods

Study design and data sources

A multicentre interrupted time-series study was conducted using monthly hospital-level administrative and financial data from selected private sector hospitals in India. The study was coordinated by a core research team in collaboration with two national healthcare organisations: the Consortium of Healthcare Organisations (CAHO) and the Christian Medical Association of India (CMAI). Representatives from these organisations invited eligible hospitals within their networks to participate.

Facilities were eligible if they were private sector healthcare institutions, including primary, secondary, tertiary, or single-specialty centres, and maintained reliable monthly medical and financial records for the study period. Participating centres were requested to provide monthly data from January 2018 to July 2021. Data were anonymised at the centre level before analysis.

Monthly data were collected for service utilisation, patient outcomes, and financial indicators. Service utilisation variables included outpatient visits, inpatient admissions, emergency department visits, ICU admissions, surgeries, deliveries, immunisations, and COVID-19 admissions. Patient outcome variables included inpatient mortality, hospital length of stay, and ICU length of stay (in days). Financial indicators included total hospital income, pharmacy income, expenditure, proportion of income from insurance, and concessions provided.

The data obtained were categorised into three analytical periods. The pre-pandemic baseline period (PP) was January 2018 to March 2020, spanning 27 months. Pandemic Period 1 (P1) was April 2020 to February 2021 and included three sub-periods: lockdown (LD) from April to June 2020, Wave 1 (W1) from July to November 2020, and the post-Wave-1 quiescent phase (QP) from December 2020 to February 2021. The quiescent phase was included within P1 for statistical reasons, given the limited number of monthly time points available for segmented regression. Wave 2 (W2) was defined as March to July 2021 (Fig. 1).

{Figure 1 here}

Figure 1. Timeline of study periods used in the interrupted time-series analysis. PP = pre-pandemic baseline, January 2018-March 2020; P1 = Pandemic Period 1, April 2020-February 2021, comprising LD, W1, and QP; W2 = Wave 2, March-July 2021.

In this study, a wave was defined as a period during which there were more than [20,000] newly diagnosed cases per day. The data were obtained from a Coronavirus tracker which provided historical details on daily new cases.[3] For the primary segmented regression analysis, LD, W1, and QP were combined as P1 to maintain model stability given the limited number of monthly time points. The results of the quantitative trends were discussed with administrators from the hospitals, and key insights elucidating the observed trends were incorporated into the discussion

Data adjustment and statistical analysis

Service utilisation, patient outcome, and financial data were anonymised before analysis. To account for differences in hospital size and baseline volumes, data were normalised separately for each hospital and each variable. For each hospital-variable combination, the baseline mean was calculated using monthly values from January 2018 to March 2020. Each monthly value was divided by this baseline mean to generate a normalised value, where 1 represented the average pre-pandemic level, values below 1 represented a reduction, and values above 1 represented an increase from baseline.

For pooled analyses, normalised monthly values were averaged across hospitals for each variable, allowing each centre to contribute equally and reducing the influence of larger hospitals. Where log-transformation was applied, the natural logarithm of the normalised values was used in regression models to allow coefficients to be interpreted as approximate relative changes.

Interrupted time-series analysis was conducted using segmented regression to estimate changes in level and trend across three analytical periods: PP, P1, and W2. The model included terms for the baseline trend, immediate level change at the start of P1 in April 2020, monthly trend during P1 from April 2020 to February 2021, immediate level change at the start of W2 in March 2021, and monthly trend during W2 from March to July 2021. In this model, the level-change coefficient represents the immediate change in the first month of a new analytical segment compared with the expected value based on the preceding trend. The trend coefficient represents the average month-on-month change within each analytical segment after the initial level change. Autocorrelation between monthly observations was assessed and adjusted using the Prais-Winsten method which involved estimating the correlation between the error at t and t-1, corr(ϵt,ϵt − 1).

The regression model was specified as:

$Y_t = \beta_0 + \beta_1 T_t + \beta_2 P1 + \beta_3 P1_t + \beta_4 W_t + \beta_5 T_{W_t} + \varepsilon_t$

where Y_t is the normalised or log-transformed outcome at month t; T_t is time in months from January 2018; P1 is an indicator for Pandemic Period 1; T_{W_t} is time since the start of P1; W_t is an indicator for the Wave 2 period; T_{W_t} is time since the start of Wave 2; and ε_t is the error term. β_0 represents the PP baseline level, β_1 the baseline monthly trend, β_2 the immediate level change at the start of P1, β_3 the change in monthly trend during P1, β_4 the immediate level change at Wave 2, and β_5 the monthly trend during Wave 2.

Model estimates were expressed as percentage changes from the pre-pandemic baseline for interpretation. Percentage differences between the pre-pandemic and pandemic periods were also calculated. Statistical significance was assessed using two-sided tests, with $p < 0{\cdot}05$ considered statistically significant.

Results

Hospitals

Quantitative data were obtained from 14 private sector healthcare centres in India. Seven centres were from the lead hospital network, six from the Consortium of Healthcare Organisations (CAHO) network, and one from the Christian Medical Association of India (CMAI) network. At the time of study recruitment, CAHO had approximately 200 registered hospitals, from which 12 were approached and six contributed data. CMAI had approximately 350

member institutions, from which 10 were approached and one contributed data. Overall, four participating centres were tertiary care hospitals, six were secondary care hospitals, and four were single-specialty centres.

{Table 1 Here}

Table 1. Characteristics of participating centres.

Pooled interrupted time-series analysis

Since hospitals provided data only for services and indicators that were reliably available from their records, not all variables were available from every centre. Details of data availability are provided in Supplementary Table 1. For each variable, available data from all contributing centres were combined to generate the pooled analysis.

Two timepoints divided the monthly hospital-level data into three analytical segments: PP, P1, and W2. Each segment had a level, representing the intercept, and a trend, representing the slope. The normalised graphs of pooled data for selected variables are presented in Figure 2. The remaining pooled and individual centre-level interrupted time-series graphs and table results are provided in the appendix.

For each variable in Table 2, the pooled all-centre coefficients describe the level and trend across the three analytical periods. The PP coefficient represents the baseline monthly trend from January 2018 to March 2020, while the P1 and W2 level-change coefficients represent the immediate changes in April 2020 and March 2021, respectively. The corresponding P1 and W2 trend coefficients represent the average month-on-month change within each period. The constant represents the baseline intercept at the start of the time series, and statistical significance is interpreted using the p value and 95% confidence interval. For example, in the pooled outpatient services analysis, the baseline intercept was 0·98 and the PP trend was non-significant, indicating a stable pre-pandemic pattern. In April 2020, outpatient visits declined by 48% compared with the expected pre-pandemic trend, followed by an average 3% month-on-month recovery during P1. In March 2021, outpatient visits showed a non-significant 4% immediate increase at the start of W2, followed by a 9% average monthly reduction during W2, which approached statistical significance.

{Figure 2 Here}

Figure 2. Interrupted time-series plots for selected pooled service utilisation, outcome, and financial indicators.

Month 1 represents January 2018. P1 begins at month 28, corresponding to April 2020, and W2 begins at month 39, corresponding to March 2021. The dots indicate actual monthly values, and the line indicates the predicted trend.

{Table 2 Here}

Table 2. Pooled segmented regression results for service utilisation and patient outcomes.

Note: PP=pre-pandemic baseline (January 2018–March 2020); P1=Pandemic Period 1 (April 2020–February 2021), comprising LD (lockdown, April–June 2020), W1 (Wave 1, July–November 2020), and QP (post-Wave-1 quiescent phase, December 2020–February 2021); W2=Wave 2 (March–July 2021). Immediate level change refers to the first month of the segment; monthly trend refers to the average month-on-month change within that segment

Services and outcomes

In the pooled all-centre analysis (Table 2), there were significant changes in monthly service utilisation and patient outcomes during the pandemic periods. In April 2020, the first month after lockdown began and the start of P1, outpatient visits decreased by 48% compared with the expected pre-pandemic trend (p<0·001), inpatient admissions by 40% (p<0·001), surgeries by 47% (p<0·001), and immunisations by 35% (p=0·024). ICU length of stay increased by 24% (p=0·023). During P1, outpatient visits showed an average month-on-month increase of 3% (p<0·001), and surgeries increased by 4% per month (p=0·001), suggesting partial recovery after the initial decline. ICU length of stay showed a significant declining monthly trend of 5% during P1 (p<0·001).

In March 2021, the first month of W2, emergency department visits increased by 24% (p<0·001), inpatient admissions by 21% (p<0·001), and ICU admissions by 98% (p<0·001). During W2, inpatient admissions subsequently declined by an average of 8% per month (p=0·002), while ICU length of stay increased by 18% per month (p=0·005).

Finances

In the pooled all-centre analysis (Table 3), hospital financial indicators changed significantly during the pandemic periods. In April 2020, at the start of P1, overall hospital income declined by 38% compared with the expected pre-pandemic trend (p=0·020). Expenditure declined by 28% (p=0·008), and concessions declined by 35% (p=0·006). During P1, there was a significant month-on-month increasing trend of 7% in the proportion of income from insurance (p=0·046) and 2% in gross expenditure (p=0·018).

{Table 3 Here}

Table 3. Pooled segmented regression results for hospital financial indicators.

Note: PP=pre-pandemic baseline (January 2018–March 2020); P1=Pandemic Period 1 (April 2020–February 2021), comprising LD (lockdown, April–June 2020), W1 (Wave 1, July–November 2020), and QP (post-Wave-1 quiescent phase, December 2020–February 2021); W2=Wave 2 (March–July 2021). Immediate level change refers to the first month of the segment; monthly trend refers to the average month-on-month change within that segment.

In March 2021, the first month of W2, pharmacy income increased significantly by 63% (p<0·001). During W2, there was a significant month-on-month declining trend of 12% in overall hospital income (p=0·001) and 19% in expenditure (p=0·008).

Centre-level contextual information suggested that the initial reduction in income, expenditure, and concessions during LD and early W1 was largely due to reduced patient footfall and lower service volumes. These indicators showed partial recovery during the latter part of P1 and increased in some centres during W2, particularly among hospitals that provided COVID-19 care.

Participating centres reported several cost-containment and operational measures during the pandemic. These included temporary salary reductions or voluntary salary deferments, in-house production of personal protective equipment, sterilisation and reuse of selected protective materials where feasible, local preparation of low-cost hand sanitiser or use of spirit-based alternatives, and stricter protocols to rationalise oxygen use and minimise wastage. However, some centres also reported substantial pandemic-preparedness expenditure, including ward restructuring, purchase of equipment, and procurement of personal protective equipment. Some hospitals also adopted government insurance schemes to support access for socially disadvantaged patients.

COVID-19 admissions and oxygen use

Among centres that provided COVID-19 admission data (Supplementary Table 2), the average monthly proportion of inpatients admitted with COVID-19 was higher during W2 than during P1, although this difference was not statistically significant. Across centres, COVID-19 admissions ranged from 6% to 30% of total inpatient admissions during the pandemic period. One of the seven centres that provided COVID-19 care admitted patients with COVID-19 only during W2, in response to the surge in cases.

Monthly oxygen-use data were available from one centre. Compared with the pre-pandemic baseline, oxygen use increased by 60% during P1 and by 92% during W2. Centre-level contextual information suggested that some hospitals restricted COVID-19 admissions because of limited oxygen availability.

Comparison by provision of COVID-19 care

A comparison was undertaken to examine whether the pandemic affected centres that admitted patients with COVID-19 differently from centres that did not admit patients with COVID-19. Percentage changes between the PP baseline and the combined pandemic period were compared for all centres, COVID-19 care centres, and non-COVID-19 care centres (Figure 3; Supplementary Table 3). For this stratified comparison, variables were included only if data were available from at least six centres, to avoid unstable estimates based on very small numbers.

In the pooled all-centre analysis, there were statistically significant reductions in outpatient visits, surgeries, deliveries, and immunisations during the combined pandemic period. In contrast, mortality, ICU admissions, hospital length of stay, ICU length of stay, income, expenditure, and concessions increased significantly.

When stratified by COVID-19 care provision, outpatient visits decreased in both groups, although the reduction was smaller among centres that provided COVID-19 care than among centres that did not provide COVID-19 care. Inpatient admissions and emergency visits increased among COVID-19 care centres but declined or changed only modestly among non-COVID-19 care centres.

Financial indicators also differed between the two groups: COVID-19 care centres showed higher income and expenditure during the pandemic period, whereas non-COVID-19 care centres showed smaller increases or reductions. These findings suggest that hospitals providing COVID-19 care experienced greater COVID-related service demand, while hospitals not providing COVID-19 care experienced greater disruption in routine service utilisation.

{Figure 3 Here}

Figure 3. Percentage change between pre-pandemic and pandemic periods, overall and stratified by COVID-19 care status.

Note: Squares indicate percentage change from the pre-pandemic baseline, and horizontal bars indicate 95% confidence intervals. The vertical line represents no change. Values left of the line indicate reductions, and values right of the line indicate increases. Results are presented overall and stratified by COVID-19 care status.

Discussion

The findings of this study show that the COVID-19 pandemic substantially affected healthcare service utilisation and hospital finances in selected private sector hospitals included in this study. The sharpest reductions in outpatient visits, inpatient admissions, surgeries, immunisations, income, expenditure, and concessions were observed in April 2020, the first month after lockdown began and the start of P1. During P1, some services, particularly outpatient visits and surgeries, showed partial month-on-month recovery. In W2, emergency visits, inpatient admissions, ICU admissions, and pharmacy income increased, reflecting the higher demand for acute and COVID-related care. The impact differed between centres that provided COVID-19 care and those that did not, with non-COVID-19 care centres experiencing greater disruption in routine service utilisation.

The impact of the pandemic varied by service type and hospital setting. A review by Kapoor et al described substantial reductions in non-COVID care across multiple services, including cancer care, nephrology, ophthalmology, trauma, and orthopaedic care.[21] Similarly, a study from an Indian nephrology centre reported an almost 50% reduction in outpatient and inpatient services compared with the previous year.[22] In one of the specialised kidney care centres in our study, outpatient and inpatient services decreased by 62% and 53%, respectively, during lockdown compared with the baseline period. An ophthalmology centre in India reported reductions of 97% in outpatient visits, 95% in elective admissions, 62% in emergency admissions, 98% in elective surgeries, and 59%

in emergency surgeries during the lockdown period from March to July 2020 compared with the previous year.[23] In the two ophthalmology centres included in our study, outpatient visits, inpatient admissions, and surgeries decreased by [70–90]% during lockdown; however, emergency services did not decline significantly in one centre, suggesting that urgent care was maintained.

A similar pattern was observed in mental health services. In one mental health hospital included in our study, outpatient and inpatient services decreased by 55% and 92%, respectively. This reduction was lower than that reported in a multicentre study by the Indian Psychiatric Society.[19] The decrease in our centre was likely related to reduced access among out-of-state patients who usually sought care at the study hospital.

Some centres used telehealth approaches to mitigate restricted access to care. However, these data were not consistently available and therefore could not be analysed. One rural centre adopted a reverse-telemedicine approach, in which patients visited the hospital while specialists provided consultations remotely from their homes or primary service locations because of travel restrictions.

The findings of this study are consistent with international evidence on the disruption of healthcare utilisation during the pandemic. Moynihan et al, in a systematic review of 81 studies from 20 countries up to August 2020, reported reductions in outpatient visits by 42·3%, admissions by 28·4%, diagnostics by 31·4%, and therapeutics by 29·6% during the first wave.[16] The reductions were more pronounced among individuals with milder or less severe conditions than among those with more severe illness, with the largest declines observed during March and April 2020. Most studies in the review were from high-income countries; only four were from low-income or middle-income countries, and three were from Asian countries: Taiwan, China, and Qatar.[16]

In a quantitative observational study using health facility data from ten countries across different income categories, Arsenault et al also found disruption in health service use preceding COVID-19 waves.[15] Cancer screening, tuberculosis screening and detection, and HIV testing were among the most affected services, with reductions of [26–96]% compared with baseline. Outpatient visits declined by [9–40]%, and maternal health services were disrupted in half of the countries, with reductions ranging from 5% to 33%. However, that study represented national trends, excluded private providers, and covered only the first nine months of the pandemic, up to December 2020.

To our knowledge, this is among the few studies from India focusing exclusively on private sector hospitals, extending into the second wave, and reporting both healthcare utilisation and hospital financial indicators. However, unlike some previous studies, our analysis did not include diagnostic utilisation, disease severity, or disease-specific clinical details.

This study has several limitations. First, the findings are not widely generalisable. The participating hospitals largely represented private not-for-profit hospitals, and the study did not capture the experience of corporate hospitals, smaller nursing homes, or the public sector, all of which contributed substantially to COVID-19 care in India. Second, the pandemic waves varied across regions, with differences by geography, urban-rural setting, and local transmission patterns. Therefore, the operational definition of waves based on national trends might not have fully reflected the timing or intensity of the pandemic in each participating centre. Third, insurance income might have been realised several months after hospital admissions in some centres, potentially underestimating income in the month when services were delivered. Finally, limited participation may have introduced selection bias, as centres with particularly positive or negative experiences might have been more likely to contribute data.

Despite these limitations, this study provides important insight into the experience of selected private sector hospitals in India during the COVID-19 pandemic. Although the overall direction of effect was similar for many centres, hospitals that did not provide COVID-19 care appeared to be more severely affected in terms of routine service utilisation. This likely reflects the disruption experienced by patients requiring non-COVID and chronic disease care. The adaptive measures undertaken by participating centres also demonstrate the resourcefulness and responsiveness of healthcare providers during a national health-system shock. Similar to the disruption caused by sudden economic crises,24 the COVID-19 pandemic revealed vulnerabilities in service continuity and financial resilience. Further evidence from corporate private hospitals, smaller facilities, and the public sector is needed to provide a more comprehensive understanding of the pandemic's impact on India's healthcare system.

The relevance of this study extends beyond the COVID-19 pandemic. Although the acute global emergency phase of COVID-19 has passed, health systems remain vulnerable to infectious disease shocks. Evidence from this study can inform preparedness for future outbreaks by identifying services most vulnerable to disruption, expected recovery patterns, and differences between hospitals that provide outbreak-related care and those that do not. These lessons are important for strengthening service continuity, critical care readiness, oxygen and supply-chain planning, and financial resilience across mixed health systems.

Conclusion

This study shows that the COVID-19 pandemic substantially disrupted healthcare utilisation and hospital finances in selected private sector hospitals in India. Elective and routine services declined sharply during lockdown and the first wave, followed by partial recovery, whereas the second wave increased demand for emergency, inpatient, and ICU care. Hospitals providing COVID-19 care experienced greater service demand and revenue, but also higher expenditure and concessions. These findings highlight the need to strengthen service continuity, financial preparedness, oxygen and ICU capacity, and operational resilience across mixed health systems for future public health emergencies.

Abbreviations

CAHO	Consortium of Accredited Healthcare Organizations
CMAI	Christian Medical Association of India
COVID-19	Coronavirus Disease 2019
ED	Emergency Department
HLOS	Hospital Length of Stay
ICU	Intensive Care Unit
ILOS	Intensive Care Unit Length of Stay
IM	Immunisations
IP	Inpatient Admissions
ITS	Interrupted Time-Series
LD	Lockdown
LOS	Length of Stay
LS	Lower-Segment Caesarean Section
MOR	Mortality
NVD	Normal Vaginal Delivery
OP	Outpatient Visits
P1	Pandemic Period 1
PP	Pre-pandemic Baseline Period
QP	Quiescent Phase
SG	Surgeries
W1	Wave 1
W2	Wave 2
WHO	World Health Organization

Declarations

Author contributions

TKG, LJ, MJSB, PJ, VA, BV, and PJV conceptualised the study and contributed to the study design. TKG, LJ, MJSB, PJ, VA, BV, DJ, PS, and PJV contributed to the methodology and interpretation of findings. PA, MC, RD, AC, FR, MP, RDR, and other participating centre representatives contributed to data provision and centre-level interpretation. JR, TKJ, and SAM contributed to data curation and data validation. LJ, JR, and PS contributed to data analysis and statistical analysis. SAM contributed to interpretation of results and manuscript review. DJ and PS provided methodological and statistical inputs and contributed to interpretation of results. TKG drafted the original manuscript. All authors contributed to critical review and editing of the manuscript and approved the final version for submission. TKG, LJ, JR, PS, SAM, and PJV directly accessed and verified the underlying data reported in the manuscript. PJV acted as guarantor and accepts responsibility for the overall content of the manuscript.

Ethics approval

The study was approved by the Institutional Review Board (Silver, Research and Ethics Committee), Christian Medical College, Vellore, India (IRB Min. No. 13668). The study involved the retrospective analysis of anonymised, aggregate hospital-level administrative, healthcare utilisation and financial data. No individual participants were recruited, and no patient-identifiable information or individual patient-level data were collected or analysed. Therefore, the requirement for obtaining individual informed consent to participate was waived by the Institutional Review Board.

All methods were performed in accordance with the relevant institutional and national ethical guidelines and regulations and with the principles of the Declaration of Helsinki.

Data verification statement

TKG, LJ, JR, PS, SAM, and PJV directly accessed and verified the underlying data. All authors had access to relevant study outputs, reviewed the manuscript, and approved the decision to submit the manuscript for publication.

Data sharing statement

The study used anonymised aggregate hospital-level data contributed by participating centres. Individual patient-level data were not collected. The aggregate dataset and statistical code may be made available to researchers upon reasonable request to the corresponding author, subject to approval by the steering committee and participating centres, and completion of an appropriate data-sharing agreement.

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Declaration of interests

The authors declare no competing interests.

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Tables

Table 1. Characteristics of participating centres.

Lead hospital centres	Type of Hospital	Covid-Care	State	No of beds	Rural/Urban
C1	Tertiary	Yes	Tamil Nadu	2,192	Urban
C2	Secondary	Yes	Andhra Pradesh	120	Rural
C3	Secondary	No	Tamil Nadu	140	Rural
C4	Secondary	No	Tamil Nadu	48	Urban
C5	Secondary	No	Tamil Nadu	57	Rural
C6	Single-Speciality (Ophthalmology)	No	Tamil Nadu	98	Urban
C7	Single-Speciality (Psychiatry)	No	Tamil Nadu	100	Urban
CAHO centres					
A1	Tertiary	Yes	Maharashtra	300	Urban
A2	Tertiary	Yes	Tamil Nadu	105	Urban
A3	Tertiary	Yes	Karnataka	340	Urban
A4	Secondary	Yes	Tamil Nadu	234	Urban
A5	Single-Speciality (Nephrology)	No	Tamil Nadu	173	Urban
A6	Single-Speciality (Ophthalmology)	No	Tamil Nadu	322	Urban
CMAI centre					
M1	Secondary	No	Himachal Pradesh	59	Rural

***** CAHO=Consortium of Healthcare Organisations; CMAI=Christian Medical Association of India.

Table 2. Pooled segmented regression results for service utilisation and patient outcomes.

Variable	PP: Baseline monthly trend Coefficient (95% CI)	PP p value	P1: Immediate level change, April 2020 Coefficient (95% CI)	P1 p value	P1: Monthly trend, Apr 2020–Feb 2021 Coefficient (95% CI)	P1 trend p value	W2: Immediate level change, Mar 2021 Coefficient (95% CI)	W2 p value	W2: Monthly trend, Mar–Jul 2021 Coefficient (95% CI)	W2 trend p value	Constant, baseline Coefficient (95% CI)	Constar p value
OP	0·001 (-0·002, 0·005)	0·430	-0·48 (-0·63, -0·33)	<0·001	0·03 (0·01, 0·05)	<0·001	0·04 (-0·17, 0·26)	0·677	-0·09 (-0·19, 0·003)	0·058	0·98 (0·93, 1·02)	<0·001
IP	0·004 (-0·002, 0·01)	0·211	-0·40 (-0·63, -0·16)	0·001	0·01 (-0·01, 0·05)	0·218	0·21 (0·13, 0·28)	<0·001	-0·08 (-0·13, -0·03)	0·002	0·95 (0·84, 1·05)	<0·001
ED	0·002 (-0·002, 0·008)	0·292	-0·009 (-0·23, 0·21)	0·932	-0·02 (-0·05, 0·008)	0·147	0·24 (0·10, 0·37)	0·001	0·03 (-0·04, 0·12)	0·346	0·96 (0·88, 1·04)	<0·001
SG	-0·003 (-0·011, 0·003)	0·282	-0·47 (-0·67, -0·28)	<0·001	0·04 (0·01, 0·07)	0·001	-0·08 (-0·47, 0·30)	0·655	-0·05 (-0·24, 0·13)	0·541	1·05 (0·94, 1·17)	<0·001
LS	0·002 (-0·006, 0·011)	0·553	-0·002 (-0·27, 0·26)	0·986	-0·17 (-0·05, 0·01)	0·308	0·02 (-0·12, 0·16)	0·751	0·02 (-0·03, 0·08)	0·439	0·97 (0·81, 1·14)	<0·001
NVD	-0·008 (-0·021, 0·004)	0·202	-0·002 (-0·29, 0·28)	0·985	-0·009 (-0·051, 0·031)	0·634	-0·01 (-0·26, 0·24)	0·926	0·08 (0·01, 0·14)	0·021	1·12 (0·90, 1·34)	<0·001
DEL	-0·002 (-0·012, 0·007)	0·567	-0·02 (-0·20, 0·15)	0·789	-0·01 (-0·03, 0·01)	0·411	0·006 (-0·11, 0·12)	0·921	0·05 (-0·001, 0·118)	0·056	1·04 (0·87, 1·22)	<0·001
IM	-0·008 (-0·018, 0·001)	0·076	-0·35 (-0·65, -0·04)	0·024	0·03 (-0·002, 0·07)	0·068	-0·07 (-0·40, 0·24)	0·637	-0·05 (-0·17, 0·07)	0·408	1·12 (0·99, 1·26)	<0·001
MOR	-0·001 (-0·009, 0·006)	0·707	0·56 (-0·06, 1·20)	0·078	0·002 (-0·08, 0·08)	0·959	0·21 (-1·74, 2·16)	0·828	0·23 (-0·42, 0·88)	0·480	1·03 (0·88, 1·17)	<0·001
ICU	0·001 (-0·018, 0·021)	0·899	0·26 (-0·22, 0·74)	0·282	-0·004 (-0·10, 0·09)	0·923	0·98 (0·68, 1·28)	<0·001	-0·23 (-0·47, 0·002)	0·053	1·05 (0·82, 1·27)	<0·001
HLOS	-0·001 (-0·005, 0·003)	0·605	0·17 (-0·03, 0·39)	0·102	-0·001 (-0·03, 0·02)	0·913	0·08 (-0·23, 0·39)	0·605	0·01 (-0·13, 0·16)	0·863	1·02 (0·93, 1·10)	<0·001
ILOS	0·001 (-0·004, 0·008)	0·566	0·24 (0·03, 0·46)	0·023	-0·05 (-0·07, -0·02)	<0·001	0·35 (-0·01, 0·73)	0·059	0·18 (0·05, 0·30)	0·005	0·98 (0·90, 1·06)	<0·001

***OP = outpatient visits; IP = inpatient admissions; ED = emergency department visits; SG = surgeries; LS = lower-segment caesarean sections; NVD = normal vaginal deliveries; DEL = total deliveries; IM = immunisations; MOR = mortality; ICU = intensive care unit admissions; HLOS = hospital length of stay; ILOS = intensive care unit length of stay.*

Note: PP=pre-pandemic baseline (January 2018–March 2020); P1=Pandemic Period 1 (April 2020–February 2021), comprising LD (lockdown, April–June 2020), W1 (Wave 1, July–November 2020), and QP (post-Wave-1 quiescent phase, December 2020–February 2021); W2=Wave 2 (March–July 2021). Immediate level change refers to the first month of the segment; monthly trend refers to the average month-on-month change within that segment

Table 3. Pooled segmented regression results for hospital financial indicators

Variable	PP: Baseline monthly trend Coefficient (95% CI)	PP p value	P1: Immediate level change, April 2020 Coefficient (95% CI)	P1 p value	P1: Monthly trend, Apr 2020–Feb 2021 Coefficient (95% CI)	P1 trend p value	W2: Immediate level change, Mar 2021 Coefficient (95% CI)	W2 p value	W2: Monthly trend, Mar–Jul 2021 Coefficient (95% CI)	W2 trend p value	Constant, baseline Coefficient (95% CI)	Consta p valu
Inc_Overall	0·009 (-0·001, 0·020)	0·104	-0·38 (-0·69, -0·06)	0·020	0·03 (-0·006, 0·08)	0·096	0·12 (-0·02, 0·27)	0·110	-0·12 (-0·19, -0·05)	0·001	0·89 (0·76, 1·01)	<0·001
Inc_Ins	-0·01 (-0·02, -0·005)	0·004	-0·02 (-0·48, 0·43)	0·918	0·07 (0·001, 0·15)	0·046	-0·26 (-1·11, 0·57)	0·526	0·007 (-0·24, 0·25)	0·950	1·21 (1·06, 1·36)	<0·001
Exp	0·01 (0·001, 0·02)	0·029	-0·28 (-0·49, -0·07)	0·008	0·02 (0·005, 0·05)	0·018	0·19 (-0·19, 0·59)	0·320	-0·19 (-0·33, -0·05)	0·008	0·88 (0·79, 0·98)	<0·001
Conc	0·02 (0·01, 0·03)	<0·001	-0·35 (-0·59, -0·10)	0·006	0·02 (-0·007, 0·06)	0·118	-0·08 (-0·51, 0·34)	0·696	-0·02 (-0·21, 0·16)	0·790	0·78 (0·65, 0·92)	<0·001
Inc_Pharm	0·01 (-0·005, 0·02)	0·172	-0·17 (-0·57, 0·21)	0·365	-0·02 (-0·08, 0·04)	0·483	0·63 (0·32, 0·94)	<0·001	-0·02 (-0·21, 0·15)	0·763	0·86 (0·71, 1·02)	<0·001

***Inc_Overall = overall hospital income; Inc_Ins = income from insurance; Exp = expenditure; Conc = concessions provided; Inc_Pharm = pharmacy income.*

Note: PP=pre-pandemic baseline (January 2018–March 2020); P1=Pandemic Period 1 (April 2020–February 2021), comprising LD (lockdown, April–June 2020), W1 (Wave 1, July–November 2020), and QP (post-Wave-1 quiescent phase, December 2020–February 2021); W2=Wave 2 (March–July 2021). Immediate level change refers to the first month of the segment; monthly trend refers to the average month-on-month change within that segment.

Figures

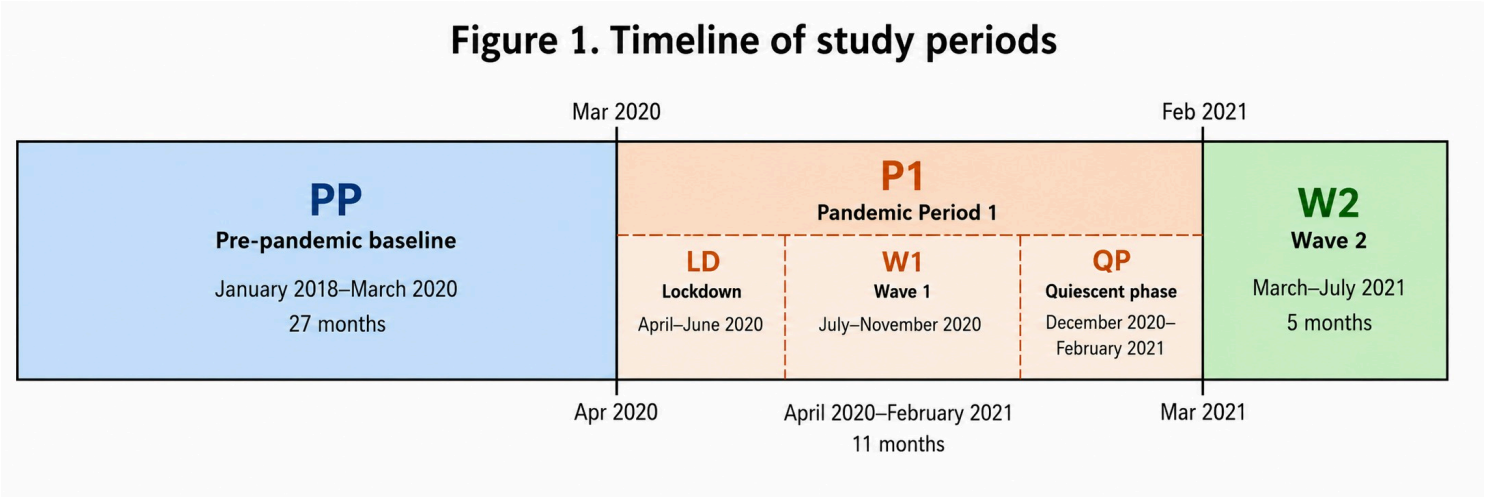


Figure 1

Timeline of study periods used in the interrupted time-series analysis. PP=pre-pandemic baseline, January 2018-March 2020; P1=Pandemic Period 1, April 2020-February 2021, comprising LD, W1, and QP; W2=Wave 2, March-July 2021.

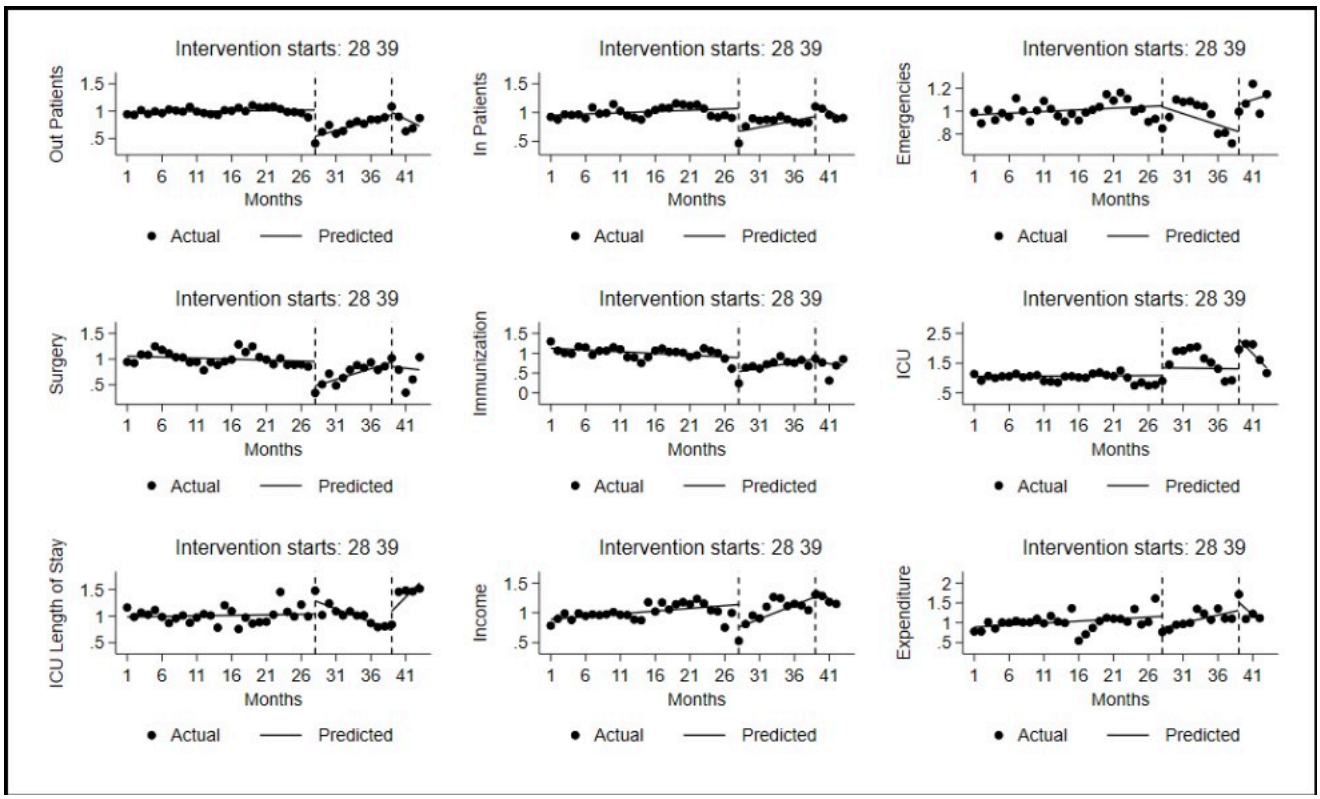


Figure 2

Interrupted time-series plots for selected pooled service utilisation, outcome, and financial indicators.

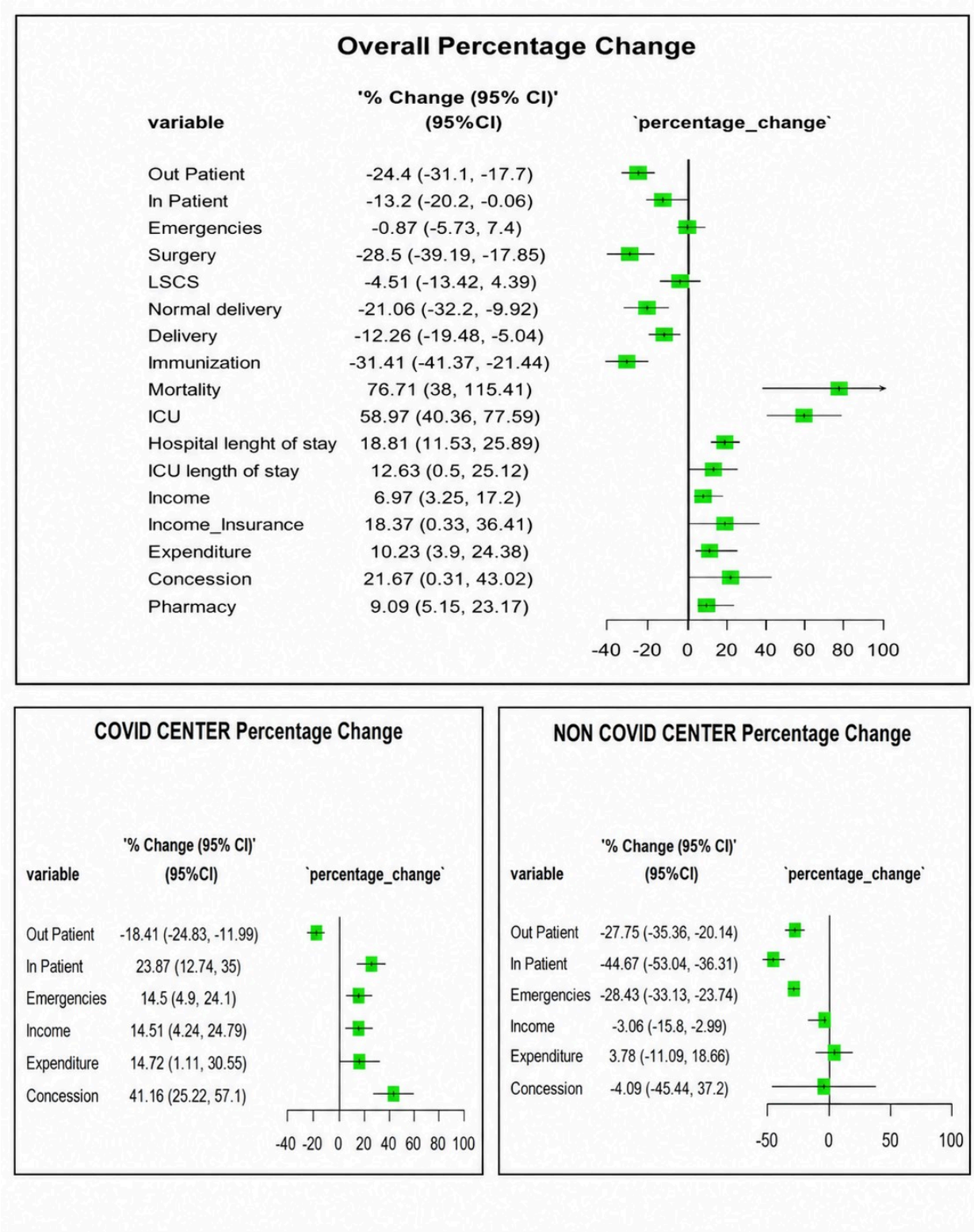


Figure 3

Percentage change between pre-pandemic and pandemic periods, overall and stratified by COVID-19 care status.

Supplementary Files

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